

Knowledge Processes in Virtual Teams

Tacit Knowledge

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Abstract: The deployment of virtual teamwork superseding traditional work structures provides ample opportunities for organizations regarding e.g., cost efficiency and employee retention. Many organizations embrace the potentials of virtual teamwork, being it modern enterprises such as start-ups or traditionally set companies integrating more virtual solutions along their evolution. Virtual teams create value by processing knowledge through the creation, transfer, retention and application of knowledge. Knowledge consists of explicit knowledge and hard to capture tacit knowledge. As tacit knowledge cannot always be easily converted to explicit knowledge in form of written documents, the knowledge processes for virtual teams are constituted differently regarding tacit knowledge. The reliance on information and communication technology for processing tacit knowledge introduces further challenges but also opens up new approaches, e.g., by working in three dimensional virtual environments. The paper at hand presents an exploratory case study about how knowledge processes regarding tacit knowledge manifest themselves in virtual teams and what technological solutions are relevant as support. A case study is performed and implications for the implementation and technological support of knowledge processes for tacit knowledge are derived.

1 INTRODUCTION

The welfare of today's society bases – more than ever – on knowledge: Most of the latest innovative and successful business models rely on data and with that on knowledge. Working on data, information and knowledge is extensively supported by technology. This enables employees to work mobile, flexible and remotely, e.g., in virtual teams (VTs). The business potential of virtual teamwork supported by information and communication technology (ICT) is considerable. Virtual teamwork can lead to a continuous workflow due to asynchronous working hours within a team. Traveling and office expenses can be cut when employees do not need office buildings. Moreover, the value creation of traditional business models depends on the transfer of knowledge and its application. As a consequence, the profile of the knowledge worker is not only common, but also predominant in most of the industrialized countries, in new as well as in traditionally set companies. Today, we face two major changes with respect to

the socio-technical prerequisites for knowledge work: First of all, individuals are much more ready to share knowledge and actively participate in the development of collective solutions (Von Krogh, et al., 2012). In addition to that, the current and upcoming workforce is used to work with ICT in their private as well as in their work life. Thirdly, technical solutions for supporting knowledge work have become much easier to use and, more importantly, more “social” in many aspects. Employees process knowledge, being it deliberately or unknowingly, when they create, transfer, retain and apply knowledge. The common distinction of knowledge into explicit (EK) and tacit knowledge (TK) (Elmorshidy, 2016) is applied for our research. The processes for EK are widely and well known, e.g., writing, storing, or transferring knowledge. In contrast to that, processes creating and managing TK are less transparent and well defined (Alavi & Tiwana, 2002). Especially, when work happens in VTs the processing and capturing of TK becomes more challenging since the personal contact is missing. As a consequence, the processes need to be

adapted and supported with appropriate ICT. Based on these prerequisites, more options to organize collaborative work and with that knowledge sharing environments arise. As VTs are considered an efficient way to organize knowledge work, more and more companies look into the potential of virtualization of teams and try to understand the mechanisms for their functioning.

VTs are by no means new as research objects. Extensive research offers insights on various aspects of VTs (Gilson, et al., 2015). Besides general analyses of knowledge processes in VTs (Fang, et al., 2014) (Rosen, et al., 2007) research on TK in VTs offers only few observations. E.g., the processes of how TK can be created (Diptee & Diptee, 2013) and shared (Elmorshidy, 2016) by VTs are analyzed. We advance these insights by providing a holistic view on all four knowledge processes (i.e., creation, transfer, retention and application, see Section 2) regarding TK in VTs and the derivation of guidance for their implementation.

The above mentioned changes in mind-set and ICT support lead to new opportunities. At the same time, it becomes relevant to think about the requirements and processes regarding the challenges introduced by TK for VTs (Alavi & Tiwana, 2002). Thus, we focus on how to implement knowledge processes for TK in VTs, by building on existing knowledge from scientific literature and performing an exploratory case study. Additionally, approaches for implementing TK processing in VTs and links for future researches are proposed.

This procedure and the derived research questions are shown in Table 1. The left column shows five components that are substantial for a valid case study design (Yin, 2014). In the right column we provide information on how and in what order these components are implemented for the case study at hand.

Therefore, Section 2 provides essential definitions of the relevant concepts. In Section 3 the case study performing interviews is presented. In Section 4 the results of the study are synthesized with the findings from literature in order to propose approaches for knowledge processes regarding TK in VTs.

2 CONCEPTUALIZATION

In order to address research questions RQ1 and RQ2 and their manifestations (see Sections 3.3 and 4) VTs, TK, knowledge system and knowledge processes, as well as factors influencing the transfer

Table 1: Key components and action plan.

Component of case study design	Implementation and section
1. Research questions	RQ1: How is tacit knowledge processed in companies adopting virtual teamwork? RQ2: What are organizational and technological solutions for effective processing of tacit knowledge in virtual teamwork? See Section 4.
2. Theoretical propositions	Concepts for virtual teamwork, tacit knowledge and knowledge processes are derived in Section 2.
3. Units of analysis and data	Interviews with one organization were conducted, transcribed and analyzed. See Section 3.
4. Linking data to propositions	The results are mapped to the knowledge processes and approaches are proposed in Section 4.
5. Criteria for interpreting findings	Criteria and their manifestation are described in Sections 3.3 and 4.

of TK are described in the following passages. The virtualization of teamwork is analyzed regarding the influencing drivers of business models (performance promise, products and services, conditions of production) as well as the organization and design of the workplace (organizational and technical).

Teams in today's work environment can be characterized by different degrees of virtuality along a continuum between more traditional and completely virtualized teams (Schweitzer & Duxbury, 2010). On the one hand, teams that can be located towards the traditional end of the continuum might use ICT so the team members do not have to be in the same office all the time and are able to work slightly different hours. Completely virtualized teams on the other hand strongly rely on ICT for being able to perform their tasks, not working face-to-face and intensely asynchronously. This can be presented by the use of collaboration platforms to chat and exchange documents for the minor degree of virtuality up to completely virtual teamwork, where the employees are spread over the globe performing any knowledge process via ICT. Modern companies such as start-ups are often far more virtualized than traditional companies or organizations that introduce virtual teamwork for certain tasks or special roles (Hanebuth, 2015). The organization whose employees were interviewed regarding their implementation of knowledge processes (Section 3) represents a degree of virtuality that is noticed to be prominent among organizations of this size and age. The teams work

in a traditional setting but use technologies for virtual teamwork as their work requires increasing mobility resulting in disperse and asynchronous teamwork.

The ways of human interaction in work environments are different for VTs compared to traditional teams. In traditional teams, employees meet in offices and can learn from each other by literally watching each other work. VTs rely on ICT for their everyday work, including all knowledge related processes. ICT, like established video call applications or virtual environments (VEs), preserve the narrative structure and experience for distance communication and enable virtual teamwork, especially supporting the handling of TK (Haase, et al., 2013). VEs include software applications, such as three dimensional meeting rooms, opportunities to work on virtual objects, the use of avatars for communication, etc. As these applications differ in their use and regarding opportunities for their operation, knowledge related processes can be assumed to be designed differently if the teams in focus work virtually, due to the prerequisites of VTs and their ICT use. Virtuality in teamwork becomes even more challenging, when focusing on processing TK in a virtual setting. TK is regarded to enable people to create ideas through their experience of the past and anticipation of the future. This ability is crucial for developing advanced and innovative ideas (Leonard & Sensiper, 1998). But as TK cannot always be converted and passed on easily via written documents (Martins & Meyer, 2014), human interaction is needed for creating, transferring, retaining and applying TK.

These knowledge processes are embedded in the knowledge system which in this context covers all areas of work systems (Alter, 2010). This does not only include ICT but also the people involved, organizational rules, and the processes performed. Therefore, VTs and the deployed ICT are building blocks of the observed knowledge system. (Section 3). Its processes can be defined as a sequence of input, alteration and output in order to create value (Heisig, 2009). Complying with this definition, knowledge processes use knowledge as object of alteration. Many different concepts of knowledge processes are derived in literature (Heisig, 2009). For the paper at hand the knowledge processes are structured into creation, transfer, retention and application of knowledge (Heisig, 2009). This discrimination serves the analysis of different knowledge related tasks and a reasonable mapping of ICT to the knowledge processes. The process of knowledge creation includes the generation of TK

from EK as well as from sources of mainly tacit character (Liu, et al., 2008). Transfer of TK is presented by the transfer from one to another person happening within a team as well as the transfer between teams. Factors influencing the quality of transfer of TK are e.g., trust, reciprocity, and organizational structure (Hao, et al., 2016). The extent of the factors' positive or negative influence on TK transfer appears to follow complex dynamics for each single case. There is no consensus in literature concerning these influencing factors (Hao, et al., 2016). The factors concerning TK transfer are especially addressed by ICT, e.g., in user generated social intranets (Elmorshidy, 2016). TK transfer is also referred to as TK sharing in literature (Hao, et al., 2016). Sharing stresses the dynamics of reciprocity and intrinsic factors such as the employees' attitudes and intentions (Hao, et al., 2016). As the concepts of sharing and transferring TK are not consistently discriminated in literature of different scientific fields, this paper and further research can add to structuring these concepts. Retention of TK can be realized by documentation, implying the conversion of TK to EK (Martins & Meyer, 2014). As TK cannot always easily be converted, another way of retaining this knowledge is within the carriers. Therefore, also employee retention is of major importance, as not documented TK would leave the organization with the employee. The process of knowledge application is presented by the actions of the knowledge carrier. The carriers are not only hosts of the knowledge but apply it through their work-related actions. Concerning TK, ideas of carriers only have a positive effect on team and company performance when they are actually applied. This pertains to disruptive innovations as well as to minor changes in everyday business. Thus, this process is of major importance, although not yet recognized by research and practice as much as the other three knowledge processes described above (Alavi & Tiwana, 2002).

Consensus has been achieved on the importance of TK in work systems (Martins & Meyer, 2014). Three arguments stressing the relevance of knowledge processing of VTs are proposed by (Fang, et al., 2014): Knowledge processes of VTs impact individual and organizational learning. VTs enable the utilization of knowledge across distances. An effective handling of tasks by virtual teamwork aims towards an efficient use of available knowledge (Fang, et al., 2014). Virtuality of work settings, including solutions from telework to 3D virtual meetings, is assumed to affect knowledge related processes in work systems (Diptee & Diptee, 2013).

However, it does not become clear, how TK is managed as a consequence of virtualization. Thus, the effects of virtuality on knowledge processes for TK and the related use of ICT are to be enlightened in the paper at hand. In order to meet this goal, we aim at deriving organizational and technological approaches for processing TK in organizations which strive for a virtual work environment. These organizations are not founded as virtual companies, but evolve from a less virtualized traditional setting towards more virtual solutions.

The following case study addresses RQ1 regarding how TK is being processed in companies adopting virtual teamwork. Based on the results of this analysis, RQ 2, focusing on adequate solutions for effective processing of TK in VT teamwork is addressed.

3 CASE STUDY

The data considered in the following has been collected in a foundation. It defines the status quo of working, knowledge processing, communication processes and their appreciation in this particular foundation. The method of data collection (i.e., interviews) was pre-defined in consultation with the foundation based on structural and organizational issues. We extracted information relevant for RQ1 (see Table 1) focusing on the exploration of existing processes related to TK.

3.1 Data Collection

In December 2016, interviews with ten employees with the duration of one hour have been conducted. These ten from more than hundred employees of an around ten year old private and independent foundation addressing socio-political topics were from different levels of responsibility. Some of them have to solve leading and organizational tasks, others financial issues and a lot of them have tasks mainly related to research and assessment. The interviews were conceptualized in order to analyze the current state of knowledge management strategies and the usage of ICT applications in this context. In sum, 49 mainly open questions without pre-defined answer possibilities have been asked via a video conference-system after having had an on-site meeting with the interviewees once. All interviews have been recorded and transcribed.

The interviewees cover a broad range of hierarchical levels of the foundation. The interviewees regularly work together as team, face-

to-face during the same office hours, but also work virtually if a personal meeting is not possible. This is the case when either being on business travels or with external partners, customers, and experts.

Table 2 presents the analysis' characteristics (Benbasat, et al., 1987) and their implementation.

Table 2: The analysis' characteristics and their implementation.

Standardized characteristics (Benbasat, et al., 1987)	Implementation
1. Phenomenon is examined in a natural setting.	Processing of tacit knowledge is analyzed in an organization.
2. Data are collected by multiple means.	Interviews are recorded and transcribed as data collection method.
3. One or few entities (person, group, or organization) are examined.	Ten employees of one organization are examined.
4. The complexity of the unit is studied intensively.	The complexity is structured by differentiating into four knowledge processes.
5. Case studies are suitable for the exploration, classification and hypothesis development stages of the knowledge building process.	The goal is to derive organizational and technological approaches for how to process tacit knowledge regarding virtual teamwork.
6. No experimental controls or manipulations are involved.	The analyzed data was collected and assessed following the Grounded Theory.
7. The investigator may not specify the set of independent and dependent variables in advance.	The dependent variables are not set, but the research goal induces virtual teamwork as context for the independent variables.
8. The results derived depend heavily on the integrative powers of the investigator.	The conceptualization of tacit knowledge processes and data analysis processes support the integrative potential.
9. Changes in site selection and data collection methods could take place as the investigator develops new hypotheses.	Changes in site selection or collection methods are regarded as opportunities for validating the findings though future research.
10. Case research is useful in the study of "why" and "how" questions because these deal with operational links to be traced over time rather than with frequency or incidence.	"Why" and "how" questions are implemented in the data collection. Ways for how to process tacit knowledge are extracted from the interview data, supporting the exclusion of arbitrariness.
11. The focus is on contemporary events.	The focus is on current developments and analyzed regarding a currently operating organization.

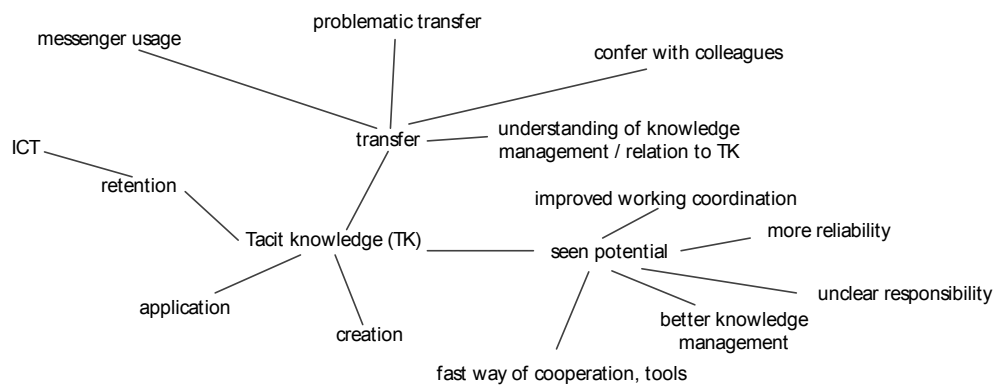


Figure 1: Code model.

answers, the teams are considered to be currently evolving from a less virtualized traditional setting towards more virtual approaches. This evolution is furthermore based on the private media usage behavior of the interviewees and on organizational modernization activities.

3.2 Data Analysis

In order to answer RQ1 and prepare for RQ2, the data set is categorized and analyzed deploying common steps of the Grounded Theory approach (Glaser & Strauss, 1998) going beyond a simple content analysis and providing further hypotheses as a result. As outlined in Table 2, the following aspects (e.g., technical issues, “applications” (e.g. social media, mail and phone)) and thereof clustered categories (e.g., ICT, transfer, fast way of cooperation, and tools) were defined, based on the conceptualization proposed in Section 2. The processes of knowledge creation, retention, transfer, and application were used to code the answers of the interviews. Based on these processes and after analyzing the available interviewees’ responses by two researchers, a systematic definition of categories was done. The results are presented in the code model in Figure 1 and discussed in Sections 3.3 and 4. The code model allows modeling while assessing the results of the interviews. Once the categories and underlying aspects were defined, the amount of mentions regarding each category was counted. It is recommended, that two researchers are executing these activities independently of each other for valid results. Therefore, and to avoid media bias one researcher used MAXQDA¹ and one researcher used

pen and paper. Results were brought together after a consistency check of the coding scheme (see Figure 1).

The chances and challenges ICT induces appear to be of major interest for the interviewees concerning TK management and a difference between desired and existing culture of knowledge management and knowledge sharing was revealed. The code model provides an excerpt of the potentials and issues seen in the TK management processes by the interview partners. The available interviewees’ answers have been scanned regarding the categories and their frequency was counted (i.e., how often an aspect and a category were mentioned – not necessarily designations, but interpreted meanings). The coding leads to the results and hypotheses as presented in the following section.

3.3 Results

The results of the interview analysis provide answers to RQ1 regarding how TK is processed in companies adopting virtual teamwork. The currently established team structure can be located in-between traditional and VTs as described above and the results represent the challenges concerning TK and its current handling. However, the results also provide an insight about how TK could be represented in knowledge systems used for virtual teamwork.

Most of the factors mentioned in the interviews concerning TK are related to the knowledge transfer process. Furthermore, in VTs working with unclear task descriptions, communication between colleagues is significant. The mentioned skills lead to the conclusion that the employees working in teams are required to be responsible for their decisions and processes and innovative at the same time. They express a tension between these job requirements. Furthermore, their work relies on TK

¹ MAXQDA is a professional research software for qualitative, quantitative and mixed methods research for defining the code theory model (online available: <http://www.maxqda.com/>)

and should be handled in an organized way with and in ill-structured situations. Due to this, it is not surprising, that communication is important for the employees to share experiences, discuss topics and processes. The interviewees state they all receive an average amount of fifty emails per day and collaborate via sharing and commenting texts. On the one hand, it is stated that using emails and chats causes a lack of being able to convey complex TK that could be transmitted better via personal contact or videoconferences. An advantage of synchronous contact is that wrong or missing information can be communicated faster, compared to asynchronous email contact. On the other hand, some interviewees elucidate that asynchronous conversations have the advantage of not interrupting thinking processes, as spontaneous calls may do. Consequently, the retrieval of information is problematic, because of missing TK by a spillover of information. Changing the ways of sharing knowledge, e.g., by using knowledge management systems that structure information in clusters, is regarded as supportive.

Being open minded and willing to share knowledge is mentioned as important for successful collaboration and communication. The importance of personal communication is stressed, regarding transferring knowledge in conversations with colleagues and experts as well as in conferences. This personal, direct transfer of experience is used when facing new projects, tasks, and exceptional situations, as well as for creative and training processes.

Transfer and creation of knowledge are difficult to distinguish in the interview results regarding the moment creation takes place: Employees collaborate to solve problems or act within unclear situations and tasks. While searching for an advice, two people share an experience and might be able (if willing) to gain ideas or create new common practices and thus knowledge for themselves. The application of knowledge very much relies on pre-created TK in form of not (yet) shared or converted knowledge (e.g., experiences, not well documented best practices), and on how it can be converted to EK and used by other team members. According to the interviewees, a common way to gain information is searching online via search engines as a starting point followed by offline (mostly informal) talks to experts, research in specific journals and books. Based on the interviewees' answers, there are some internal guidelines available within the organization (e.g., how to start and finalize a project), but not regarding creation, transfer and retention of knowledge in a formal way. This leads to the

availability of a certain amount of TK which is rarely transferred to EK. According to the interviewees, such a transfer within the investigated organization mainly happens after a private talk in an informal way in which the persons involved notice that similar research has already been performed or certain knowledge is already available.

Yet, all the interviewed employees are willing to share their knowledge with colleagues, if this knowledge is important for them. Currently, this happens via extensive meetings. In order to retain TK, personal communication and meetings should be structured and focused. The interviewees prefer a to-do-list rather than a protocol after the meeting.

The documentation of meetings and project results leads to the process of retention of TK. The employees use tools for storing knowledge, in order to keep access and share with colleagues. Virtuality becomes more significant while being away on business. ICT supporting virtual knowledge retention are e.g. automated tracking tools for communication and meetings, email applications and organizational tools (e.g. trello or clouds). However, several disadvantages were described concerning ICT use: Using knowledge storage tools, the knowledge stored is abridged, sometimes unclear, unstructured and should be updated with content. Such tools can furthermore distract from work processes if they need to be updated manually. This can be overcome by implementing automated tracking tools, generating documentation from data collected along written communication (email, chat) and also tracking spoken communication in calls, video-calls and virtual meetings in VE.

Interviewees see a problem in the often unfiltered presentation of information. Figure 2 provides an overview of the frequency in the interviews regarding the described categories. The

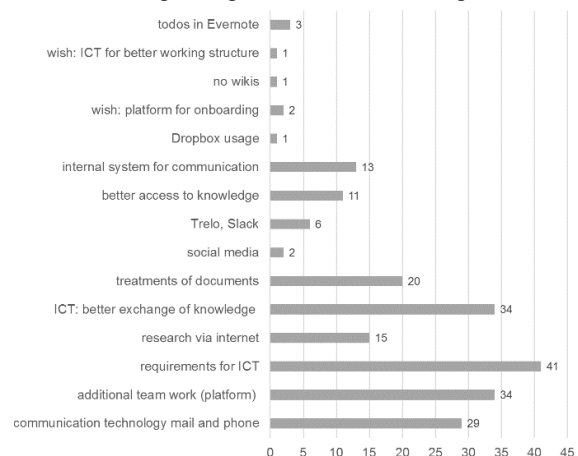


Figure 2: Frequency of categories related to ICT.

majority is related to general ICT requirements, followed by issues relevant in rather traditional working environments (e.g., additional team work, mail and phone, treatment of documents). Less often mentioned topics are related to suggestions (e.g., that one would not like to use wikis or Dropbox) or to wishes (e.g., use ICT for better working structure or platforms for the special case onboarding). In order to be able to transfer TK to EK and retain it, interviewees see potential in user-friendly and automated tools. These tools are required to combine storage, support transfer and provide features for retaining experience by transforming TK to EK.

4 DISCUSSION

Based on the results (Section 3.3), as derived along the Grounded Theory approach, following hypotheses are derived:

- 1 If team members are aware of the existence and location of related TK, duplication of work (e.g., research to same or similar topic, definition of best practices, and research for previous experiences) would be avoided.
- 2 If TK is converted to EK, documented and communicated in a continuous and constant way, transparency concerning available knowledge would be provided.
- 3 If the activity of knowledge documentation is a complex and time-consuming task, it prevents from doing the daily business and is, in sum, not supportive.

These hypotheses and the according results (Section 3.3) as well as the conceptual foundations (Sections 1 and 2) are synthesized for addressing RQ2, providing support towards solutions for effective processing of TK in virtual teamwork. The organizational implementation of the knowledge processes for TK and the corresponding technological support are shown in Table 3. The results are presented for TK. Options for TK that require or include the conversion to EK are marked with (EK).

The results in Table 3 show, that creation of TK does not necessarily require EK but relies on the interaction with team members or other teams. In order to support informal talks, open meeting rooms could be established. These open meeting rooms require an always online video room which can be visited by employees e.g. during coffee breaks for informal talks or can be attached to a personal workplace. E.g., if a VT includes employees working in two cities in office buildings, each office

Table 3: Implementation and technological support of knowledge processes for TK in VTs.

Knowledge process	Implementation	Technological support
Creation	Online search, talk to experts, informal talks	VE, open meeting rooms
Transfer	To team member, to other VT, using clustered knowledge	VE, wiki (EK), email and chat (EK)
Retention	Within carrier (supported by employee retention), converted to EK for storage	To-do-lists (EK), wiki (EK), individual handover (EK), tracking tools (EK)
Application	Use of TK for tasks	VE, video calls

could set up a real room with some seating and an always on online camera, so employees can spontaneously meet, just as they are used to from coffee breaks in traditional office settings. These technological solutions need organizational support for employees to recognize the benefits and for supporting a technological progressive and open minded culture within the organization.

Another technological opportunity that can be applied for solutions such as VEs, chats and phone calls is the tracking of conversations. The tracking can be automated and the collected data can directly be converted to EK using adequate algorithms. The challenge for this opportunity is how to convert TK that can be only correctly interpreted when cultural aspects, tone of voice, gestures and content are combined and mapped to the preconditions of the recipient. Even though already several solutions exist and research in this field is very active, this is a highly relevant open link for further research.

5 CONCLUSIONS

TK proves to be a valuable but hard to capture resource in knowledge processes of VTs. All four identified knowledge processes are recognized to be a challenge for VTs. But these challenges can be addressed by organizational and technological solutions as shown in this paper. The main results of the interviews conducted among the employees are that communication rules are helpful, but must not be too detailed and complicated and need to be coherent across teams. In order to provide transparency concerning available knowledge, rules need to be documented and communicated.

Knowledge processes regarding TK are represented in a similar way in work environments for VTs and traditional teams regarding retention and application of knowledge. Challenges occur

through virtuality concerning knowledge creation and transfer. These can be addressed by inducing communication and documentation rules, as well as by using ICT for synchronous teamwork, such as VEs (RQ1 and RQ2). Organizational knowledge processes meet the requirements of individual knowledge processes when providing supportive management of TK. This leads to an organizational culture of enabling and valuing knowledge work.

Even though the interviews provided relevant insights, drawing ideas from interviews in one organization only can be regarded as limitation of this work. As the selected organization represents a common size and degree of virtualization, the results are nevertheless assumed to represent a large group of organizations. However, there are open points, concerning managing and supporting the harvesting of TK through ICT. Knowledge creation and application can be measured using respective reports (Argote & Ingram, 2000). As this is more difficult when surveying TK, further research is required to provide report applications and rules for TK. Creation of TK is based on human interaction, e.g. in VEs, and could be augmented by human-machine-interaction and even machine-machine-interaction as already tackled by research concerning neuronal networks. This participation of machines introduces further opportunities for reporting through the immanent conversion of TK to EK in digital devices. Knowledge conversion from TK to EK, especially concerning experience-related issues is also crucial for efficient work.

Besides the goal of knowledge retention, written and oral discussions could be tracked for detecting risk of troubles, serving as early warning system, but at the same time introducing supervision and impairing organizational trust. Therefore, the support and governance of cultural changes that are required when introducing new ICT are of major importance. Built on the results from the research above, effective VTs can be established for different degrees of virtuality, based on organizational foresight and new technological achievements.

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