FROM ISOLATION TO COLLABORATION - HOW THE INCREASING DIFFUSION OF MOBILE DEVICES HAS CHANGED PRACTICES OF KNOWLEDGE SHARING IN NON-OFFICE SETTINGS

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Research

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Abstract

The increasing diffusion of mobile devices such as smartphones or tablets has not only revolutionized how people communicate with each other, but has also changed work practices and the way employees share knowledge. Knowledge management studies have to date mainly focused on office settings but paid little attention to non-office workplace settings. However, the use of mobile devices also changes the way employees can be supported and support each other in non-office settings and thus create new application areas for knowledge management. In this research, we applied a three step qualitative inquiry with 36 experts in the construction sector to investigate how the increasing diffusion of mobile devices has affected existing work practices that are associated with knowledge sharing in non-office settings. We found that the use of mobile devices helped to transform isolated work practices into collaborative work practices, thereby reducing the spatial, temporal, contextual, and social barriers to knowledge sharing. As such, an increase in connectivity can be seen as an indicator for potential development of increased collaboration across work sites. We conclude the paper with a discussion of implications for organizations concerning the support of knowledge sharing in such settings and an outlook on future work.

Keywords: barriers, construction sector, knowledge sharing, mobile devices, non-office settings, work practices

1 Introduction

In today’s networked world people tend to be connected to their work colleagues, superiors and clients as well as family and friends almost 24/7 via their mobile devices (Kolb et al., 2008; MacCormick et al., 2012). Smartphones have become our constant companions and we rarely experience “offline” periods (Dery et al., 2014; Soror et al., 2012). The tremendous development of technological infra-

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structure and data transfer has changed workplaces so that people are now able to work wherever they are and whenever they want (Dery et al., 2014; Harvey and Novicevic, 2006). Some of the advantages of ubiquitous and near-constant connectivity are immediate access to documents and people, independently from time and location and greater perceived flexibility and autonomy (Mazmanian et al., 2013; Wajcman and Rose, 2011). Thus, the use of mobile devices combined with social software provides many opportunities for knowledge management in general and for knowledge sharing in particular (Pawlowski et al., 2014).

The increasing diffusion of mobile devices affects individual employees and also organizations as a whole. Employees manage their implicit knowledge more efficiently by sustaining continuous collaboration and knowledge sharing (Razmerita et al., 2009). On the basis of the definition of smartphones by Watkins et al. (2012) we specify the mobile devices used in this study as reconfigurable communication devices allowing location-independent download of apps and content via 3G, 4G, and/or Wi-Fi networks. Mobile devices enable rapid search, access and retrieval of information and supported communication and collaboration between community members (Deng et al., 2012). The use of mobile devices and social software, however, has affected people’s private and professional life, and not always positively (MacCormick et al., 2012). Within organizations, work practices have remarkably changed due to the use of mobile devices and their affordances (Mooney et al., 2010; Norman, 1999; Wajcman and Rose, 2011). Along with the diffusion of new technologies, new norms concerning autonomy, work modes, work attitudes, and social interactions have emerged in organizations (Mazmanian et al., 2013; Murphy, 2007; Watson, 2010).

So far, researchers have mainly investigated the effects of the use of mobile devices on knowledge sharing for new or future work practices and co-located office workers (Durst and Runar Edvardsson, 2012). However, little research can be found on how the use of mobile devices has changed existing work practices in non-office settings, where a combination of manual, professional and managerial work is often a) relatively isolated (e.g., never at a head office), b) non-stationary, i.e., sites change over time c) interdependent, i.e., separate firms or contractors must coordinate their knowledge and efforts to achieve overarching goals and/or project completion (e.g., teams working with other teams), and d) generally tightly time-bound.

While this kind of work has been going on for a long time, workers in non-office settings increasingly use mobile devices to, among other things, share knowledge. The hope is that these new technologies enable people to make better and timelier local decisions, and solve tasks more effectively (Von Krogh, 2012). Hence, our research question is as follows.

RQ: How has the increased diffusion of mobile devices affected daily work practices that are associated with knowledge sharing in non-office settings?

The remainder of this paper is structured as follows. After we describe the theoretical background and our applied methodology, we analyse the results of our investigation. Specifically, we will take the example of ‘validation seeking which we define as reassuring one’s own opinion by approaching peers or superiors. We then describe in detail how an increase in validation seeking behaviour appears to be due to workers’ increasing use of mobile devices. Finally, we discuss positive and negative effects of the various communication and organisational barriers overcome by the increased diffusion of mobile devices and reflect on implications for organizational support of knowledge sharing and outline avenues for future research.

2 Research Background

The use of mobile devices and social media has changed work norms and practices over the last years (Mazmanian et al., 2013). The ease and speed of information transition in a real-time format has led to a 24/7 availability and responsiveness between individuals and organizations and therefore facilitates the work of distributed teams all over the world (Harvey and Novicevic, 2006; Kolb, 2008). Connectivity can be seen as an enabler for performance as the Internet-based computing platforms and the
extended investments in technological infrastructure support the exchange of data throughout the world (Harvey and Novicevic, 2006; Wajcman and Rose, 2011). As a result the increasing diffusion of mobile devices has not only affected the work environment in general, but has also led to the rise of new work practices, new ways knowledge is created and shared and provides many opportunities for knowledge management (Pawlowski et al., 2014).

Mobile devices offer features to support and coordinate knowledge sharing in the form of mobile messaging and content sharing (Deng et al., 2012). They are the basis for mobile knowledge management, which means that knowledge acquisition and knowledge sharing are increasingly promoted (Zhang and Shuzhen, 2014). Further the available communication and interaction features of mobile devices encourage knowledge sharing and generating of new knowledge location-independent (Liaw et al., 2010). Due to the time and space independency that the use of mobile devices provides, sharing and exchange of knowledge is not limited to specific locations or a small group of people, where knowledge would be “restricted”, but expands to everyone (da S. Souza et al., 2012). As a result, each mobile user has access at all times and all places, to all resources and communication channels (Davis, 2002).

Overall, mobile devices appear to be promising tools to facilitate the ad-hoc acquisition of external knowledge in workplace environments. Seeking external knowledge can be performed by using devices that can be flexibly used at home, in various kinds of workplaces, on the move, and even during leisure activities (Wang and Shen, 2012). The context sensitivity of available information is individually enriched, personalized and influenced and the information can be discussed, appraised and supplemented via social networks, blogs, and wikis. This in turn can support the content supply and communication and, ultimately, improve knowledge sharing (Weiss and Leimeister, 2012).

The existing literature on knowledge sharing mainly focuses on in-office work situations, which take place within tight organizational boundaries (Razmerita et al., 2009; Von Krogh, 2012). By contrast, as noted above, there is little understanding on how to share knowledge in non-office settings and, as such, this is still an emerging area of research (Bigliardi et al., 2014). One reason for the lack of literature on this topic might be that workers engaged in non-office settings are historically called “blue collar” workers and are frequently rated as non-knowledge workers (Huang, 2011). Research on the use of mobile devices has been mainly focused on the establishment of new work practices (Cousins and Robey, 2015), on measurable performance outcomes (Chung et al., 2014), or on barriers of adopting mobile work practices (Raguseo et al., 2015). Further, empirical examinations of how existing work practices changed and how workers in non-office settings collaborate through the use of mobile devices are scarce (Kietzmann et al., 2013).

Summing up, as we identified a lack of research on the effects of the increasing diffusion of mobile devices in non-office settings and on existing work practices related to knowledge sharing, we will investigate this issue by conducting a qualitative research study in the construction sector. Moreover, we identify the positive and negative effects of the increased diffusion of mobile devices that are associated with these changed work practices.

### 3 Methodology

In the context of an EU funded project that focuses on the enhancement of informal learning and collaboration with the use of mobile devices, we conducted a qualitative research study with an interpretive lens, to find out how the use of mobile devices has changed work practices in the construction sector. In order to answer our research question, how the increasing diffusion of mobile devices has affected daily work practices associated with knowledge sharing in non-office settings, we conducted a study between March 2013 and July 2015 consisting of three phases with experts of five networks of organisations in the construction sector in Germany shown in Figure 1.
Research Phases

1st Phase
Focus Group

Impact of the introduction of mobile devices on the team level

2nd Phase
Semi-Structured Interviews

Impact of mobile devices on knowledge sharing and informal learning

3rd Phase
Confirmatory Semi-Structured Interviews

In depth investigation on how validation seeking changed with the introduction of mobile devices

Research Focus

Identification of work practices affected by the introduction of mobile devices

High impact of mobile devices on knowledge sharing
Validation seeking through mobile devices increases knowledge sharing

Research Outcomes

Enhancement of validation seeking via mobile devices and implications for knowledge sharing

Figure 1. Research procedure

First, we performed one focus group with eight participants, followed by 23 semi-structured interviews and five confirmatory semi-structured interviews. The focus group as well as the interviews, were conducted by two researchers and audio recorded. In the latter, the audio recordings were transcribed, cleansed, coded and analysed with the help of Atlas.ti (Friese, 2014).

For the focus group, as well as for the semi-structured interviews, demographic diversity was guaranteed in terms of age and professional background. Our interviewees were aged between 20 and 60, were members of five different construction networks with different professional backgrounds ranging from foremen, architects, workers, apprentices, and instructors to company owners and network coordinators. Since women are underrepresented in the construction sector, the majority of our interviewees were men. Our investigated networks ranged from a regional industrial and labour association to an informal online community of 1,600 members who build, renovate, or are interested in half-timbered buildings.

Phase 1: Focus group session

The main goal of the focus group session was to investigate the impact of the use of mobile devices at team level. Here, we discussed general practices such as finding, sharing and reusing information, building knowledge, social interactions, developing ideas etc. and their implementation of mobile devices in the daily work life with our participants. In this phase, we used the open coding technique (Glaser, 1992) to be open to any new phenomena. Three researchers conducted the coding, so that we followed up in short time cycles on our current findings. Among others, we identified three different practices such as validation seeking, swapping responsibilities, and knowledge cascading, which were heavily affected by the increased diffusion of mobile devices.

Phase 2: 23 Semi-structured interviews

During the second phase and in order to specify the focus of our research the goal was to investigate how knowledge sharing behaviour and informal learning is affected by the increasing diffusion of mobile devices in networks. Thereby, we focussed on the practice of validation seeking. Although, swapping responsibilities and knowledge cascading are interesting practices, we found, based on our data
analysis, that validation seeking had the greatest impact on our interviewees’ work life. While swapping responsibility stands for the general pattern to push off responsibility to the counterpart and knowledge cascading is the gradual distribution of knowledge, validation seeking is here defined as reassuring one’s own opinion by approaching peers or superiors.

Here, we used the axial coding technique (Corbin and Strauss, 1990) and met regularly to discuss, verify and challenge our findings. We revealed the importance of mobile devices for knowledge sharing and our interviewees focused particularly on the practice of validation seeking, and its impact on knowledge sharing.

**Phase 3: 5 Confirmatory semi-structured interviews**

The goal of the confirmatory semi-structured interviews was to confirm out gained insights as well as to acquire deeper insights about how the use of mobile devices altered the practice of validation seeking over time. Therefore, we tried to find out (1) if and how validation seeking is applied personally, in the organization or the network over time as well as (2) who is involved in this process and which mobile devices are used. We asked our interviewees to describe specific situations. We used the axial coding technique (Corbin and Strauss, 1990) and conducted an iterative textual analysis of the interview transcripts. The goal was to understand the linkages between the use of mobile devices and the change of the practice of validation seeking. We further focussed on the implications of this development for knowledge sharing and collaborative work.

**The use of mobile devices in the German construction sector – Case description**

The construction sector requires a combination of physical, technical and organizational abilities and work mainly happens on construction sites outside offices. Employees work independently or in small teams on-site. A particular challenge of the construction sector is the fact that the workforce has to face problems related to physical contexts that need to be solved promptly in order to move forward. Therefore, construction workers are exposed to a great pressure and interdependency with other firms. For example, the electrician cannot begin his or her work before the bricklayer has not finished. In order to reach the expected outcomes, they need to cooperate and communicate with each other to overcome difficulties and challenges that could arise within the working environment. Hence, a continuous knowledge sharing is vital. As a result, work relies on consistent on-going communication between the workers themselves, as well as with their supervisors, sub-contractors, suppliers, and professional services as well as in some cases, the owner/client.

Before the use of mobile devices such as tablets and smartphones and high network coverage on the construction site, construction workers had to make many minor and some major decisions mostly on their own in order to satisfy their supervisors and the client without any time lag. They worked very independently and took the responsibility for their own decisions most of the time. If they faced a critical problem and wanted to validate their opinion they were reliant on their colleagues or superiors’ knowledge on site or called them via phone. However, describing the context of a construction site in all its complexity is very challenging. Hence, the communication partner didn’t get a holistic impression, which could have led to wrong advices. A particularly great change has occurred with the availability of mobile bandwidth to transfer photo and video data, which presented itself as a major turning point in our study and will be described below. The sector is also somewhat idiosyncratic in the sense that the increasing diffusion of mobile devices has led to great changes in their work practices in a very short period of time, in comparison to office work situations where the change happened steadily, but in small, incremental steps over the last few decades.

**4 Results**

Due to our 3-phase data collection over a timeframe of two years we were able to observe changes in the perceptions of our interviewees on alterations of knowledge sharing practice change relative rapidly. Furthermore, we explicitly asked our interviewees how and why the knowledge sharing practices changed over time. While investigating the change of work practices in general and particularly the
knowledge sharing practices at construction sites, we discovered that a precondition for knowledge sharing was overcoming the temporal, spatial, contextual, and social barriers experienced at such sites. We found that prior to the increased diffusion of mobile devices on the construction site, our interviewees were facing these four barriers, which hampered knowledge sharing and led to isolated work practices. The functionalities of mobile devices, including the improved availability of colleagues and superiors, however, has led to more collaborative work practices that enable and support knowledge sharing. In the following sections, we will describe the four barriers and explain how employees were able to overcome them.

4.1 Temporal barriers

The temporal barriers describe the time lag between the occurrence of a work problem and the possibility to ask for a solution or for assistance to solve the problem. Historically, workers of the construction sector worked quite independently, because there was no practical means to communicate with them while on site. Decisions were consequently taken mainly individually, along with the subsequent risks that accompanied each decision, as described by one of our focus group participants (FG): “I would say 20 years ago, on the construction site I was alone on site. Then we had our first telephones; there were these huge boxes that had no signal. There we had to, if we had to work further, we had to take the decisions ourselves. We had to take the decisions ourselves and then we could construct the entire site.” Thus, workers had to decide themselves about all the actions taken, and the only alternative available was to refer to other colleagues on site.

The increased diffusion of mobile devices in the working environment enabled seamless communication between workers and changed significantly the means of knowledge sharing. Their independence in decision making has decreased, which has led to an increase of inter-dependent knowledge sharing, including increased validation seeking from others. (FG): “So I know from personal experience that a lot of people call us quite frequently or write a message or email to ask a certain question concerning a specific topic on their construction site.” Smartphones, tablets and notebooks have turned communication on construction sites into a continuous process and enhance knowledge sharing in a systematic base, a fact that offers increasing opportunities to access the required knowledge to solve work problems ad-hoc. The convenience of mobile devices provides an efficient way to connect with peers and supervisors in order to exchange knowledge, solve problems, seek validation and therefore accomplish tasks. (I3): “That’s a super alternative, if we have to till somewhere and the subsoil is poor. Just make a photo and share it via WhatsApp. He asked me what happened afterwards (…) I get this on my phone immediately, and then we call each other and discuss it.”

4.2 Spatial barriers

The spatial barriers describe the geographic distance between individuals, organizations and within networks while sharing knowledge. As soon as construction workers integrated mobile devices into their working environment, they reached a level of communication with their peers and supervisors that were not only fast, but also independent of their location. The use of mobile devices allowed users to connect with colleagues on different sites to share required knowledge. (I3) “We have an average team size of 2.5 persons and these teams are operating in northern Germany. Of course, it is great if such distributed teams can share thoughts about work problems.” The use of mobile devices increases the possibility to share contextual information of work problems even between dispersed sites, allowing workers to solve problems on one site by getting support from colleagues or supervisors that are on other sites, which are often far away.

Due to this ease and speed of data transfer, people tend to validate their opinion more and more to back up their own decisions. As a result, the independence of the past, which could lead in mistakes on the construction site or delays, is being replaced by interdependent decision making, where workers share knowledge (and responsibility) with geographically distant peers. A major advantage that the
use of mobile devices has brought to the construction site is that workers now have the ability to work on their tasks, cooperate with their colleagues, and even enlighten their customers without moving from place to place. Not only are decisions supported remotely but also mobile devices on site increasingly support documentation. (I1): “One of my peers asked me about the foam cement on WhatsApp. This a cement which floats. We have built a floating road through a moor region. And then I reported about that and provided some details and experiences I made. I described that and provided some pictures from this construction site”

Apart from the efficiency that the use of mobile devices provides during the time on site, the workers have the possibility to carry the information home and refer to it at any point in time. (I2): “They will file away everything. So I always file away a copy for myself at home just to be sure if something comes up. I will say, yes that’s right I was here with this colleague and we did this and that and write down what the weather was like and things like that. So of course there are folders everywhere. So on a USB stick everything is smaller. USB Stick - enter the date - tack, tack, tack and I can call up everything right away.”

4.3 Contextual barriers

The contextual barriers describe the lack of contextual information necessary to make an informed decision, such as the weather conditions, the soil quality, or the materials (for example, cement or timber composition and/or conditions) associated with the task at hand. The use of mobile devices with advanced multimedia capabilities on site raised a significant advantage for the construction sector. Firstly, calls and emails provide the opportunity to ask questions, clarify issues and support documentation. Due to the functionalities that enable rapid knowledge sharing, mobile devices quickly diffused and are now heavily used by the workers of the construction sector. (I5): “There was the situation when I collaborated with the mixer company and asked if we could try something to take another bitumen mixture. So, I called the mixer company and sent a picture to explain him the situation to visualise it.”

A major development, however, lies to the fact that the communication between the workers is enriched with multimedia exchange. The use of mobile devices supports picture and video exchange, which enables a more detailed description of the problem context. (I3): “I have a picture in my mind and I can precisely say, you can solve that in this and that way. That happens definitely. It is indeed very convenient, I have to say.” The ease of describing an issue or an object like a working machine by the use of a video or a picture enables the sharing of richer contextual knowledge, which is transferred and therefore enhances the process of knowledge sharing. The use of mobile devices provide a convenient way to depict the issues that the construction workers face during work and exchange them with peers and supervisors to validate their own opinion. (I4): “There are situations where, in an ideal case, the craftsman takes a picture of the situation, sends it to his supervisor and says I talked to the architect on site and I think it is ok.” and (FG): “So for example, so we have to do a lot of photographic proofs so to say, so when something is not prepared or is not working properly. So basically that we can take the photos and send it to the office right away so that the site manager can contact the building owner immediately, and says ok listen. [...] So for these issues it works perfectly with these things, telephone and all these things, iPhone or smartphone.”

4.4 Social barriers

The social barriers describe the limitation to access certain networks or approach specific individuals for sharing knowledge, especially from remote work sites. This is not to say that those who have historically worked on construction sites are non-social, or anti-social. Indeed, construction ‘crews’ can be highly cohesive and tightly knit social groups. The barrier is that there is only a limited number of individuals on a given site at any point in time. The increasing diffusion of mobile devices, however, appears to be changing the social interactions in the construction sector. The use of mobile devices
offers an efficient and easy way to contact people that they trust and rely on for specific issues. (FG): “I stick to my circle of friends and when it is important I always just ask craftsmen I know already. But in case of quick decisions I contact the people I know that they are competent.” And another one added (FG): “When I don’t know how to proceed, I search for a solution in my group of friends. What do they say? How do they deal with this situation?” Furthermore, when the workers face serious issues where they have to take important decisions they approach their superiors in order to back up their opinion. (FG): “So for me and the site manager it is clear, so for me personally, when I get into such a situation again, when I think that doesn’t work like that, I will contact my superior.”

The use of mobile devices enables communication among employees from different sites and with different roles within the working environment. As a result, the employees tend to refer to their colleagues and even organize group discussions via WhatsApp or Facebook to search for a solution or validate their opinion. (FG): “So you can always point back to written things. And then you have it, when you get it as email, SMS, or WhatsApp, then you have it here. My friend you told me 2.500 meters and not 2000 or something like that.” This is perhaps where mobile devices are most markedly revolutionizing communication in the construction sector. The daily work life of workers in the construction sector is now characterized by group work and continuous communication with friends, colleagues and superiors, but also with unknown persons in social networks. People explore additional ways of support and look up information on the Internet or in practitioner forums while connecting with new people and expanding their network. (FG): “But finally the overall impression counts...so you constantly learn something new. You get to know new people and get new inspirations. You should never underestimate that.” The possibility to access social media via mobile devices provided construction workers the possibility to get in touch with a great variety of people to validate their opinion ad-hoc and solve miscommunication issues. As a result, through the use of mobile devices the practice of validation seeking is now intensified and extended beyond one’s local social network, which increases the overall knowledge sharing between a wide and dispersed network of interested parties.

5 Discussion

In the following discussion, we want to elaborate on (1) the change of knowledge sharing practices since the increased diffusion of mobile devices in the construction sector, (2) the positive but also negative effects caused by the decrease of the four barriers, which have been enabled by the increased diffusion of mobile devices as well as (3) the implications for organizations that aim to promote knowledge sharing in non-office settings. The temporal, spatial, contextual and social barriers are becoming smaller in the connected world. Indeed, we have found that frequent transmissions among individuals have improved knowledge sharing and collaborative problem solving approaches. However, the diffusion of mobile devices, and therefore the increase of connectivity, has brought not just positive but also some negative effects on work practices in non-office settings. We want to point out both sides of the coin, present the implications of this development for organizations, and show how the negative implications of the reduction of the four barriers can be prevented or limited by a change in current knowledge management practices.

5.1 The shift from isolated to collaborative work practices

On the basis of our findings, we have developed the following model, which shows the shift from isolated to collaborative work practices such as validation seeking due to the use of mobile devices.
The shift from isolated, self-determined work practices to collaborative, cooperative work practices has been mainly enabled by the use and increased diffusion of mobile devices, which allowed our interviewees to overcome the temporal, spatial, contextual as well as social barriers. The reduction of these barriers implies that our interviewees now have the opportunity to access and share knowledge whenever they want (temporal), wherever they are (spatial), transmitting contextual rich information, and approach whomever they want. To put it in a nutshell, the increase of connectivity that brings improved availability and responsiveness of peers and superiors has caused the simplification of collaboration over distance, time, and social and contextual boundaries and resulted finally in improved knowledge sharing.

Formerly, our interviewees used to ask their superiors and peers on-site, approached other colleagues occasionally when they met them in person, or had to wait until they return to the office to look up information. Nowadays, our participants reported just picking up their phone and call or text someone to ask for help every time they face a problem. Moreover, they can also send videos and photos, so that their colleagues can contribute to and/or benefit from their experience. Thus, problems can be solved almost instantaneously with real-time, contextually rich knowledge sharing.

Mobile devices have become the constant companion of construction workers, and due to this ubiquitous access to information and knowledge, they approach their colleagues or superiors, or search for the solution on the Internet independent of working or non-working hours.

Due to extensive improvements of the technical infrastructure and network coverage almost everywhere, even in rural areas, our interviewees can approach their colleagues and superiors not only whenever they want, but also wherever they are for example on a solitary construction site. This breakdown of isolation has led to more collaborative work practices such as the intensification of validation seeking, as people are not restricted by the geographical barriers anymore. Construction workers are no longer dependent on the knowledge and expertise of their colleagues and superiors on site, they can approach people far away who have faced similar situations and have particular experience to solve the specific problem. People can now benefit from their knowledge and learn how to deal with the situation faced by enhancing their own skill repertoire and expertise.

In addition to powerful mobile devices, a high network coverage to transmit photos and videos was essential for the observed transformation. Verbal or written descriptions of the actual situation often lacked of contextual factors and embeddedness in the actual environment. Therefore, their respondents were not aware of all circumstances and not able to capture the entire complexity. As a result, solutions often didn’t fit the problem or couldn’t be applied. Nowadays, our interviewees can provide rich contextual information by taking photos and videos and therefore have a higher chance to get valuable
suggestions to solve their problems and to validate their own approach as the respondent(s) get a more comprehensive view on the problem faced. However, people do not just request help; they also post images and videos of their own solution of a specific situation, such as an innovative building technique or the use of a new machine, in their social media groups or in Internet forums.

Knowledge is generally made widely available for almost everyone within the company and beyond, via social networks. Due to the diffusion of mobile devices on the construction site, collaboration and knowledge sharing happens on a larger scale now. Formerly, our interviewees approached trusted peers with high professional and social proximities such as their peers and superiors on site or their friends and colleagues from school. Their possibilities to contact unknown people were very limited, and as a result they just had access to a rather small knowledge base. Nowadays, people do not just approach peers they already know; rather they extend their network, by asking and posting their problems in social media channels. People try to crowdsourcing the solutions for any problems they face or validate their opinion by taking advantage of the media richness of nowadays’ technology. They approach a multitude of knowledge sources and people from different areas that they would have rarely met in person under different circumstances. Hence, they rely not only on trusted and proximate peers, but they also have the chance to share knowledge with a more diverse group of people. The development from isolated work practices to collaborative work practices leads to collaboration and cooperation with complete strangers on the Internet, who however can turn into colleagues or friends at the time. This development again improves knowledge sharing, as the knowledge is exchanged among a greater number of participants. Furthermore, a greater variety of solutions and a collaborative problem-solving supporting knowledge sharing is enabled.

While studying the barriers, we cannot draw a strict line between the four. They are highly intertwined so that overcoming geographical distances in order to approach people who are far away, implies that our interviewees are also able to approach unknown experts whom they would otherwise may have never met. Put differently, overcoming the social barriers by addressing a person in an Internet forum implies overcoming the geographical barriers.

### 5.2 The flip side of decreased barriers

The increasing diffusion of mobile devices has led to the reduction of the four barriers and therefore to collaborative work practices and improved knowledge sharing. However, there is always the other side of the coin. Our findings revealed direct positive consequences of overcoming the four barriers, but we also discovered some negative effects associated with an increase of connectivity at the individual, organizational and network level. In the following table, we show some positive as well as negative effects of the diffusion of mobile devices, which has led to the reduction of the four barriers, in the construction sector (Table 1).

Although there is still a spatial or geo-physical barrier between individuals and groups which will always remain (Kolb, 2008) the use of mobile devices has reduced this distance in a figurative sense and has led to constant access to information and knowledge at any time. Due to the use of mobile devices, it doesn’t matter if people are located in the same city or if they are living on different continents and time zones in order to solve problems collaboratively or validate each other’s opinions (Dery et al., 2014; Kolb et al., 2008). However, some interviewees reported that this 24/7 availability has not only positive effects. They claimed that the increase of validation seeking sometimes led to constant interruptions, especially for the middle management. People do not dare to take over decisions anymore and have lost their self-confidence and independence, which leads to this constant need for reassurance from others. They also report increased distractions and interruptions from superiors and colleagues within the organization or network. Furthermore, although people might have faced a similar situation and can provide a good solution they do not see the actual situation, as they are not physically on the construction site, and may oversee important aspects, which were not reported by the person who asked for help. Therefore, there is always the risk that the more knowledgeable peer provides unintentionally misinformation to solve the problem.
On the other hand, due to the further development of mobile devices and data transfer, the contextual barriers decreased and people are now able to transfer not only text or voices messages but also photos and videos. As mobile Internet became affordable, it became so easy to share general experiences, problems faced, but also success stories. Social media plays a big role in this development as they provide the platform where photos and videos are shared, liked and commented (Kaplan and Haenlein, 2010; Kietzmann et al., 2011) which stimulates the user's curiosity and participation and therefore supports knowledge sharing. However, our interviewees also reported challenges of managing the complexity, as they sometimes feel overwhelmed by the great amount of incoming data via various communication channels. Here the challenge is to find appropriate knowledge structures to cope with the complexity (Sánchez-Pi et al., 2012).

### Table 1. Positive and negative effects associated with decreased barriers

<table>
<thead>
<tr>
<th>Barriers</th>
<th>Positive effects associated with the decreased barriers</th>
<th>Negative effects associated with the decreased barriers</th>
</tr>
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<tbody>
<tr>
<td><strong>temporal</strong></td>
<td>Constant access to information and knowledge during work and non-working hours&lt;br&gt;Instantaneous problem solving and constant validation seeking</td>
<td>Increase of validation seeking leads to constant interruptions of the work flow&lt;br&gt;Threat of losing self-sufficiency and independence; increase need for reassurance from others</td>
</tr>
<tr>
<td><strong>spatial</strong></td>
<td>Access to information and knowledge from everywhere&lt;br&gt;Enabling collaboration of distributed teams</td>
<td>Risk of misleading advice due to misinformation or lack of contextual factors as the more knowledgeable peer is not on site</td>
</tr>
<tr>
<td><strong>contextual</strong></td>
<td>Transmitting contextual factors via photos and videos&lt;br&gt;More comprehensive view of the problem faced&lt;br&gt;Better documentation</td>
<td>Managing complexity of the overwhelming amount of incoming data (especially for experts giving advice)&lt;br&gt;Challenge for context-aware systems to find an adequate knowledge structure</td>
</tr>
<tr>
<td><strong>social</strong></td>
<td>Extending the professional and personal network via social media and online forums&lt;br&gt;Collaboration with a very diverse group of people</td>
<td>Need to identify and verify trustworthy knowledge sharing partners&lt;br&gt;Lose control over the knowledge which is shared</td>
</tr>
</tbody>
</table>

Social media does not only provide the platform for rich media exchange but also the access to a broad network of people and organizations (Briones et al., 2011; Park et al., 2009). Due to this possibility, people can broaden their own personal and professional networks. They can approach complete strangers, family members and friends who are far away, friends from school they lost track of, or certain experts in their field of interest. Overcoming the social barriers has led to an enlarged network of people and groups to collaborate with. The downside of this, leads to the challenge of identifying trustable knowledge sharing partners. First, people have difficulties to judge and evaluate the sources, as there is an overwhelming amount of doubtful advices on the Internet and many "experts" that claim they know the truth. Second, people lose the control with whom they actually share their knowledge and they have to connect with care (Manhart et al., 2015a).

### 5.3 Implications for knowledge sharing and limitations

Having revealed the positive as well as some of the negative effects of knowledge sharing due to the reduction of the four barriers resulted from the increased diffusion of mobile devices, we want to present the implication for knowledge management and how organizations can counter these new chal-
lenges. We believe that the established hierarchical structures and reporting mechanisms are currently not designed for the new and constant communication flows. Alike Von Krogh (2012) we also emphasize that knowledge management should rethink the supportive knowledge management processes and implement solutions on the individual, the organisational as well as on the intra-organisational level. Especially in our case, the consideration of the network level turned out to be crucial. Responding to the threats of the spatial barrier, the challenge for knowledge management in organizations and networks is to provide supportive systems that can capture the context of a problem situation. There are some promising solutions of contextual applications for knowledge management, (Dennerlein et al., 2015; Ning and O'Sullivan, 2012; Perera et al., 2014), but how to apply such solutions in non-office settings is still an open issue. The pre-determined semantic structures (jargon) valid for many groups, communities or even organisations may be inappropriate for these new work practices. Organisations should support their employees by providing appropriate learning frameworks while building effective knowledge structures to support scaffolding of knowledge (Ley et al., 2014; Pata et al., 2016). To encounter the challenges rising from knowledge sharing in large (social) networks where the reliability of the source is not approved, appropriate rating schemes should be introduced. This, however, is the responsibility of the network providers as these networks outreach organizational or (formal) network boundaries. To counteract the uncontrolled diffusion of knowledge particularly in cross-organisational knowledge sharing settings, strategies for the protection of competitive knowledge are needed (Manhart et al., 2015b).

Beside the drawbacks of qualitative research, this study has three limitations that should be acknowledged. First, as we conducted focus group sessions and one on one interviews, we were able to capture the perceived change of knowledge sharing practices of our interviewees, but not the real changes. Although, we think that the perception of our interviewees is a reliable foundation for our model, modified ethnographic approach for Information Systems research could reveal not just the perceived but also the real changes of knowledge sharing practices (Maier and Thalmann, 2012). This, however, was not feasible due to time constraints and access to participants. Second, our findings are based on the construction sector in only one country so in order to generalize our findings, other countries and sectors should be taken into consideration as an avenue for future research. Third, the quotes used in this paper were translated from German into English and double checked. The coding, however, was conducted with the original transcripts by native German speakers.

6 Conclusion

In this paper, we investigated how the increased diffusion of mobile devices has affected knowledge sharing work practices in non-office work settings. Specifically, we looked at the practice of ‘validation seeking’ and found that notwithstanding geographical isolation, it has been largely transformed into a collaborative work practice. In particular, we found four barriers, which have been overcome by ICT use. The new collaborative work practice in turn allows for improved knowledge sharing. The advanced communication capabilities of mobile devices such as photo and video sharing has opened up new dimensions of knowledge sharing. However, similar to other industries, the increasing diffusion of mobile devices in construction has also brought negative effects along such as many interruptions and unintended distribution of critical knowledge.

Traditionally knowledge sharing has been studied mainly as an office-bound practice of so-called ‘knowledge workers.’ The use of mobile devices, however, have altered this stereotype and knowledge sharing has been broadened to non-office manual labour contexts. By using mobile devices, workers in remote workplace settings are now able to use ICT for knowledge sharing during execution of their work. In addition to the well- established research and practical application in office settings, knowledge sharing could now take non-office settings into consideration. Indeed, the use of mobile devices supported knowledge sharing has become common practice for the construction sector allowing continuous communication, expanding of social interaction and development of individual knowledge.
Therefore, another avenue for future research would be to investigate how existing work practices have changed in other non-office settings such as healthcare and to develop hypotheses on the basis of our qualitative results, which can be tested in future research. Moreover, comparative research on the differences between office and non-office workplace settings for knowledge sharing seems promising. Furthermore, we seek to find ICT solutions for reducing the negative consequences of the reduced barriers, such as continuous distractions of the middle management.

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