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ROSEMARY FRANCISCO

CAN KNOWLEDGE BE CREATED AND SHARED ON THE MOVE?

The case of collaborative problem-solving in the mobile workers' context

São Leopoldo
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To Marcos, for your unconditional love and partnership

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“The mind that opens to a new idea never returns to its original size”

Albert Einstein

ABSTRACT

Mobile workers are professionals who frequently work on the move, far from a fixed workplace, often performing knowledge-intensive activities. Mobility brings challenges to the processes of knowledge creation and sharing of these workers, and the existing literature lacks theoretical frameworks to explain these phenomena. Considering this gap, this study seeks to answer the following research question: *How knowledge creation and knowledge sharing are carried out in collaborative problem-solving situations in the mobile workers' context*? The primary purpose of this investigation is to analyse how knowledge creation and knowledge sharing are carried out in collaborative problem-solving situations in the mobile workers' context. To reach the research goals, this study applied Activity Theory (AT) and its key concepts as a theoretical lens. This theoretical approach allowed better understanding both the individual (the mobile worker) as well as his relations in his/her social context. Besides, the adoption of the Design Science Research method (DSR) provided tools for a deeper understanding of the research problem and also to propose an approach to stimulate knowledge creation and sharing through collaborative problem-solving in the mobile workers' context. The results of this study helped to understand the fundamental needs of mobile workers related to knowledge creation and knowledge sharing to solve work problems. It was observed that these workers use their ICT tools, especially mobile ICT, to conduct the majority of their collaborative problem-solving situations and subsequently, to create and share knowledge on the move. The findings also highlight how mobile technologies are used to support collaborative problem-solving in the mobile work' context. Therefore, the key argument tested and supported in this thesis is that collaborative problem-solving mediated by mobile ICT can support and stimulate knowledge creation and knowledge sharing in the context of mobile workers. This research makes a theoretical contribution by exploring this key argument with the use of AT as a theoretical lens. Since this theory was not used so far to analyse practices of knowledge creation and sharing in the context of mobile workers, this study contributes to the expansion of this theory in this subject. The results of the empirical data also provided lessons from the practice that can contribute to the theory, mainly considering the diversity of workplaces that mobile workers can use to perform their work activity. Also, this study provides methodological and practical contributions; through a detailed descriptive of how to apply the DSR in IS (Information Systems) studies, in addition to the artifact developed that can be used in practice. Finally, this study addresses some questions that can be explored in future research.

Keywords: Mobile work, Mobile knowledge workers, Knowledge creation, Knowledge sharing, Activity theory, Design science research.

RESUMO

Trabalhadores móveis são profissionais que freqüentemente trabalham em movimento, longe de um local de trabalho fixo, muitas vezes realizando atividades intensivas em conhecimento. A mobilidade traz desafios aos processos de criação e compartilhamento de conhecimento para esses trabalhadores, e a literatura existente carece de *frameworks* teóricos para explicar esses fenômenos. Considerando esta lacuna, este estudo procura responder à seguinte pergunta de pesquisa: Como a criação e o compartilhamento de conhecimento são realizados em situações colaborativas de resolução de problemas no contexto dos trabalhadores móveis? O objetivo principal deste estudo é analisar como a criação e o compartilhamento do conhecimento são realizados em situações colaborativas de resolução de problemas no contexto dos trabalhadores móveis. Para alcançar os objetivos da pesquisa, este estudo aplicou a Teoria da Atividade (AT) e seus conceitos-chave como uma lente teórica. Esta abordagem teórica permitiu uma melhor compreensão tanto do indivíduo (o trabalhador móvel) quanto das suas relações no seu contexto social. Além disso, a adoção do método de pesquisa *Design Science Research* (DSR) proporcionou ferramentas para uma compreensão mais profunda do problema de pesquisa e também para propor uma abordagem para estimular a criação e o compartilhamento do conhecimento por meio da colaboração na resolução de problemas no contexto dos trabalhadores móveis. Os resultados deste estudo ajudaram a compreender as necessidades fundamentais dos trabalhadores móveis em relação à criação e ao compartilhamento de conhecimento para a resolução de problemas de trabalho. Observou-se que esses trabalhadores utilizam suas ferramentas de TIC, especialmente as TIC móveis, para conduzir a maioria de suas situações colaborativas de resolução de problemas e, posteriormente, criar e compartilhar conhecimento em movimento. Os resultados também destacam como as tecnologias móveis são usadas para apoiar a resolução colaborativa de problemas no contexto do trabalho móvel. Portanto, o principal argumento testado e suportado por esta tese, indica que a resolução colaborativa de problemas, mediada por TICs móveis, pode apoiar e estimular a criação e o compartilhamento do conhecimento no contexto de trabalhadores móveis. Esta pesquisa faz uma contribuição teórica explorando este argumento chave com o uso de AT como uma lente teórica. Uma vez que esta teoria não foi utilizada até agora para analisar as práticas de criação e compartilhamento de conhecimento no contexto dos trabalhadores móveis, este estudo contribui para a expansão desta teoria neste assunto. Os resultados empíricos também forneceram lições da prática que podem contribuir para a teoria, considerando, principalmente, a diversidade de locais de trabalho que os trabalhadores móveis podem usar para realizar suas atividades de trabalho. Além disso, este estudo fornece contribuições metodológicas e práticas; por meio de um descritivo detalhado de como aplicar o DSR em estudos de SI (Sistemas de Informação), além do artefato desenvolvido que pode ser usado na prática. Finalmente, este estudo endereça algumas questões que podem ser exploradas em futuras pesquisas.

Palavras-chave: Trabalho móvel, Trabalhadores do conhecimento móveis, Criação do conhecimento, Compartilhamento do conhecimento, Teoria da Atividade, Design Science Research.

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LIST OF ABBREVIATIONS

AT	Activity Theory
BYOD	Bring your own device
CLM	Change Laboratory Method
CRADLE	Center for Research on Activity, Development and Learning
CoP	Community of Practice
ESM	Experience Sampling Method
ICT	Information and Communication Technologies
IS	Information Systems
MCoP	Mobile Community of Practice
MFW	Mobile Field Worker
MKW	Mobile Knowledge Worker
SECI	Socialization, Externalization, Combination and Internalization
SRM	Self-Report Method
UMT	Ubiquitous and Mobile Technologies
ZPD	Zone of Proximal Development

SUMMARY

1 INTRODUCTION

The knowledge workforce as was known is shifting. Global economic factors, increasing professional specialization, improvements of customer relations, rapid technological advancements along with the diffusion of Information and Communication Technologies (ICT) and the acceptance of corporate bring your own device (BYOD) programs, has driven a considerable increase in mobile workers in organisations (Chen, 2015; Jarrahi & Thomson, 2016; McDaniel et al., 2016). According to McDaniel et al. (2016), "the percentage of information workers working away from the office at least a few times a month — whether it be from home or while traveling or commuting — is up more than 60% in just three years (2012 to 2015)". In spite of this increase, however, little is known about the consequences in the organisational practices (Karanasios & Allen, 2014; Reynolds, 2015) and also about professional practices or actions outside of traditional centralised offices (Jarrahi & Thomson, 2016).

Because the mobile workers are professionals who frequently work on the move, far from the main workplace, they constantly use mobile technologies to support their work (Cavazotte, Lemos & Villadsen, 2014; Karanasios & Allen, 2014; Kietzmann et al., 2013; Koroma, Hyrkkänen & Vartiainen, 2014; Mazmanian, Orlikowski & Yates, 2013). By the usage of mobile apps these professionals have (1) access to real-time data and ad hoc information from everywhere, (2) reduced inefficiencies in time-management of employees, (3) reduced home-to-office or office-to-office travel times, (4) saving time due to the reduction of unproductive and redundant work, (5) faster invoicing, (6) reduced stock keeping, (7) increased employees and customer satisfaction, and (8) increased quality of data and information (Stieglitz, Lattemann & Brockmann, 2015). One disadvantage, as mentioned by Sørensen (2011), is that this scenario involving the mobile worker is complex because of constantly evolving technologies and emerging standards. This complexity leads organisations and employees envisage challenges, uncertain situations and constant changes in working practices (Sørensen, 2011a; Stieglitz et al., 2015).

Another negative consequence is related to the difficulties to create and share knowledge in the mobile workers' context (Kietzmann et al., 2013). Considering that the work activities of these professionals are performed far from the main workplace, and often on the move (Koroma et al., 2014), barriers to create and share knowledge

may arise (Kietzmann et al., 2013; Lundin & Magnusson, 2003). These barriers do not necessarily are technological; they also can be social barriers. As state by Chen & Nath (2008), work on the move can affect the sense of belonging to a work team. According to these authors, “Mobile workers have feelings of isolation as they lose the support network that traditional workers have in the office; therefore, it is important for managers to understand the signs of these symptoms and find ways to address them” (Chen & Nath, 2008, p. 48). Consequently, admitting that knowledge creation and sharing is fundamental for business competitiveness (Davenport & Prusak, 1998; Pandey & Dutta, 2013), not promoting these processes among mobile workers and their “fixed” co-workers, can be an obstacle to the competitive advantage of firms.

Furthermore, because the mobile workers’ context differs from the fixed workplace, to promote knowledge creation and knowledge sharing practices among them is not a trivial task (Kietzmann et al., 2013).

1.1 RESEARCH PROBLEM

According to Bosch-Sijtsema, Ruohomäki and Vartiainen (2010), the main difference between mobile workers and their “fixed” co-workers is that the mobile workers can not have a dedicated desk to work in the main workplace and also work less than 20 hours per week in this place. Then, the majority of their working hours is performed on the move. On the contrary, their “fixed” co-workers worked mainly in the office and had a dedicated or fixed desk at their disposition. The term “mobile” means the freedom these workers have to perform their work practices anytime anywhere, mainly where and when the results of the work are better achieved (Harmer & Pauleen, 2012; Vartiainen, 2008). Besides, because they are supported by mobile technologies, to keep in touch with their co-workers and to have access to the systems and information they need (Cavazotte et al., 2014; Mazmanian et al., 2013), they have the opportunity to achieve the goals of their work activity wherever they are.

However, despite these potential advantages, the context of mobile workers also brings challenges both in the individual and in the organisational spheres. Regarding the individual dimension, the main challenges are related to the relationship with others (Kietzmann et al., 2013; Koroma et al., 2014). Work alone restricts the opportunity to strengthen relationships (Kietzmann et al., 2013), increases the lack of support and also motivates the feeling of being “invisible” in the parent organisation

(Koroma, Hyrkkänen, & Vartiainen, 2014). This occurs both for the workers considered as mobile field workers (MFWs) such as technicians, and mobile knowledge workers (MKWs) like executives and knowledge workers in general (Chen, 2015). Moreover, mainly in the case of the MKWs[1], the challenges in the organisational dimension are closely related to the management and interaction with these workers, since they have more autonomy and freedom and often work better without intense control and surveillance (Cavazotte et al., 2014). As a result, these challenges can reflect directly in the standards used to promote knowledge creation and sharing in organisations (Kietzmann et al., 2013).

In this study, the definition of knowledge creation and knowledge sharing are based on the approaches of learning and development (Engeström, 1987; Vygotsky, 1978). These approaches reinforce that learning is a social practice (Engeström, 1987; Lave & Wenger, 1991; Nonaka & Takeuchi, 1995). Thus, learners need to participate in a context and community, share their knowledge, already consolidated, and create new knowledge. In the individual dimension, to create a new knowledge means, for instance, the development or acquisition of new ideas and beliefs, and in the organisational aspect, means the collaborative creation of work practices (Engeström, 1987). Therefore, to have opportunities to create and share knowledge it is necessary for mobile workers to participate in social practices that result in learning. However, as already mentioned, the context of these workers and their characteristics can reduce these opportunities.

The literature review discloses that the studies about mobile workers did not focus on understanding knowledge creation and sharing in the context of their work. The results obtained from a systematic literature review (see APPENDIX A – SYSTEMATIC LITERATURE REVIEW) and a bibliometric study (see APPENDIX B – BIBLIOMETRIC STUDY) shows that the primary concern of the majority of studies that involve mobile workers is related to the acceptance and adoption of mobile technologies.

Also, according to Jarrahi & Thomson (2016, p.1), mobile workers are “[…] an increasingly visible yet understudied population […]”. Likewise, it was hard to find studies about these professionals since many terms are used in the literature to describe mobile workers. Terms such as: “mobile worker”, “nomadic worker”, “digital

[1] This study focuses on the mobile knowledge workers (MKWs)

nomad", "digital flâneurs", "remote worker", "mobile multi-locational worker", "outsider", "off roader", "off-site rover", "road warriors", "road workers" and "global cruisers" are all used to refer to them. The variety of terms used, however, can cause confusion to understand who is the mobile worker and what are the main characteristics of his/her work, as well as it hinders further research and development on this topic.

Only two studies were found (Kietzmann et al., 2013; Lundin & Magnusson, 2003) that addressed, respectively, knowledge sharing and collaborative learning in mobile work. The research goal of the first study (Lundin & Magnusson, 2003) was to understand how IT can support learning where work tends to be mobile. In this study, workplace learning is viewed as the development and sharing of knowledge at work, in collaboration with colleagues and peers and the creation of new knowledge is seen as a change in understanding, referred to as process learning. Thus, support for this collaboration is needed. However, in this case, the authors did not specify the type of mobility of workers or how the mobility affects learning.

The research goal of the second study (Kietzmann et al., 2013), in turn, was to analyse how mobility and mobile technologies shape community collaboration and explore the implications for the management of mobile employees. The mobility considered in this study has three dimensions: (1) the dual role of location – location does not matter but at the same time it really does, (2) the physicality of the environment and (3) the formative context of the movement of people, devices and information. This study highlighted the difficulty for mobile workers to participate in communities of practice to share knowledge due to the characteristic that they mainly interact on the move. The authors reinforce that it is time to focus on mobility in a discussion of community-based knowledge sharing, as collaboration across organisational boundaries increasingly occurs through mobile IT.

This research differs from these two studies, first because it seeks a broader exploration and understanding of the context of knowledge mobile workers, and also understands the challenges they face to create and share knowledge, especially involving problem-solving situations. This investigation will consider cultural, cognitive and social aspects related to the human activity that is performed by these professionals.

Following that, this thesis has a set of assumptions. The first one is that learning happens in ongoing everyday activities (Engeström, 1987), thus, learning at work in the context of mobile workers is more complex (Lundin & Magnusson, 2003;

Muukkonen et al., 2014). As mentioned by Vartiainen et al. (2007, p.9), “Good team members know how to exploit the skills and expertise of others, but the mutual understanding that enables such behaviour is more difficult to achieve with greater dispersion of team members”. Therefore, being a mobile worker means been at distance from the main workplace, which restricts social relationships (Jarrahi & Thomson, 2016). This characteristic can cause fewer opportunities for communication and informal learning, often observed in informal mechanisms for ‘keeping in touch’ with others, such as cubicle chats, cafeteria discussions, and impromptu team meetings (Jarrahi & Thomson, 2016; Vartiainen et al., 2007).

However, one practice that can be successful in promoting knowledge creation and sharing in the mobile workers’ context is collaborative problem-solving (Kietzmann et al., 2013; Lundin & Magnusson, 2003). According to Engeström (1987) collaborative problem-solving occurs when the isolated individual interacts with his community either to get help or to collaborate in problem-solving situations. Learning from others and learning by doing are major practices of collaborative problem-solving and contribute to individual and organisational knowledge creation and knowledge sharing (Engeström, 1987). Then, another assumption is that mobile ICT can support and help mobile workers in keep contact with their community (Mazmanian et al., 2013); these technologies can also support collaborative problem-solving.

Therefore, a key proposition to be tested in this thesis is that collaborative problem-solving mediated by mobile ICT can support and stimulate knowledge creation and knowledge sharing in the context of mobile workers. Consequently, this work explores the following research question: *How knowledge creation and knowledge sharing are carried out in collaborative problem-solving situations in the mobile workers’ context*?

1.2 RESEARCH GOALS

The primary goal of this research is to *analyse how knowledge creation and knowledge sharing are carried out in collaborative problem-solving situations in the mobile workers’ context*. Thus, to attend this main objective of the study, some specific goals were defined as follows:

a) To identify the main characteristics and challenges of the mobile work context;

b) To identify which factors are involved in the processes of knowledge creation and sharing in the context of mobile workers;
c) To analyse the way by which mobile workers create and share knowledge, especially during problem-solving situations;
d) To analyse how mobile technologies are used to support collaborative problem-solving in the mobile work context;
e) To propose an approach to stimulate knowledge creation and sharing through collaborative problem-solving in the mobile knowledge workers' context.

1.3 JUSTIFICATION

As already mentioned, the emergence of globally distributed teams allied to the evolution of mobile and ubiquitous technologies (MUT) has allowed a considerable increase of mobile workers. However, despite this increase, little is known about the consequences to organisational practices (Karanasios & Allen, 2014; Reynolds, 2015). The increasing mobility of these professionals leads organisations and their employees to face constant challenges and changes in their work practices (Muukkonen et al., 2014). Changes in work practices, in turn, lead to the need for new skills and abilities (Lönnblad & Vartiainen, 2012), especially regarding problem-solving. To acquire new skills and abilities it is fundamental to have a favourable environment for the creation and sharing of knowledge, regardless of time and space. In this sense, more studies are needed to discuss how knowledge creation and sharing can occur in this new dynamic and flexible environment supported by mobile ICT (Kietzmann et al., 2013).

Vartiainen et al. (2007) also point out that to interact with others through technologies, mobile workers have challenged knowledge sharing and organisational learning. Based on a literature review, Wang & Noe (2010) consolidated a conceptual framework, which addresses the state of art of knowledge sharing researches. In their framework, the authors identified five areas of emphasis: the organisational context, the interpersonal and team characteristics, the cultural characteristics, the individual characteristics and the motivational factors. The context (online, face-to-face) is presented as one topic of study that needs to be deepened in future research, which also reinforces and justifies this thesis.

One of the expected contributions of this work thus is to expand the literature about knowledge creation and knowledge sharing, mainly related to the context of

mobile workers. As already mentioned and presented as a research gap, only two studies, so far, addressed part of this issue. Furthermore, this study aims also to contribute to the expansion of the theory of learning used in this research (Engeström & Sannino, 2010), since learning in mobile workers' context, based on this approach, is not yet covered in the literature.

Furthermore, Palomäki et al. (2014) claim that there is a need to develop new methods to study mobile workers in their own contexts. According to the literature review these authors have made, they reinforce that "There is an urgent need for mobile research methods and instruments in studying professional activities because the traditional methods have shortcomings and their results cover only narrow fields related to work" (Palomäki et al., 2014, p.310). Besides, "[…] the more varying the workplace and the more mobile the work are in nature, the more difficult and resource-intensive it is to study their work patterns and contexts" (Palomäki et al., 2014, p.302). Nørskov & Rask (2011) also claim: "As the Internet becomes more and more integrated into our everyday lives, the importance of applying and adapting research methodologies to virtual communities increases as well". Likewise, Jarrahi & Thomson (2016) mention that the context of mobile work is related to social and environmental factors, thus conventional and widely used research methods need to be adapted.

In this sense, another expected contribution of this thesis is methodological, because the existing literature has not yet provided actionable approaches for understanding knowledge creation and knowledge sharing in the context of mobile workers. In this research, the Design Science Research (DSR) (Peffers et al., 2007) was used to better understand the research problem and also to create a solution (artifact) that aims to contribute to the processes of knowledge creation and sharing in the mobile work context, as will be detailed later on. Consequently, the current research also aims to contribute to practice. As the main results of the DSR applied, an artifact composed by one method and one mobile app was developed to support and stimulate learning in mobile work, based on collaborative problem-solving. As highlighted by Kietzmann et al. (2013) and Lundin & Magnusson (2003), an artifact like this can be important because professionals become more distributed in time and space and there is a need to support collaboration and learning in this new context of work.

1.4 THESIS STRUCTURE

This thesis is organized into seven chapters. In the first chapter, the introduction and the main purpose of this study were presented. In the second chapter, the main characteristics of mobile work and mobile workers are explored, and also a review of the literature about the main concepts and theories related to knowledge creation and knowledge sharing is presented. The third chapter, in turn, present and discuss the conceptual background chosen to support the empirical study.

The fourth chapter describes the research method and the fifth chapter presents the research results. Finally, in the sixth and seventh chapters, the discussion of the results and the conclusions of this research are presented, respectively. In the conclusions chapter an agenda for future research and theoretical development is suggested.

2 LITERATURE REVIEW

This chapter is dedicated to present the findings of the literature review about mobile work and mobile workers, and also the theories that discuss knowledge creation and sharing.

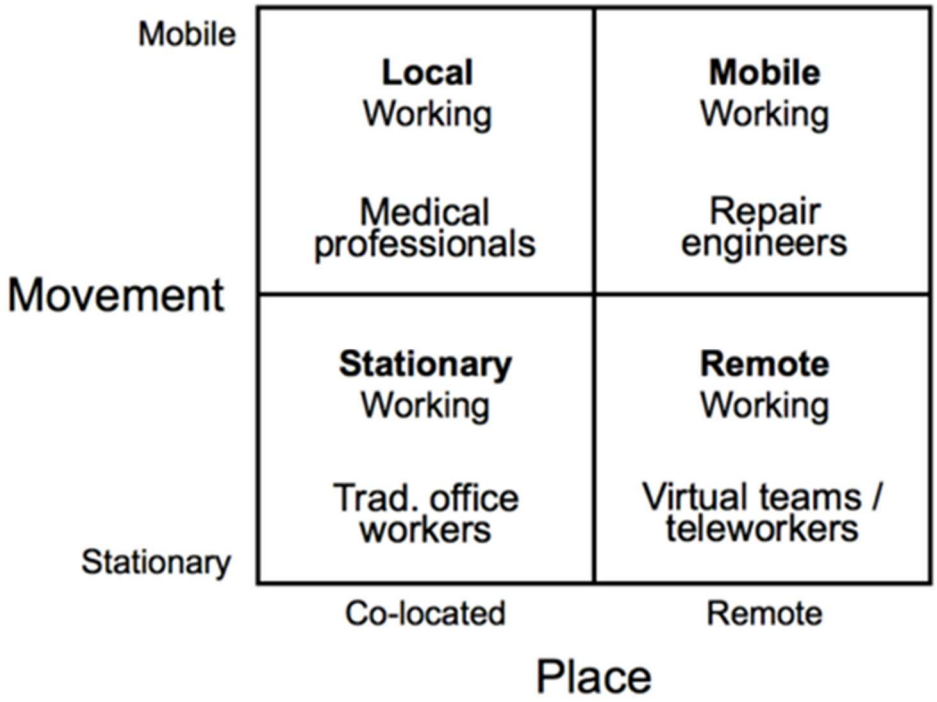
2.1 MOBILE WORK AND MOBILE WORKERS

According to Sørensen (2011) flexible work practices can take various forms: telework, home-office, shared offices, multifunctional offices - where tables are available in the organisation, and the workers can use them according to their need (hot-desking) -, virtual work teams, and also mobile work. Sørensen (2011) additionally points out that these new forms of work require new ways of conducting, coordinating, managing and measuring work. This situation is because, in the most cases, the decision of when, how and where to work becomes a primary concern of the own professional (Coenen & Kok, 2014).

Mobile work is the most radical form of flexible work (Sørensen, 2011a) because it enables workers to carry out their organisational activities outside the organisation's borders and also collaborate with other workers regardless of time and location. According to Vartiainen et al. (2007) mobile work involves a change in the definition of traditional office because of the diversity of workplaces that workers can perform their work activities, many times dissolving the boundaries between home and workplace. Besides, the quality of work done becomes critical depending on the workplace and the support obtained from the technological infrastructure and tools.

Sørensen (2011) presents a categorization that defines the types of work. Figure 1 illustrates this classification. According to Sørensen (2011), mobile work is the most complex kind of work because the professional is mobile, in a locational and interactional meaning (Kakihara & Sørensen, 2002b), and also geographically far from its fixed base of work and co-workers.

Figure 1 – Types of Work



Source: Sørensen (2011).

Mäkinen (2012) explains that *mobile* defines the characteristic of a professional who needs to move to different places and perform his practices of work while travelling, frequently using information and communication technologies (ICT) to support this work. Thus, mobile technologies can provide support and extend the work beyond the office independent of the occupation or hierarchical position of professionals, from technicians to executives (Chen & Nath, 2008; Cohen, 2010). Mobile work increases the idea that the place where the work can be done is irrelevant; the most important is where the work is performed in the best way (Cohen, 2010; Vartiainen et al., 2007).

Regarding where the work can be done, Wiberg & Ljungberg (2001) stand out that the importance of where the mobile work is performed depends on the tasks to be done, the time and space. These authors elaborated a framework, which explains this dependency. According to this framework, there are four categories of work on the move. These categories and their meaning are presented in Figure 2.

Figure 2 – Four categories to work on the move

		Place: Independent	Place: Dependent
Time	Independent	**1. Anytime, anywhere**: tasks that can be done independent of time and place; they can be done anytime, anywhere	**2. Anytime, particular place**: tasks that need to be done in a particular place but can be done anytime
	Dependent	**3. Particular time, any place**: Tasks that can be done independent of place but at a certain time or in a certain order	**4. Particular time, particular place**: Tasks that must be done in a particular place within a particular time

Source: Wiberg & Ljungberg (2001).

The categories to work on the move presented in Figure 2 reinforce the complexity of the context of mobile workers. They many times need to figure out by themselves what, where, when and how their tasks need to be done. As mentioned, many professionals are acting as a mobile worker in a variety of organisations and segments, and most of them use ICT to support and perform their work better. However, there are specific types of mobile workers. The following section discusses this classification and the main characteristics of these workers.

2.1.1 Types of Mobile workers

Mobile workers are defined here as professionals who are more than 20% of their work time working in movement away from their main fixed workplace (Drake, Jaffe, & Boggs, 2010; King & Hart, 2002). In other words, mobile workers are mobile in a locational, geographical and timing sense. Vartiainen (2008) explains that mobile workers are the professionals who work at least one working time of the month, away from the main workplace. Bosch-Sijtsema et al. (2010) and Vartiainen (2008) also define the high-intensity mobile worker as the professional that work ten hours or more per week, away from the main workplace.

The mobile workers usually accomplish their activities working at various locations, distant from the physical workplace (Sørensen, 2011a) instead of spending a long period in one fixed place such as an office (Kakihara & Sørensen, 2002b). Furthermore, they usually are workers whose jobs intrinsically require being out of the office or away from their desk to conduct their activities in a particular location and

point of action (Basole, Seuss, & Rouse, 2013). Therefore, the interactions of these professionals with others in their work practices occur mainly on the move (Kakihara & Sørensen, 2002a).

Basole (2008), Yuan & Zheng (2009) and Stieglitz, Lattemann & Brockmann (2015) classify the mobile workers into two categories: mobile *knowledge* workers (MKWs) and mobile *field* workers (MFW). This classification is important once that each type of worker has a particular behaviour, motivation and also requires distinct types of work supports (Yuan & Zheng, 2009). The MKWs, generally, perform knowledge-intensive work, enjoy a relative degree of autonomy and have flexible working arrangements (Cavazotte et al., 2014). Moreover, they are more dependent on information to better execute their activities compared to MFW (Basole, 2008; Kietzmann et al., 2013). MFW, instead, need to be constantly in the field to perform their activities (Yuan & Zheng, 2009). In general, both the location and time required to perform the tasks are more restricted for MFW.

MKWs regularly have also more flexibility to perform their activities than others (Cavazotte et al., 2014; Yuan & Zheng, 2009). Unlike MFW, their tasks are rarely repetitive and require a variety of abilities and resources to be accomplished (Basole, 2008; Cavazotte et al., 2014; Harmer & Pauleen, 2012; Kietzmann et al., 2013; Yuan & Zheng, 2009). MFW, in contrast, often perform standardized tasks and need to follow procedures strictly.

MKWs tend to use ICT to have easy access to people and information (Cavazotte et al., 2014; Chen, 2015; Dal Fiore, Mokhtarian, Salomon, & Singer, 2014; Karanasios & Allen, 2014; Kietzmann et al., 2013; Mazmanian et al., 2013; Pauleen, Campbell, Harmer, & Intezari, 2015). By contrast, MFW use mobile devices for job dispatching, location tracking and navigation (Yuan & Zheng, 2009). Even so, both are using ICT to perform better, and that means to improve productivity, allowing easier access to people, information, and more efficient ways of working (Pauleen et al., 2015).

While MKWs seldom need control and supervision to perform their activities, managers tend to be more apprehensive about MFW (Karanasios & Allen, 2014; Kietzmann et al., 2013; Yuan & Zheng, 2009). This concern leads managers to frequently use ICT to control and supervise these workers (Kietzmann et al., 2013). Furthermore, whereas MKWs are more independent, self-organized and devoted to their performance, MFWs, in turn, often have an opposite behaviour (Harmer &

Pauleen, 2012; Kietzmann et al., 2013; Yuan & Zheng, 2009). MKWs often feel proud in their achievements, and seek recognition and reward when the work is well done (Harmer & Pauleen, 2012). Because the activities performed by MKWs tend to be more complex and demand a considerable amount of information (Yuan & Zheng, 2009), these could be a motivation to look forward to have a better performance. The summary of the characteristics of the different types of mobile workers is presented in Figure 3.

Figure 3 - Types of Mobile Workers

	Mobile *Knowledge* Worker (MKW)	**Mobile *Field* Worker (MFW)**
Type of work	• Perform knowledge-intensive work.	• Location and time are critical factors to execute tasks.
Primary Resource to Work	• Information	• Mobility
Work Activities	• Non-repetitive work; • Often do not follow standard procedures; • Often involved in activities to create new ideas, new technology or creative content; • May perform tasks independently or collaboratively.	• Repetitive tasks; • Often follow standard procedures; • May perform tasks independently or collaboratively.
Technology Infrastructure	• Mobile devices such as laptops, tablets and smartphones; • Internet connectivity for information searching, communication, transaction processing and mobile office operation.	• Mobile phone and smartphones; • IT resources related to notification, job dispatching, location tracking and navigation.
Management	• Do not need procedures and supervision; • Difficult to monitor and know how the tasks are performed; • Management control is substituted by work performance.	• Managers and/or staff tends to monitor them; • Control and supervision related to the use of technology infrastructure.
Professional traits	• Scarce and valuable skills (i.e.: autonomy and self-control);	• Lack of ambition (KIETZMANN et al., 2013; Yuan & Zheng, 2009);

	• Highly developed technological capabilities; • Look forward being the best; • Want to be recognised.	• In general, do not have initiative to improve their skills and achieve better results at work (KIETZMANN et al., 2013; Yuan & Zheng, 2009).
Worker Examples	Managers, Sales people, Consultants, IT professionals, Professors, Journalists, Health care professionals, Real estate agents, Tourist guides, etc.	Field service workers (such as Local maintenance workers), Warehouse workers, Products or service deliverers, Truck and taxi drivers, Security guides, and Emergency personnel (such as Fire-fighters, Ambulance, and Police), etc.

Source: The author.

Accordingly to Figure 3, MKW has particular characteristics, motivations and behaviours. These workers and the hindrances they have faced to create and share knowledge is the focus of this study. Therefore, to better understand their context, it is important to identify what are the main workspaces they tend to work and what are their primary practices of work. The next section addresses these topics.

2.1.2 Workspaces and practices of Mobile knowledge workers

There is no specific place at which the MKW has to work (Vartiainen, 2008). They often have high levels of spatial and temporal mobility, so they generally work in a diversity of locations as well as different times zones (Jarrahi & Thomson, 2016). According to Palomäki et al. (2014), MKWs usually perform their work activities in various locations, such as home, main workplace, while travelling or commuting, in public places, and in customer's or remote offices. Kakihara & Sørensen (2002b, p.6) comment that "[…] these professionals move extensively to serve their current and potential clients, and other members of ongoing projects". Cohen (2010) also mentions that any non-work spaces (such as airports or coffee shops) can be transformed into workspaces, depending only on the support and the material used by the worker.

Vartiainen (2008) proposes three types of workspaces that can be used by MKWs: (1) the physical workspace, (2) the virtual workspace and (3) the mental/social workspace. Physical workspaces are physical locations where MKWs can perform their tasks. Virtual workspaces, on the other hand, refer to a working environment

mediated by technologies. These spaces consist of various tools and media for individuals and groups to work and interact with each other (Vartiainen, 2008). Finally, a mental/social workspaces are related to the cognitive working space in which individuals and groups can share cognitive constructs (Vartiainen, 2008). Efficient communication, collaboration and strength relationships are necessary to join in a mental space (Hansen, 1999). Figure 4 presents the common types of workspaces found in the literature. It is very common for MKWs to move between these workspaces in a dynamic and unpredictable way (Jarrahi & Thomson, 2016).

Figure 4 – Common Types of Workspaces

Physical workspaces	Virtual Workspaces	Mental / Social Workspaces
• Home; • Main office; • Moving places such as cars, bus, airplanes etc.; • Customer premises; • Partner premises; • Company's other premises; • Conference venues; • Hotels; • Airport lounge; • Coffee shops; • Restaurants.	• E-mail; • Audio conferencing; • Videoconferencing; • Chat; • Group calendar; • Document management; • Presence awareness; • Findability[1] tools; • Groupware systems; • Wikis; • Weblogs; • Social networks; • Instant messages.	• Thoughts; • Beliefs; • Ideas; • Mental states; • Goals; • Values.

Source: Elaborated based on Vartiainen (2008).

Regarding primary work practices, Chen & Nath (2008) point out that MKWs perform a wide variety of tasks. They mention that these tasks range from e-mailing to everything they need to do at work. For this reason, they need a strong support of ICT to conduct and perform their work activities. The most usual ICT support they need is: (1) to access e-mail, (2) to access enterprise transactional systems, (3) to synchronize

[1]Peter Morville defined the term "findability". He defines findability as "the quality of being locatable and navigable". Morville establishes the definition at two dimensions, the objects the participant is searching for and the system in which the participant is doing the searching. "Locatable" refers to the objects of the search: the documents, images, or any content the participant finds important. "Navigable" is the quality of the system to support the participant's movement as he looks for documents (Morville, 2005).

calendar and contact information, (4) to use shared resources such as documents, meeting rooms and printers among others (Vartiainen et al., 2007; Yuan & Zheng, 2009).

As indicated by Vartiainen et al. (2007), knowledge work often requires collaboration due to the complexity to perform it alone. Considering this situation, virtual meetings and call conferences are often used by the MKWs considering the difficulty to meet face-to-face (Vartiainen, 2008). Besides, many times it is not possible to meet virtually, due to some restriction related to location or infrastructure. Thus, collaboration is maintained mainly by telephone and text messaging tools (Vartiainen, 2008).

Jarrahi & Thomson (2016) identified five types of practices that are performed by MKWs in their context. The authors propose a framework, which relates these five types of practices with the aspects of the context of MKWs. These authors defined as “information practices” all professional activities performed by the MKWs in their context. The aspects of the context identified by them are: (1) spatial context representing the workplaces, (2) temporal context representing different times and time zones, (3) the social context representing social interaction with co-workers, management, partners and customers, and finally, (4) the material context representing the tools and resources used by these workers when performing their work activities. Figure 5 presents this framework and the relation of these practices with the aspects of the MKWs’ context.

As illustrated in Figure 5, the five information practices defined by Jarrahi & Thomson (2016) are: (1) ensuring information access, (2) maintaining technological acuity, (3) keeping social cohesion, (4) upholding work rhythm and (5) enacting personal-professional balance. To ensure information access the MKWs need to be able to access documents, files, information and also to interact with their community (social structure) anytime (temporal context) anywhere (spatial context). Then, they need to use a variety of technologies to support this kind of information practice, such as cloud storage and online systems. Besides, they have the responsibility for their own technological toolset and its setup. As the information practices “maintaining technological acuity” and “upholding work rhythm” highlight, they need to be ready to deal with the constraints of all the tools and infrastructures used and also be able to exploit what are available in the present work context.

Likewise, about keeping social cohesion, and avoiding social invisibility or

disconnectivity that permeates the mobile worker context, it is necessary for these workers to keep the professional presence and interaction with their community, both at distance and face-to-face. However, at the same time, it is important for them to be able get balance between their work and their private life.

Figure 5 – Five types of practices and the aspects of the MKW' context

Information practice	Spatial structure	Temporal structure	Social structure	Material structure
Ensuring information access	Access to information resources across different spaces (e.g., access to documents from a home office, in transition and client sites using Dropbox).	Access to information resources across different times and time zones (e.g., access to documents through offline drives during "black-out" periods).	Access to information and updates about social ties (e.g., list of professional contacts on LinkedIn with expertise in business analytics).	A variety of technologies and technological tools that facilitate access to information (e.g., extensive use of cloud storage and digitizing services).
Maintaining technological acuity	Awareness and leverage of available technological infrastructures in multiple places (e.g., use of portable WiFi detector and connector for use on-the-road).	Awareness and leverage of available technological options to handle time-based challenges (e.g., use of cellphone or laptop backup batteries to support long workdays outside home).	Adaptation to the technological needs and preferences of partners and clients (e.g., use of multiple cloud services or email accounts to accommodate collaboration with different clients).	Appropriated, individualized, understood assemblages of technological infrastructures that support mobile work (e.g. use of various free mobile applications).
Keeping social cohesion	Strategic combination of virtual and face-to-face meetings (e.g., periodic travel to corporate offices as in order to remain visible).	Continuous and constant contact with partners, colleagues, clients and other social and professional ties (e.g., constant attention to corporate IM system).	Developed and augmented social infrastructures (e.g., extensive use of social networks for locating experts and expertise).	Social media tools that maintain and permit leverage of a professional network (e.g., use of LinkedIn for promoting one's skillset and potentials).
Upholding work rhythm	Flexible and versatile mobile offices (e.g., conference calls while driving).	Flexible work hours (e.g., dividing work hours between family and household commitments).	Expansion of weak ties (e.g. meeting professionals working from the same Starbucks).	A mobile office defined based on a variety of technologies and technological tools and connectivity (e.g., extensive use of laptops and mobile devices rather than desktop computers).
Enacting personal-professional balance	Separate or integrated personal and professional spheres (e.g., working only outside the home).	Temporal structures separating or integrating personal and professional spheres (e.g., designating off-times).	Separation between personal and professional networks (e.g., use of Facebook only for personal connections).	A connection or disconnection to various technologies as appropriate (e.g., switching off the Wi-Fi router after 10pm).

Source: Jarrahi & Thomson (2016, p. 18).

Therefore, to perform their professional practices, it is necessary for the MKWs to hold a basic set of tools, as illustrated in Figure 5, as the material structure. To be ready to work anytime anywhere and collaborate or even help their co-workers and customers, a toolset and resources (such as laptops, smartphones and tablets) are necessary to allow these workers to create a sort of a temporary workspace (Dal Fiore et al., 2014; Jarrahi & Thomson, 2016; Vartiainen et al., 2007). However, as these professionals are always on the move, it is necessary also to reduce the carry-on materials with them. For this reason, they tend to use tablets and online documents (Hislop, Bosch-Sijtsema & Zimmermann, 2013; Jarrahi & Thomson, 2016).

As presented in this section, the MKWs' practices have a significant influence and dependency on the use of ICT devices and systems (Vartiainen et al., 2007). Besides, the MKWs' practices are many times "[…] contingent, improvisational and not necessarily reflective of formal structures, rules, procedures, or codified tricks of the trade" (Jarrahi & Thomson, 2016, p.9). It is also important to reinforce that the practices used by these workers can differ drastically from one organisation to another (Chen & Nath, 2008). The practices can be very particular dependent of the segment and the culture of the organisation (Chen & Nath, 2008). Hence, the context of MKWs is more flexible and is constantly changing, leading the workers and managers to face many challenges. Some of these main challenges are discussed in the next section.

2.1.3 Challenges faced during Mobile work

Distribution of working locations, asynchronous and synchronous ways of working and the diversity of people they tend to deal with (Vartiainen, 2008), these are some of the main issues MKWs need to face in their work routine. Moreover, the diversity of people they interact with increases, because they usually work in a variety of projects, many times in parallel. Besides, they frequently need to travel, in general, by car, bus and airplanes and in some cases, they also travel internationally, passing through different time zones, cultures and languages (Vartiainen, 2008).

The main challenges faced by MKWs range from issues such as (as explained after):

- the technology infrastructure available (Cavazotte et al., 2014; Chen, 2015; Dal Fiore et al., 2014; Harmer & Pauleen, 2012; Jarrahi & Thomson, 2016; Karanasios & Allen, 2014; Kietzmann et al., 2013;

Koroma, Hyrkkänen & Vartiainen, 2014; Pauleen et al., 2015; Yuan & Zheng, 2009);

- information management needs (Jarrahi & Thomson, 2016; Mäkinen, 2012);
- management (Cavazotte et al., 2014; Chen, 2015; Harmer & Pauleen, 2012; Karanasios & Allen, 2014; Kietzmann et al., 2013; Koroma et al., 2014; Mazmanian et al., 2013; Pauleen et al., 2015; Yuan & Zheng, 2009);
- workplaces features (Jarrahi & Thomson, 2016; Kietzmann et al., 2013; Koroma et al., 2014; Mäkinen, 2012; Vartiainen, 2008; Yuan & Zheng, 2009);
- work materials available (Koroma et al., 2014; Mäkinen, 2012);
- multiple relationships (Kietzmann et al., 2013; Koroma et al., 2014; Vartiainen et al., 2007; Vartiainen, 2008) and
- boundaries between social and work context (Cavazotte et al., 2014; Chen, 2015; J Koroma et al., 2014; Mazmanian et al., 2013; Pauleen et al., 2015; Sørensen, 2011b).

About the technology infrastructure, there is a great concern about the security of mobile devices and data (Chen, 2015; Koroma, Hyrkkänen, & Vartiainen, 2014). Been on the move increases the chance of robbery and also makes difficult to keep the company's IT backup schedule, for instance (Koroma et al., 2014). Likewise, these workers frequently use their own devices and equipment to work (Jarrahi & Thomson, 2016). The adequacy of infrastructure capabilities from the organisation or from the temporary workplaces is another issue faced by these workers (Harmer & Pauleen, 2012; Koroma et al., 2014). This infrastructure needs to support their productive capacity. Besides, the devices' capabilities can also be a barrier; sometimes is not easy to deal with small screens, connection failures, lack of battery or energy and many systems and applications to perform specific tasks (Koroma et al., 2014).

Regarding the information management, Mäkinen (2012) mentions that there are at least three types of problems. The first one is related to access and versioning of documents, for instance. The second one is related to technical and usability problems to access the information from mobile devices. And the third one is regarded to the infrastructure available in the workplace to access and manage the information needed. Figure 6 presents a consolidated list of the biggest problems faced by the

MKWs, related to the information management.

Figure 6 – Information management problems

Information management problems	Device dependent problems		Adjusting to mobile working environment
	Technical problems	Usability problems	
Document versioning and version management	No network connections, poor network	Weight of mobile devices	Technical environment makes insecure
Losing records	Poor capacity of mobile devices	Size of mobile devices	Forced to adapt even if not ready
Information scattering to many devices	Synchronisation or compatibility of multiple devices	Small display	No technical education
Information retrieval	Problems with old equipment	Difficult to read from display	Slow learning
Confidentiality of records	Making backups	Equipment getting old	Global work
Access to records	Transferring data from one device to another	Changing battery disturbs working	Networking of work
			Coping with technical problems
			No personal devices available

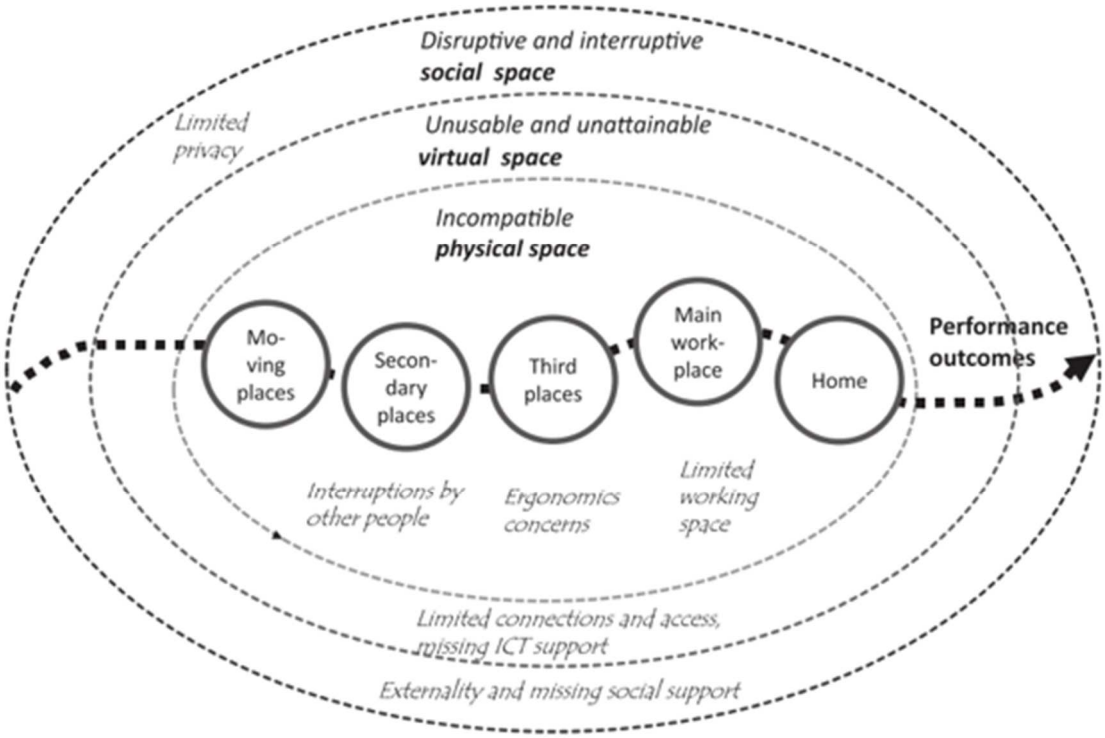
Source: Mäkinen (2012).

Regarding management, as MKWs have different characteristics and needs, the traditional management techniques and bureaucratic models of supervision do not work with them (Chen, 2015; Kietzmann et al., 2013; Pauleen et al., 2015). These professionals require new styles of management that encourage and engage them to deliver valuable outcomes without a restrict control and supervision (Harmer & Pauleen, 2012). Managers need to build an environment based more on trust, commitment and collaboration rather than on direct control (Kietzmann et al., 2013).

It is common to MKWs experience unpredictable situations and changes in schedules with clients, partners and also in timetables and routes (Koroma, Hyrkkänen, & Vartiainen, 2014). Besides, work on the move or in public spaces can be very challenging and even dangerous sometimes. For instance, many MKWs tend to work on the move, and many times, while they are driving, they often receive calls and messages related to work (Jarrahi & Thomson, 2016). About work while driving, they can reduce the attention in the traffic and could promote accidents. In public places, in turn, they do no have the adequate resources or equipment to work, such as a table or a suitable chair. Furthermore, they tend to have noisy and no privacy to work, which affect their work productivity (Koroma, Hyrkkänen, & Vartiainen, 2014).

The number of visits is also difficult to predict, and because of this intense commute between places and people to attend, frequently there is no enough time to learn about that location and people. For instance, specific configurations to use at a client's site and real needs of people visited (Koroma, Hyrkkänen & Vartiainen, 2014). As presented, depending on the workplace, the MKWs can face different issues. Figure 7 illustrates the typical problems encountered by these professionals in the workplaces they tend to work.

Figure 7 – Common issues on mobile workplaces



Source: Koroma, Hyrkkänen, & Vartiainen (2014).

Concerning to work material, as already mentioned, MKWs need to continuously carry all their work tools to be prepared to establish their mobile office anywhere (Koroma et al., 2014). They must be ready for the unexpected, so it is important to develop certain abilities and "survival strategies" to deal with problems (Mäkinen, 2012).

Regarding the relationships, according to Vartiainen (2008), the primary purpose of work on the move for the MKWs, is to meet people: co-workers, partners and clients. These workers consider important to meet people face-to-face to communicate and negotiate better. Nevertheless, many times there is not sufficient time to establish a

strong relationship with the people visited (Koroma, Hyrkkänen & Vartiainen, 2014). Moreover, the high mobility also constrains the best and most used support channel, their workmates (Vartiainen et al., 2007). Thus, this intensive work on the move contributes to use different ways to solve problems or deal with the same situations, then, it is very common that the same issue faced by one MKW can be solved in a different way by another MKW.

Another issue faced by MKWs is related to the pressure they tend to feel to prove their loyalty to their community and help their colleagues or also support their managers (Koroma et al., 2014; Mazmanian et al., 2013). As mentioned by Mazmanian et al. (2013, p.1341) "[…] they used their mobile email devices to be continually connected, thus managing their commitment to others by staying in touch with the flow of communication […]". Hence, many times it is necessary to impose barriers to be concentrated in a particular activity or even stay unavailable at specific time. On the other hand, technical problems can leave them "invisible" mainly in collaborative activities that they are participating in a remote way (Vartiainen et al., 2007). Sometimes, this can lead to a sense of frustration for not being part of the same group. At other times, it may be the trigger to keep them busy with other activities and remain passive or non-participatory in the current collaborative activity.

Finally, regarding the boundaries between social and work context, due to the greater availability of individuals to the organisation, through the removal of temporal and geographic boundaries (Sørensen, 2011a), the MKWs need to deal with information and work overload, as well as lack of privacy. These challenges can affect not only their professional life but also their quality of life (Pauleen et al., 2015).

Figure 8 summarises the main challenges discussed in this section. The next section discusses how mobile ICT can support MKWs.

Figure 8 – Challenges in the mobile workers context

Type	Challenges addressed	References
Technology infrastructure	• Security of devices and data • Working with their own devices • Responsibility for their own technical skills	Cavazotte et al. (2014); Chen (2015); Dal Fiore et al. (2014); Harmer & Pauleen (2012); Jarrahi & Thomson (2016); Karanasios & Allen (2014); Kietzmann et al. (2013); Koroma, Hyrkkänen &

	• Infrastructure capabilities in the organisation and in temporary workplaces • Capabilities of devices and equipments (small screens, lack of battery etc.)	Vartiainen (2014); Pauleen et al. (2015); Yuan & Zheng (2009)
Information management	• Barriers to access and manage information • Versioning of documents • Variety of sources necessary to get information	Jarrahi & Thomson (2016); Mäkinen (2012)
Management models	• Traditional management and bureaucratic models of supervision • Lack of new styles of management that encourages the delivery of valuable outcomes • Trust, commitment and collaboration instead of control	Cavazotte et al. (2014); Chen (2015); Harmer & Pauleen (2012); Karanasios & Allen (2014); Kietzmann et al. (2013); Koroma et al. (2014); Mazmanian et al. (2013); Pauleen et al. (2015); Yuan & Zheng (2009)
Workplaces	• Distribution of working locations • High mobility due to a series of travel by car, bus and airplanes • Different time zones, cultures and languages • Unpredicted situations in scheduling, timetables and routes • Personal security when working on the move (robbery or even the focus while driving) • Adequate places and structure when working on the move	Jarrahi & Thomson (2016); Kietzmann et al. (2013); Koroma et al. (2014); Mäkinen (2012); Vartiainen (2008); Yuan & Zheng (2009)
Work materials/devices	• Need to carry all the work materials • Need to have “survival strategies” for unpredicted situations	Koroma et al. (2014); Mäkinen (2012)
Relationships	• Asynchronous and synchronous ways of working • Diversity of people to deal with • Time to strengthen relationships • Relative social invisibility and disconnectivity that comes with working mobile and remotely	Kietzmann et al. (2013); Koroma et al. (2014); Vartiainen et al. (2007); Vartiainen (2008)

	• Commitment with colleagues and managers increases the barriers between time “on” and “off” • Sense of loyalty and obligation to others	
Boundaries between social and work context	• Availability of individual to the organisation • Temporal accessibility (modification of the temporal boundaries of the relationship between the individual and the organisation) • Geographic accessibility (interaction anywhere) • Information and work overload due to the removal of organisational boundaries • The lack of privacy and increase in workload (possibility of invasion of intimate space)	Cavazotte et al. (2014); Chen (2015); Koroma et al. (2014); Mazmanian et al. (2013); Pauleen et al. (2015); Sørensen (2011b)

Source: Literature review.

2.1.4 Mobile ICT supporting Mobile work

The constant use of mobile ICT in the workplace can considerably change the activities of mobile workers. The spread of mobile technologies combined with shifts in the business environment offers radically different forms of creating, sharing and mobilising information (Jarrahi & Thomson, 2016). For this reason, information and knowledge will no longer be linked to an office but will be composed of constant and continuous collaboration, on-the-fly communication and coordination among distributed actors. These practices, using a wide variety of ICT artefacts combined to meet the specific tasks will regularly allow communication, interaction and collaboration with people within and outside the boundaries of the organisation (Jarrahi & Thomson, 2016; Sørensen, 2011a).

The study of use of mobile ICT in the context of mobile work is defined as Enterprise Mobility (Sørensen, 2011a). According to Sørensen (2011a) six capabilities of mobile ICT can be applied to support the context of mobile work: (1) the portability of devices and services; (2) connectivity with others or with remote information services; (3) pervasiveness – technology’s ability to perceive the service environment;

(4) the intimacy with the users in terms of possibilities of individualization associated to the identification of users; (5) priority as symmetry/asymmetry support services; and (6) the memory of on going relationships as opposed to a series of isolated encounters. These mobile ICT capabilities are explained as follows.

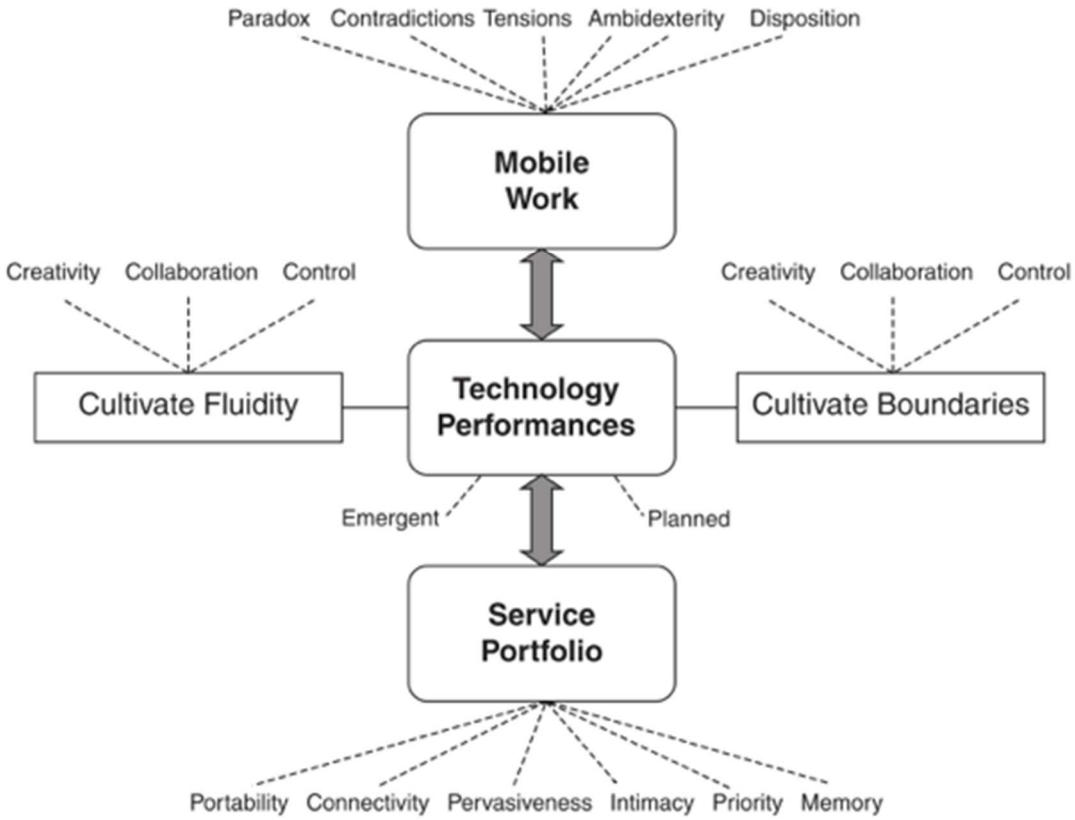
The portability of the computers and other devices can allow workers perform their work practices wherever they are. However, the portability alone is not sufficient to get the work done; it is also necessary the combination of the portability and connectivity. Moreover, the pervasiveness (ubiquitous computing[2]) allied with the portability allows mobile ICT to "perceive" its environment, becoming context-aware to better support mobile work. For instance, the application of these capabilities permits the use of GPS digital maps by the mobile workers during commuting between workplaces (Dal Fiore et al., 2014).

Regarding the intimacy, these technologies support MKWs wherever they are and whatever they do; the intimacy increases due to the relationship between the human body and technology (Sørensen, 2011a). Despite the benefits related to being connected and available all the time, there are also disadvantages mainly related to dilemmas and conflicts about privacy and surveillance. Thus, to deal with these issues, the MKWs can make use of the priority and memory capabilities of mobile technologies and choose between cultivate fluidity or boundaries in their relationships, when necessary.

In addition to these mobile ICT capabilities, Sørensen (2011a) also presents three perspectives on mobile work: (1) creativity, which denotes the mobile worker engaging in interaction management; (2) collaboration, where the mobile worker negotiates mutual interdependencies with others; and (3) control, meaning activities aimed at the supervision, planning and management of mobile work. The influences of these mobile ICT capabilities and perspectives on mobile work are illustrated in Figure 9.

Figure 9 – Influences of Mobile ICT Capabilities and Perspectives on Mobile Work

[2] The term ubiquitous computing was defined by Weiser (1991). According to the author, the term refers to the capability of the technology to disappear into the fabric of everyday life, becoming indistinguishable, but at the same time, in constant presence to support the users when necessary.



Source: Sørensen (2011a).

As observed, mobile and ubiquitous technologies help the mobile worker to be part of collaborative activities, cultivating fluidity and thus eliminating the barriers of time and space. However, on the other hand, staying away from his base but still having access to resources anytime, anywhere conducts the worker to cultivate the boundaries, and to remain autonomous with control over his activities. In a flexible work environment, successful employees are often self-motivated and prefer to be self-managed (Chen & Nath, 2008). This scenario indicates the importance of technologies as an agent in the mobile worker's context despite its effects, both social and technological in the work practices.

As mentioned before, the primary purpose of this research is *to analyse how knowledge creation and knowledge sharing are carried out in collaborative problem-solving situations in the mobile workers' context*. The professionals' focus of this study is the mobile knowledge workers because, to perform their work activities, they often have to make complex decisions based on expert knowledge and ad hoc information. However, this study also contributes to the mobile field workers since, as highlighted by Stieglitz et al. (2015), even mobile field workers can benefit from knowledge creation

and sharing via mobile collaboration since these processes can help to detect inefficiencies and unproductive and redundant work.

Before analysing how mobile workers accomplish knowledge creation and sharing in their own context, it is important to understand the theoretical background regarding these two processes. Next section discusses these topics in detail.

2.2 KNOWLEDGE CREATION AND KNOWLEDGE SHARING

In this study, the definitions of knowledge creation and knowledge sharing are based on the approaches of learning theories (Engeström, 1987; Vygotsky, 1978). Sfard (1998) mentioned that theories of learning come and go, and then she stated that to understand learning it is better to concentrate on basic metaphors of learning. This author identified two main metaphors: the acquisition metaphor and the participation metaphor.

The acquisition metaphor is based on the idea of the acquisition of something (Sfard, 1998). Following this metaphor, the knowledge creation can be understood as the accumulation of knowledge, and the human mind as a container to be filled. This metaphor brings the idea of gaining possession, learning as making an acquisition, and it is more adopted by the old models and theories of learning. The knowledge sharing, according to this metaphor, can be understood as the sharing of a possession, the knowledge or concept. However, as highlighted by Sfard (1998), if knowledge becomes a possession, this can brings the idea of the possessor as superior to others.

The participation metaphor, in turn, presupposes that the learner is a person interested in participating in certain kind of activities, and the creation and sharing of knowledge is performed through learning by doing or in doing and participating in a social community rather than only accumulating or transfering private possessions (Sfard, 1998). The author also stated that this second metaphor is more adopted by the new models and theories of learning. However, as mentioned by Sfard (1998, p.10), one metaphor is not enough: “each one has something to offer that the other cannot provide”.

Later on, Paavola & Hakkarainen (2005) identified a new metaphor of learning. According to these authors, the third metaphor, named as the knowledge-creation metaphor, define learning as a “process of knowledge creation which concentrates on mediated processes where common objects of activity are developed collaboratively”

(Paavola & Hakkarainen, 2005, p.535). Engeström & Sannino (2010) reinforced that both acquisition and participation metaphors have little concern about the transformation and creation of a culture. The authors mentioned that these metaphors "depict learning primarily as a one-way movement from incompetence to competence" (Engeström & Sannino, 2010, p.2). According to them, the third metaphor introduces the idea of "learning something that is not yet there" (Engeström & Sannino, 2010, p.2). Thus, the learners can collaboratively construct new concepts and knowledge (Paavola & Hakkarainen, 2005).

> The Knowledge-creation metaphor conceptualizes learning and knowledge advancement as collaborative processes for developing shared objects of activity. Learning is not conceptualized through processes occurring in individuals' minds, or through processes of participation in social practices. Learning is understood as a collaborative effort directed towards developing some mediated artifacts, broadly defined as including knowledge, ideas, practices, and material or conceptual artifacts. The interaction among different forms of knowledge or between knowledge and other activities is emphasized as a requirement for this kind of innovativeness in learning and knowledge creation (Paavola & Hakkarainen, 2005, p.569).

Therefore, according to the third metaphor, the processes of knowledge creation and knowledge sharing are made via participation and expansion of the individual and the organisational knowledge. Figure 10 presents a summary of these three metaphors of learning.

Figure 10 – The three metaphors of learning

	Knowledge acquisition	Participation	Knowledge creation
Main focus	A process of adopting or constructing subject-matter knowledge and mental representations	A process of participating in social communities	A process of creating and developing new material and conceptual artifacts
		Enculturation, cognitive socialization	Conscious knowledge advancement, discovery, and innovation
		Norms, values, and identities	
Theoretical foundations	Theories of knowledge structures and schemata	Situated and distributed cognition	Knowledge-creating organizations
	Individual expertise	Communities of practice	Activity theory
	Traditional cognitivist theories	Sociologically-oriented epistemology	Knowledge-building theory
	Logically-oriented epistemology		Epistemology of mediation
Unit of analysis	Individuals	Groups, communities, networks, and cultures	Individuals and groups creating mediating artifacts within cultural settings

Source: Paavola & Hakkarainen (2005).

Based on these metaphors of learning and aiming to better understand how the processes of knowledge creation and knowledge sharing are accomplished in the context of mobile workers, the main theories about learning were studied. The next

section presents the main ideas of these theories and which one was chose to understand the research problem.

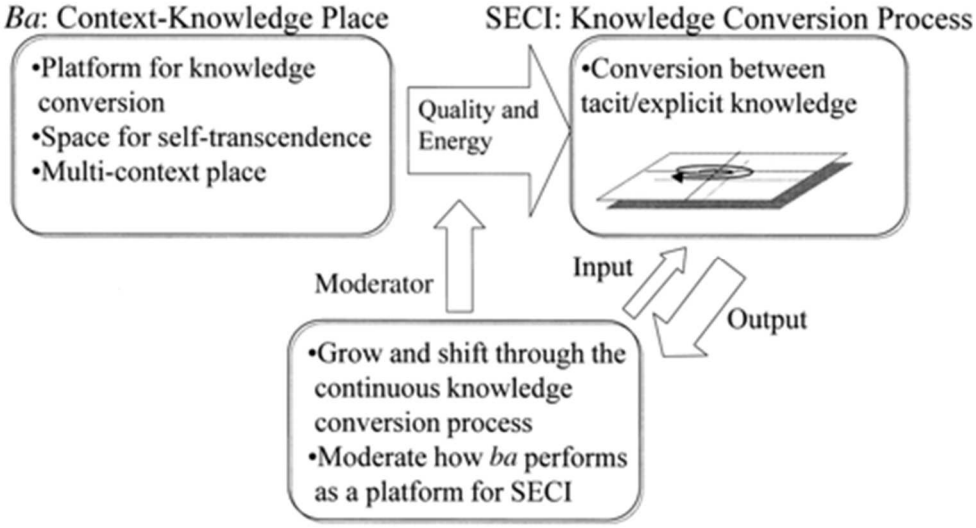
2.2.1 Main theories of Knowledge Creation and Sharing

The systematic literature review (see APPENDIX A – SYSTEMATIC LITERATURE REVIEW) allowed the identification of three main theoretical approaches related to the knowledge creation and sharing in the organisational context: 1) the organisational knowledge creation theory, 2) situated learning theory and 3) activity theory. These theories are presented in the subsequent sections.

2.2.1.1 Organisational knowledge creation theory

The organisational knowledge creation theory is a theoretical approach that focuses on the creation of knowledge in organisations (Nonaka & Takeuchi, 1995). In this approach, the authors proposed a knowledge creation model based on three elements (Figure 11): (1) “Ba” the shared context for the knowledge creation, (2) the SECI process or the knowledge spiral (Figure 12) - Socialisation, Externalisation, Combination and Internalisation - that allows the conversion of tacit knowledge to explicit knowledge and (3) the knowledge assets. To create knowledge it is necessary that the “Ba” can be established and the knowledge assets can be available, such as individual knowledge to be shared. Then, the process of knowledge creation is performed through the knowledge spiral that consists of four types of knowledge conversion: from tacit knowledge to tacit knowledge (socialisation); from tacit to explicit knowledge (externalisation); from explicit to explicit knowledge (combination) and from explicit to tacit knowledge (internalisation). These three elements of knowledge-creating process and their relation are represented in Figure 11.

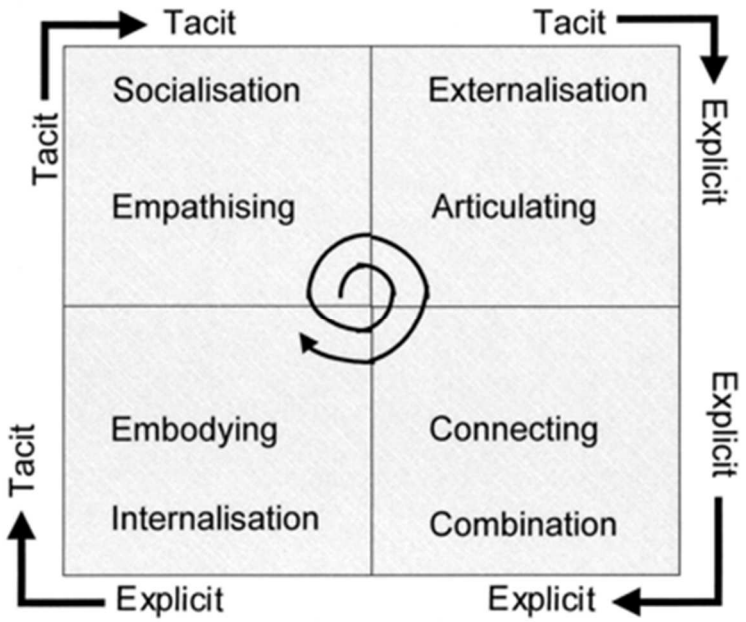
Figure 11 – Three elements of the knowledge-creating process



Source: Nonaka et al. (2000)

In each step of the SECI model, a type of knowledge content is created. The socialisation starts the iterative knowledge-creation. This phase allows the creation of the “shared knowledge”. This knowledge is generated through mental models and shared skills; the individual knowledge is shared with others. Externalisation, in turn, permits the creation of “conceptual knowledge”, where metaphors and analogies enable the generation of this knowledge. At the Combination phase, units of already existing explicit knowledge are combined and exchanged. Finally, in the Internalisation phase, the explicit knowledge of the organisation is internalised by individuals and transformed in tacit knowledge and into action through “learning by doing” (Nonaka & Takeuchi, 1995). Figure 12 presents the knowledge conversion of the SECI process.

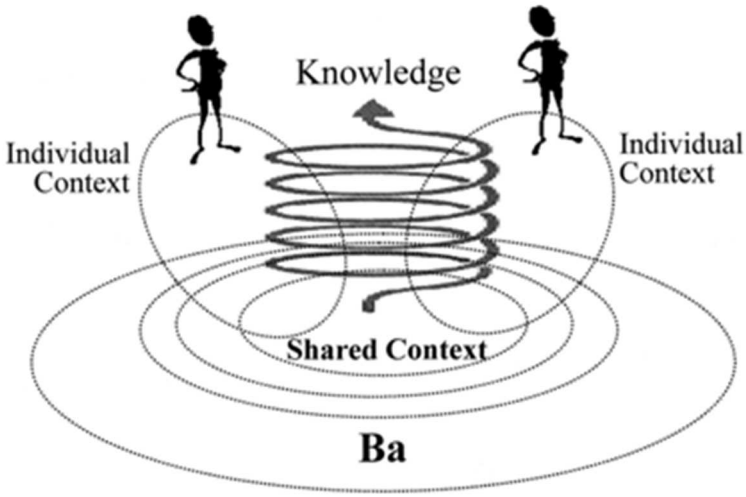
Figure 12 – The Knowledge conversion of the SECI process



Source: Nonaka et al. (2000)

However, to create knowledge in an effective way, a context is needed (Nonaka et al., 2000; Popadiuk & Choo, 2006). Also, it is necessary to understand and construct meanings among the participants in this context, so that knowledge creation takes place (Choo, 2001; Nonaka et al., 2000). Nonaka et al. (2000) name this space as: “Ba”. According to the authors “Ba” is the shared space of interaction where information is interpreted and becomes knowledge. The “Ba” does not necessarily mean a physical space. It can take a physical form of a business or an office space, a virtual form such as an intranet, an email, a mailing list, meetings and social events, and also can assume a mental form as shared ideas and ideals (Popadiuk & Choo, 2006; von Krogh, Nonaka, & Rechsteiner, 2012). In this shared space the construction of meanings occurs and, like all knowledge, this sense is situated in the social, historical or cultural context. Figure 13 illustrates how the “Ba” allows the knowledge creation and sharing.

Figure 13 – Ba for knowledge creation and sharing



Source: Nonaka et al. (2000)

Particularly in the socialisation and externalisation phases of the SECI process, it is important for the participants to share time and space (Nonaka et al., 2000). The proximity of the interaction is important in the shared context because it allows the use of a common language among the participants. Thus, it is necessary to select the language to be used in each phase of the SECI carefully, since each step has a specific requirement to allow the knowledge creation.

Also, the context for knowledge creation is particular regarding who and how participate (von Krogh et al., 2012). Thus, the participants of the “Ba” are random and according to the necessity and context. This characteristic usually impacts the process of knowledge creation and sharing. Participants put the processes of knowledge creation and sharing in motion, and they spontaneously collaborate and alternate between leader and follower, seeking to gradually formalise this practice and ensure the collective and constant pursuit of their interests (von Krogh et al., 2012).

The processes of knowledge creation and sharing are participatory and count on several individuals sharing and acquiring knowledge through transactional memory (von Krogh et al., 2012). Through this memory, it is possible to know the expertise of the participants and identify who knows what within the group (Lyytinen & Yoo, 2008). Besides, the processes of knowledge creation and sharing are not a single time event, but rather an incremental and continuous process of the organisation (Song, 2008).

The systematic literature review allowed observing how the studies are addressing the organisational knowledge creation theory. The following studies are highlighted: (1) Holste & Fields (2010) that investigated the influence of trust as a factor

for the use and sharing of knowledge; (2) Lam & Lambermont-Ford (2010) that examined individuals' willingness to share and integrate their knowledge; (3) Wu, Senoo & Magnier-Watanabe (2010), which proposed an ontological change in the SECI model as a tool to diagnose the context of knowledge creation in organisations; (4) Teng & Song (2011) that evaluated two types of knowledge sharing - requested and voluntary - as well as their relationship to task, culture, technology and processes; (5) and Rusly et al. (2014), which analysed the influence of readiness to change in the knowledge sharing process.

2.2.1.2 Situated learning theory

The second theoretical approach identified for knowledge creation and sharing is called situated learning theory. This approach is based on a social perspective and is commonly used to understand the processes of organisational learning. The theory explains that, for people learn it is necessary for them to interact with others, the group they belong to, and practice in their own context. According to Lave & Wenger (1991), people learn through participation (practices), in addition to observation and interaction with members of the social group of which they are part (communities of practice).

The community of practice (CoP) can be defined as a group of people who share a concern or a passion for something and regularly interact to learn how to do better (Lave & Wenger, 1991). Learning in this approach emphasises the acquisition of knowledge as a result of practical training sessions, where knowledge can be applied (Handley et al., 2007). Learning then occurs in the domain and context in which the community and its participants are situated, being inseparable from social practice (Lave & Wenger, 1991).

According to Wexler, Tam & Maine (2005, p.8) "CoP brings together three elements — a domain of knowledge or problem area, a community of knowledge workers who develop meaningful relations and, lastly, an accumulation of practical knowledge about how to solve real and persistent workplace problems". CoPs develop their practice through a variety of activities (Wenger, McDermott & Snyder, 2002). Figure 14 presents typical examples of these activities.

Figure 14 – Examples of activities in CoPs

Activity type	**Example**

Problem-solving	“Can we work on this design and brainstorm some ideas; I’m stuck.”
Requests for information	“Where can I find the code to connect to the server?”
Seeking experience	“Has anyone dealt with a customer in this situation?”
Reusing assets	“I have a proposal for a local area network I wrote for a client last year. I can send it to you and you can easily tweak it for this new client.”
Coordination and synergy	“Can we combine our purchases of solvent to achieve bulk discounts?”
Discussing developments	“What do you think of the new CAD system? Does it really help?”
Documentation projects	“We have faced this problem five times now. Let us write it down once and for all.”
Visits	“Can we come and see your after-school program? We need to establish one in our city.”
Mapping knowledge and identifying gaps	“Who knows what, and what are we missing? What other groups should we connect with?”

Source: Wenger, McDermott & Snyder (2002).

CoPs have an environment that supports voluntary and mutual engagement among the participants that have common objectives such as knowledge sharing and the generation of learning (Lave & Wenger, 1991). Lesser, Fontaine & Slusher (2000) also point out that the CoPs are at the centre where the processes of knowledge creation and knowledge sharing take place. Gammelgaard & Ritter (2005), however, differ CoPs from informal networks of people who communicate, share information and build relationships. According to Gammelgaard & Ritter (2005), CoP stands out mainly for the group’s intention to create practices and develop domains of knowledge from a single perspective.

Cox (2004) presents a critical review of four seminal papers on CoPs. Among these works are Lave & Wenger (1991) and Brown & Duguid (2001). According to Cox (2004), one of the problems with this theoretical approach concerns the complex description of an entity that is quite difficult to identify. Also, Handley et al. (2007) reinforce that although many researchers have adopted the theory of situated learning, there are still few theoretical models that help in the comprehension and adoption of the theory. As a result of their work and initiative to address this gap, the authors present a theoretical model that allows the understanding of situated learning in the context of communities and networks of practice (Handley et al., 2007).

The literature review also allowed to analyse the studies regarding situated learning in the contexts influenced by technologies and to identify concerns related to this project, as well as gaps and research opportunities. Some of these works are

highlighted. The work of Zhang & Watts (2008) that investigated how the concept of CoPs can be applied to online communities and how organisations can make better use of online social structures for their practice of knowledge management. Similar to this approach is the work of Vuori & Okkonen (2012), that investigated the motivational factors that affect knowledge sharing through an intra-organisational social media platform. Biancani, McFarland & Dahlander (2014) explored the concept of semi-informal organisations and investigated how the collaborative links are generated within knowledge-intensive organisations. And Pangil & Moi Chan (2014), in turn, investigated the relationship between trust and the effectiveness of a virtual team, based on the mediating effect of knowledge sharing.

2.2.1.3 Activity Theory Overview

The third theoretical approach, identified for the analysis of learning contexts and the knowledge creation and knowledge sharing, is Activity Theory (AT). The AT aims to analyse how human activities are performed through the interaction of the individual in his or her social context (Engeström, 1987; Leontev, 1978; Vygotsky, 1978). The theory proposes elements and concepts that allow a more accurate analysis of how human activities are performed, such as the interaction and cooperation of individuals during the activities. Also, within a historical and cultural context it is possible to observe which contradictions may arise in forms, working tools and participants involved in this context (Engeström, 1987; Leontev, 1978). As mentioned by Lundin & Magnusson (2003, p. 275), “Since the practitioners’ understanding of their work is changed by engaging in the practice itself, new knowledge is created. Engaging in practice is a learning process. This learning process cannot be examined without understanding the practice”.

Besides, the model proposed by Engeström (1987) suggest that learning is based on the expansive and qualitative changes in the human activities. According to (Engeström, 2001b, p.138),

> In important transformations of our personal lives and organizational practices, we must learn new forms of activity, which are not yet there. They are literally learned as they are being created. There is no competent teacher. Standard learning theories have little to offer if one wants to understand these processes.

Thus, AT also brings the idea of the third metaphor of learning, the knowledge-creation metaphor, by providing elements that allow the learners learn something new through the innovative learning at workplaces based on collaborative mastering of culturally new practices and knowledge (Paavola & Hakkarainen, 2005). Therefore, considering these characteristics and noting that the principles of the AT provide a better lens for understanding the research problem outlined, the current research used it as the main theoretical approach. As mobile knowledge worker has particular characteristics, motivations and behaviour, their dynamic and knowledge intensive work environment can be understood, in the light of AT, as expansive learning and transformation, once the contradictions that emerge need to be solved to promote change and development (Engeström, 1987, 2000b, 2001b).

Likewise, the concepts and the framework of AT provides a better understanding of how the work activities are structured and performed by these workers. Based on AT it is possible to recognise who is involved in the mobile workers' activities, what artefacts help or constrain their actions as well as the identification of how and why they create and share knowledge, through learning actions during their work practices.

Furthermore, few studies use AT as a framework to analyse the context and practices accomplished by mobile workers (Allen et al., 2013; Karanasios & Allen, 2014). Also, none study so far has addressed the processes of knowledge creation and knowledge sharing in the mobile workers' context, based on AT. As Mäkinen (2012) points out, researchers that address approaches towards better supporting mobile work could use the Engeström's model of AT (Engeström, 1987). According to this author, this model can help to better understand the relationship between the individual, his/her main work activities and his/her social relations, which allow explaining the knowledge needs to achieve the activities goals.

More details about AT is presented in Chapter 3 THEORETICAL BACKGROUND: ACTIVITY THEORY. Figure 15 presents a synthesis of the identified approaches for understanding the processes of knowledge creation and knowledge sharing in an organisational context.

Figure 15 – Main characteristics of the theoretical approaches

Theoretical Approach	**Organisational knowledge creation theory**	**Situated Learning**	**Activity Theory**
Definition	Organisation's capacity to foster the knowledge creation and knowledge sharing through the SECI process (Nonaka, 1994; Nonaka & Takeuchi, 1995)	Learning is situated in a context and needs the practices and social interaction among the members of a community (Lave & Wenger, 1991)	It analyses the relation of the individual to his/her social context, besides observing the contradictions between the elements and the expansion of learning through the solution of these contradictions (Engeström, 1987; Leontev, 1978; Vygotsky, 1934)
Main concepts	Tacit and explicit knowledge, sense making	Knowledge domain, community of practice (CoP)	Activity System, Zone of Proximal Development, Contradictions, Expansive Learning
Where it occurs	“Ba” – shared knowledge space	Domain / Situated context	Activity Systems and network of activity systems
Analysis unit	SECI process	CoP	Individual and social interaction through the Activity Systems
Metaphor of learning	Participation	Participation	Knowledge-creation
Knowledge creation and sharing	The knowledge is created and shared based on knowledge assets and acquired via learning by doing through participation in the “Ba” and SECI process.	The knowledge is created and shared via learning by doing through participation in a community of practice.	The knowledge is expanded; it is something that was not there. This is made through learning actions (learning in doing) and participation of individuals of the Activity Systems in collaborative and problem-solving situations.

Source: The author.

3 THEORETICAL BACKGROUND: ACTIVITY THEORY (AT)

This chapter is dedicated to the presentation of the theoretical background used in this study to address the research problem. First, the activity system is defined, and the three generations of the AT are presented. Then, the contradictions are described, and the four levels of the contradictions that affect the activity system are shown. Next, the Zone of Proximal Development is explained. Finally, the expansive learning and its phases of a cycle of expansive development are discussed.

3.1 ACTIVITY THEORY: KEY CONCEPTS

Activity Theory has its origins in the 1920s and 1930s through the studies of the Russian psychologists Vygotsky, Leontev and Luria (Engeström, Miettinen, & Punamäki, 1999). However, these authors stand out that the main philosophical root of Activity Theory is the work of Karl Marx. In Vygotsky's studies, there is a permanent concern related to human development, learning and the relationship between development and learning (Engeström, 1987). According to Sannino, Daniels, & Gutierrez (2009, p.1),

> Activity theory seeks to analyse development within practical social activities. Activities organize our lives. In activities, humans develop their skills, personalities, and consciousness. Through activities, we also transform our social conditions, resolve contradictions, generate new cultural artifacts, and create new forms of life and the self.

Engeström (1987) proposed that AT has three generations. In the first generation, the concept of mediation is presented and it is suggested that the relation between the subject and his object is always mediated through an instrument (Engeström, 1987). The first generation is based on the Vygotsky's work, and its unit of analysis was object-oriented action mediated by cultural tools and signs (Engeström et al., 1999). In this first generation, social relations and mediation by others were not addressed. These concerns were discussed by the second generation of the AT.

The second generation, hence, expands the concept of the individual action to an Activity System. Leontev made this expansion by distinguishing collective activity and individual action (Engeström et al., 1999). Human activity, according to Leontev (1978), is the form of relation of a subject with an object, motivated by objectives to be achieved. The human activity is realised based on individual actions, which have a

conscious orientation towards a goal and is related to a particular time and place. The actions, in turn, are carried out through operations, which are performed without conscious attention. The operations are the actions that have become automated routines through repetition and practice.

According to Engeström (1987), the activity is the complex form of the relationship between people and his social context and involves collective and cooperative acting. The common objective directs the activity (Leontev, 1978). Also, the activity is performed through individual actions, which are motivated by specific goals (Engeström, 1987). These actions, in turn, are carried out through operations, which refer to the operational level. “Every operation, however, is the result of a transformation of action that takes place as a result of its inclusion in another action and its subsequent ‘technization’” (Leontev, 1978, p.102). Leontev (1978) defines actions as the “what” should be done and operations as the “how” should be done. Figure 16 shows the three levels of the activity system.

Figure 16 – The three levels of the activity system

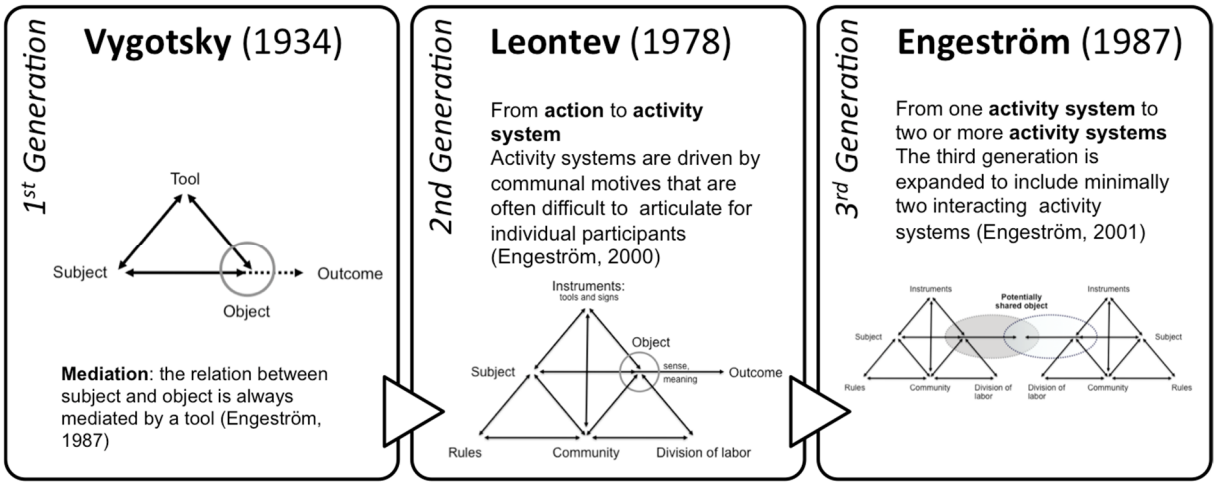
Level	Oriented towards	Carried out by	Example
Activity	Object/Motive	Community	“The activity of participators in common work is evoked by its product, which initially directly answers the need of each of them.” (Leontev, 1978, p. 99). Activity example: Collective Hunting
Action	Goal	Individual or group	“The development of the technical division of work necessarily leads to isolation of, as it were, intermediate partial results, which are achieved by separate participators of collective work activity, but which in themselves cannot satisfy the workers’ needs. Their needs are satisfied not by these ‘intermediate’ results but by a share of the product of their collective activity” (Leontev, 1978, p. 99). Actions examples: Catch the animal, Kill the animal
Operation	Conditions	Routinized human or machine	“The action has a specific quality that ‘formulates’ it specifically, and particularly methods by which it is accomplished. I call the methods for accomplishing actions, operations” (Leontev, 1978, p. 102). Operations example: Hammer use

Source: Adapted from Leontev (1978).

It is also important to emphasise that human beings are involved in several activities, and these are distinguished according to the objects to which they are oriented (Leontev, 1978). Although each element and relationships are distinct in each

particular activity, nevertheless the activities have the same structure (Virkkunen & Newnham, 2013). Therefore, all human activities have the basic elements and relationships depicted in the triangle of the Activity System. The third generation, consequently, expanded the scope of the Activity System and proposed that the human activity is always interrelated with other activities (Engeström, 2001a). As a summary, AT uses the object-oriented, artefact-mediated and collective activity system as its unit of analysis (Engeström et al., 1999). The three generations of the AT proposed by Engeström (1987) is presented in Figure 17.

Figure 17 – The three generations of Activity Theory



Source: Elaborated based on Engeström (1987, 2000, 2001).

The triangles in the activity system model represent the multiple relationships of cultural mediation in human activity. Virkkunen & Newnham (2013, p.33) state that

> The intellectual and practical instruments used in the activity and its rules and division of labor mediate the subjects' interaction with the object of the activity and with the other members of the community of those working on the object.

The elements of the activity system are strictly interrelated. Thus, the object and the other elements of the activity system can exist only in association with each other and when they are in mutual interaction (Engeström, 2000a). Besides, it is important to reinforce that a tool, a rule, and a form of division of labour are different kinds of cultural artefacts (Virkkunen & Newnham, 2013). However, an artefact only becomes an instrument – a mediating artefact of the activity – when the subject uses it to deal with the object. The basic concept is that a subject – an individual or sub-group – is

driven by a motivation(s) to act upon an object – a person, collective or thing – using cultural–historical tools – technologies, collaborative practices, information tools and so on (Karanasios & Allen, 2014). The elements of the activity system and their definition are presented in Figure 18.

Figure 18 – Activity System Elements

Element	Definition
Instruments (Tools and Signs)	Artefacts used to mediate the relationship between the subject and his object in the activity accomplishment. The instruments can be any tools or signs that allow the subject to transform his object in an outcome.
Subject	Individual or sub-group who perform the activity is selected as the viewpoint of analysis.
Object	The object refers to the problem scope or 'raw material' at which the activity is directed to and which is transformed into outcomes using external and instrumental tools (mediating tools and signs). The object represents the objective nature of the human activity and allows the individual controls his own motives and behaviours during the accomplishment of the activity. The activity, thus, is directed to the satisfaction of these objectives.
Community	Individuals or sub-groups who share the same object. The community is located in the activity under study, within the socio-cultural context of those who share the same object of activity. Rules and division of labour mediate the relationship between subject and community.
Division of Labour	The division of labour refers to both the horizontal division of labour among the members of the community as well as the vertical division of power and status.
Rules	The rules refer to the explicit and implicit rules, norms and conventions that restrict the actions and interactions within the activity system.

Source: Engeström (1987).

The activity systems and the elements aforementioned are in constant movement through relatively long cycles of qualitative transformations (Engeström, 2001a). These changes reflect on disturbances at work, such as ICT malfunctions, unscheduled changes in task assignments, information difficulties and non-work-related interruptions (Koroma et al., 2014). When these disturbances are aggravated, the individual participants begin to question and deviate from established standards to solving the contradictions (Engeström, 2001a). More details about the contradictions are presented in the next section.

3.2 CONTRADICTIONS OF THE ACTIVITY SYSTEM

Activity systems are driven by common goals that are often difficult to articulate among participants (Engeström, 2000a). There is also a continuous movement between the components of the activity and, this constant movement, promotes the occurrence of internal contradictions (Cole & Engeström, 1993; Engeström, 2000a). “From an actor’s perspective, an inner contradiction means that two things that determine his or her action or two processes that the action is a part of in the system pull the action in opposite directions” (Virkkunen & Newnham, 2013, p. 52).

Contradictions are essential for the activity system since they are a dynamic source of transition and development (Cole & Engeström, 1993; Engeström, 1987). The occurrence of contradictions in the system causes questioning about the forms and patterns of work and new and better forms of organisation (Engeström, 2000a). The new and better forms of work emerge since rules and procedures are questioned, reinterpreted, reformulated or modified to meet the motives/goals and needs of all participants. In this way, contradictions are like a driving force for the change/transformation of the activity (Engeström, 1987).

According to Engeström (1987), there is always constant construction and renegotiation within the activity system. This type of situation implies contradictions in the system. The contradictions are classified as 1) **primary**: it occurs within the components of the system, 2) **secondary**: it takes place between the components of the system, 3) **tertiary**: it happens between the current activity system and its new form, the new activity system that is being transformed and (4) **quaternary**: it occurs between the activities systems, the new activity system generated can lead to mismatches in the relation with the other existing systems, that already interacted with the old format of the transformed system (Engeström, 1987).

The primary contradiction is directly related to the use value and exchange value of the product generated by the subject and distributed to the community. According to Engeström (1987, p. 104),

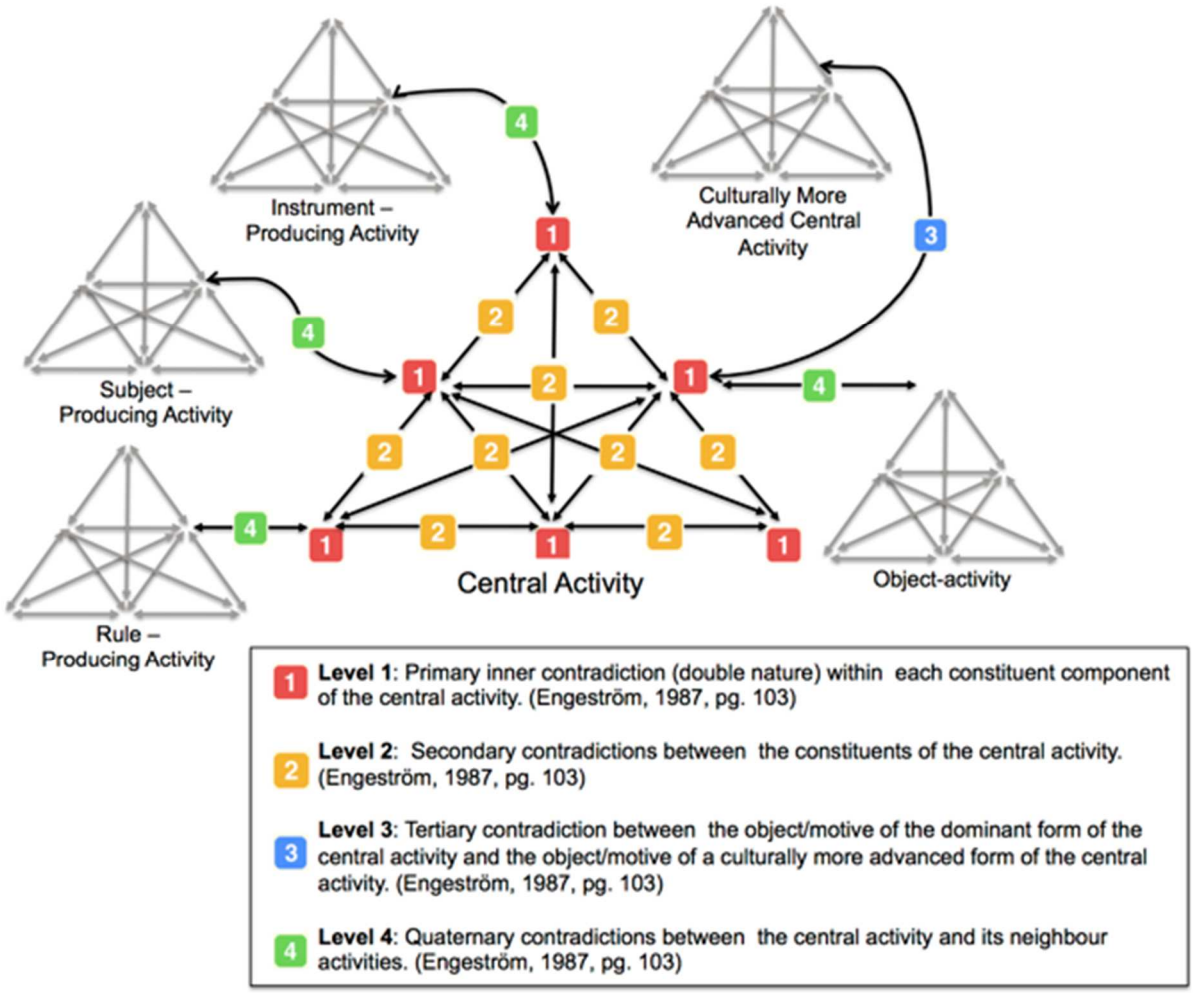
> The primary contradiction, the dual nature of use value and exchange value, may be by focusing on any of the corners of the 'central activity' of the doctor. For example, instruments of this work activity include a tremendous variety of medicaments and drugs. But they are not just useful preparations - they are above all commodities with prices, manufactured for a market, advertised and sold for profit. Every doctor faces this contradiction in his daily.

As time passed, the tendency is the primary contradictions in the system to worsen, and eventually lead to a global crisis in the activity system (Engeström, 1996a). The state of “crisis” conducts to new forms of the activity and, inevitably, to its change (Engeström, 1987). New instruments, such as new technologies, can be introduced or adapted in the activity system, making it evolve over time. Also, new forms of activity emerge as solutions to the contradictions. Thus, the constant disturbances caused by the primary contradictions lead the subject and the community to elaborate new ways of work, with the purpose of solving crisis. But the changes in the manner of work will imply the evolution of contradictions to the secondary level, conflicts and tensions between the elements of the system emerge (Engeström, 1999).

Harmonising and stabilising these new or adapted elements of the system solve the secondary contradictions. The solution of the secondary contradictions results in a new model for the activity system (Engeström, 1987). This new model, however, may present conflicts between the elements of the new, more expanded activity and the elements of the prior activity. Then, the tertiary contradictions take place. According to Engeström (1987), it is possible that the cause of these imbalances is the incomplete or insufficient development of the new elements of the activity system. Thus, the solution of the tertiary contradictions will allow the implantation and operationalisation of new model of activity.

However, since the activity system is not isolated and it is a part of a broader system of relationships (Engeström, 1987), during the implementation of new concept of activity it is very likely that the new activity will begin to conflict with the parallel activities - the instances in course of the old activity - that still follow the old logic. From this situation emerge the quaternary contradictions (Engeström, 1987). Therefore, only after solving all these contradictions the new activity system consolidates and become stabilised. The four levels of contradiction are summarised and illustrated in Figure 19.

Figure 19 – Four Levels of Contradictions of the Activity System



Source: Adapted from Engeström (1987).

The focus of analysis of activity system is not on the components of the activity but the contradictions between them, so the proposed framework becomes a tool to investigate the contradictions (Engeström, 1987). The development of an activity is understood as the resolution of the contradictions within and between the activity systems. This development is based on the joint construction and participation in collaborative practices and depends on, to a large extent, on the motives, ideals and cooperation among the practitioners (Engeström, 1987). Then, from the resolution of the contradictions, there is an expansive learning process and, as a consequence, new practices, forms of work or instruments emerge and consolidate. The following section presents the zone of proximal development, which is the main concept for the expansive learning proposed by Engeström (1987).

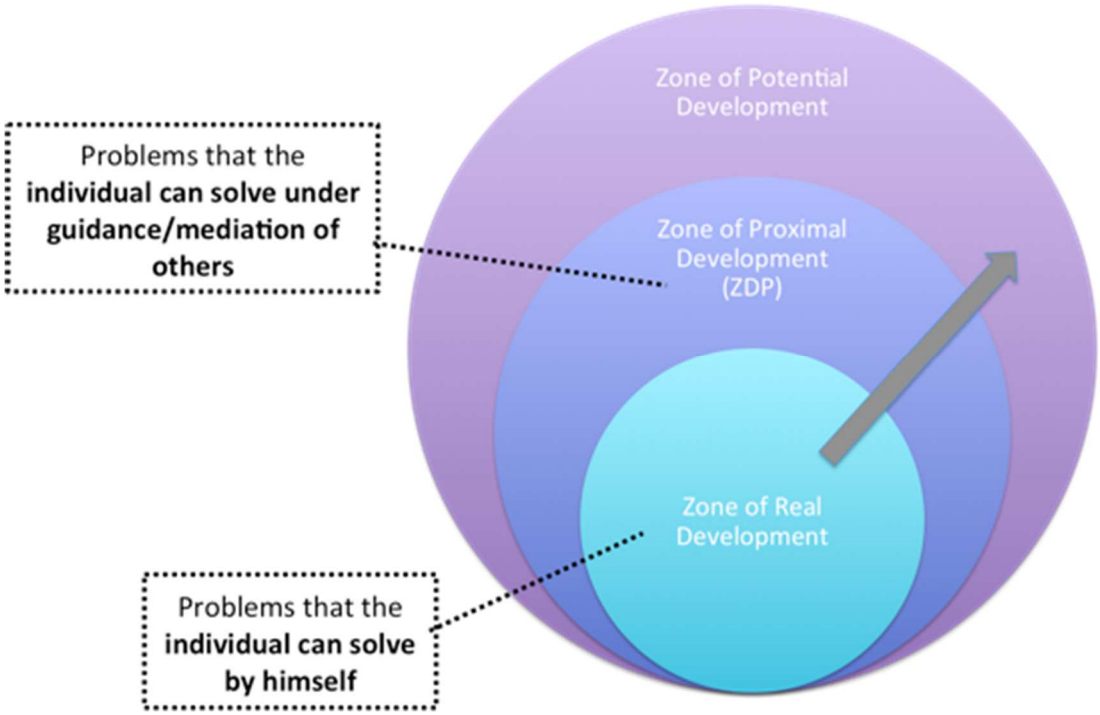
3.3 ZPD – ZONE OF PROXIMAL DEVELOPMENT

Vygotsky proposed the original definition of the Zone of Proximal Development (Engeström, 1987). This first definition, however, is based on the development and learning of the individual (Engeström, 1987). According to Vygotsky (1978), the definition of learning the interdependence of the individuals involved in the process, including the person who are learning, the person who are teaching, and the relationship between them. Human learning presupposes a specific social nature and a process through individuals that permeate the intellectual life of those around them (Vygotsky, 1978). Also, learning awakens some internal development processes, which can operate only when the individual interacts with people in environment and when cooperation with peers (Vygotsky, 1978).

According to Vygotsky (1978), the human development comprises two levels of development: 1) the level of real development and 2) the level of potential development. The level of real development consists of the individual mental functions already established based on the results of completed development cycles. This level refers to the set of activities that the individual can accomplish alone since it relates to the psychological functions that this person has already built up to a given moment. The level of potential development, in turn, relates to the set of activities that the individual cannot do alone but can perform with the support of a more experienced colleague. When this experienced person gives him some proper guidelines, the learner will be able to move forward and carry out the activity. Vygotsky (1978) characterises the level of potential development as a prospective mental development. This distance between real development and potential development is defined by Vygotsky as the Zone of Proximal Development (ZPD) (Engeström, 1987). Figure 20 illustrates the definition of ZPD. According to Vygotsky (1978), ZPD is defined as

> The distance between the real developmental level as determined by independent problem-solving and the level of potential development as determined through problem-solving under adult guidance or in collaboration with more capable peers (Vygotsky, 1978, p. 86).

Figure 20 – Zone of Proximal Development



Source: Elaborated based on Vygotsky (1978).

The ZPD's approach implies an understanding of learning and development as a process of appropriation of the knowledge historically created from social interactions (Engeström, 1987). However, it is important to emphasise the importance of the active participation of the subject in this process, since the appropriation of the knowledge is not a passive action it depends on the transformation and appropriation of the knowledge by the subject (Vygotsky, 1978).

Whereas Vygotsky definition of ZPD is based on individual perspective (Engeström, 2010), Engeström (1987) proposed a new concept for the ZPD, directing it towards a more development-oriented and learning-oriented approach in collective actions arising from relations with work. In this new definition of ZPD, Engeström (1987, p.164) included an organisational perspective:

> The distance between the present everyday actions of the individuals and the historically new form of the societal activity that can be collectively generated as a solution to the double bind potentially embedded in the everyday actions.

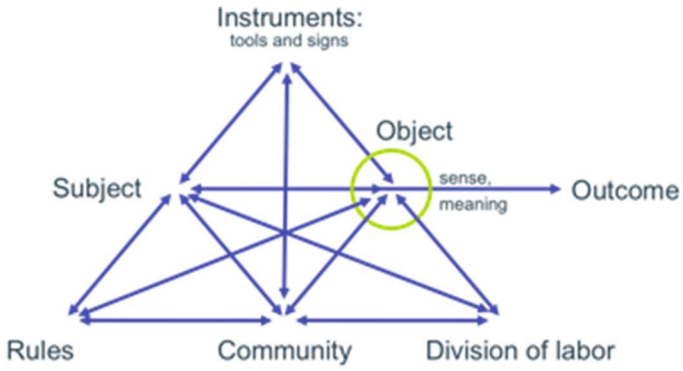
This new definition of ZPD can be interpreted as a key concept, which allows the participants in an Activity System to solve the contradictions and evolve to the activities to a more advanced form. However, in order to evolve the activities it is

necessary to perform an expansive learning. The main characteristics of expansive learning and its steps are detailed in the next section.

3.4 EXPANSIVE LEARNING

According to Engeström (1987), expansive learning is a type of learning in which participants, through collective zones of proximal development, provoke transformations and development in their activity systems. The expansive learning occurs when the isolated individual interacts with his community, to solve contradictions that permeate the activity and, based on sense, create a new motive or object for the collective activity, with a new principle of operation or organisation (Engeström & Sannino, 2010). As state by Engeström & Sannino (2010, p.2) “In expansive learning, learners learn something that is not yet there. In other words, the learners construct a new object and concept for their collective activity, and implement this new object and concept in practice.” Figure 21 illustrates this situation proposed Engeström & Sannino (2010).

Figure 21 – The sense meaning of the activity object



Source: Engeström (1987).

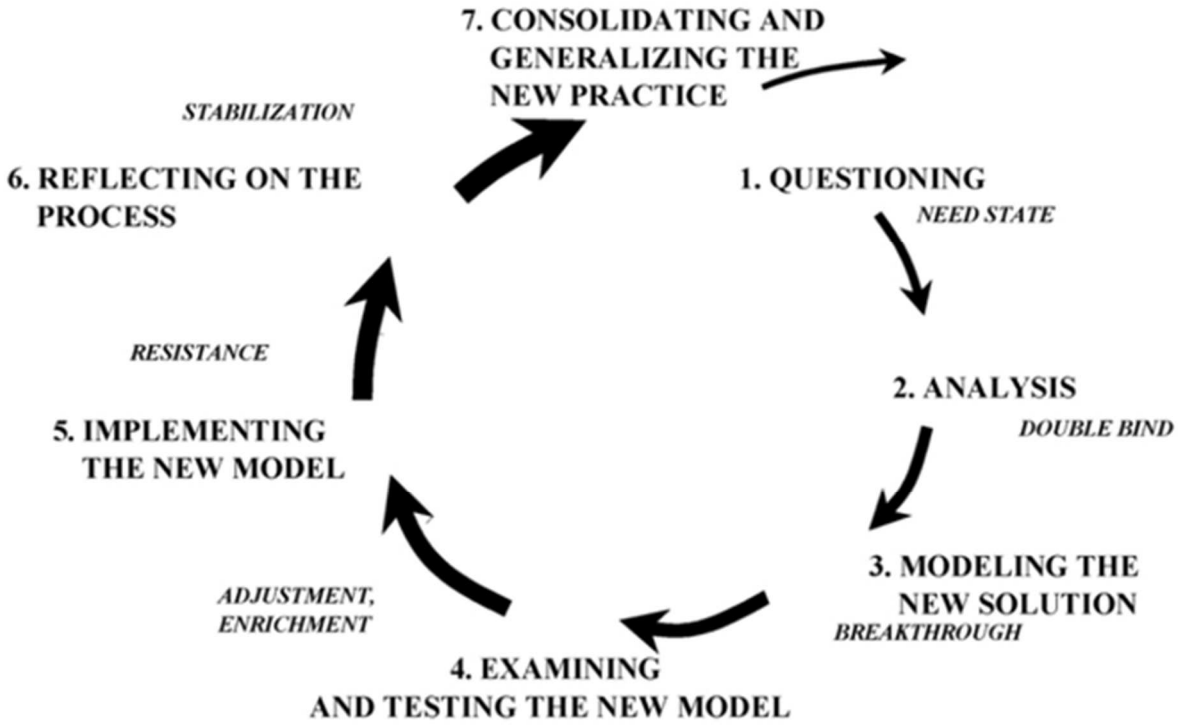
According to Engeström & Sannino (2010, p.6),

> The circle around the object in Figure 21 indicates at the same time the focal role and inherent ambiguity of the object of activity. The object is an invitation to interpretation, personal sense making and societal transformation. One needs to distinguish between the generalized object of the historically evolving activity system and the specific object as it appears to a particular subject, at a given moment, in a given action. The generalized object is connected to societal meaning; the specific object is connected to personal sense.

Expansive learning promotes the evolution of the activity in a new pattern or structure, and this involves the collective interaction between participants through the ZPD (Engeström, 1996a). According to Engeström (1987), expansive learning occurs in a learning cycle composed of learning actions. In each action, a different kind of contradiction drives development, thus enabling the evolution of the stable activity system to a more advanced one (Engeström, 1987). Figure 22 illustrates the sequence of learning actions in an expansive learning cycle. The typical sequence of these learning actions is described as follows (Engeström, Rantavuori, & Kerosuo, 2013; Engeström & Sannino, 2010):

1. The first action is questioning, criticizing or rejecting some aspects of the accepted practice and existing wisdom. For the sake of simplicity, this action is named questioning.
2. The second action is analysing the situation. Analysis involves mental, discursive or practical transformation of the situation in order to find out causes or explanatory mechanisms. Analysis evokes “why?” questions and explanatory principles. One type of analysis is historical-genetic; it seeks to explain the situation by tracing its origins and evolution. Another type of analysis is actual-empirical; it seeks to explain the situation by constructing a picture of its inner systemic relations.
3. The third action is modelling the newly found explanatory relationship in some publicly observable and transmittable medium. This means constructing an explicit, simplified model of the new idea that explains and offers a solution to the problematic situation.
4. The fourth action is examining the model, running, operating and experimenting on it in order to fully grasp its dynamics, potentials and limitations.
5. The fifth action is implementing the model by means of practical applications, enrichments, and conceptual extensions.
6. The sixth action is reflecting on and evaluating the process.
7. The seventh action is consolidating and generalizing the outcomes into a new stable form of practice.

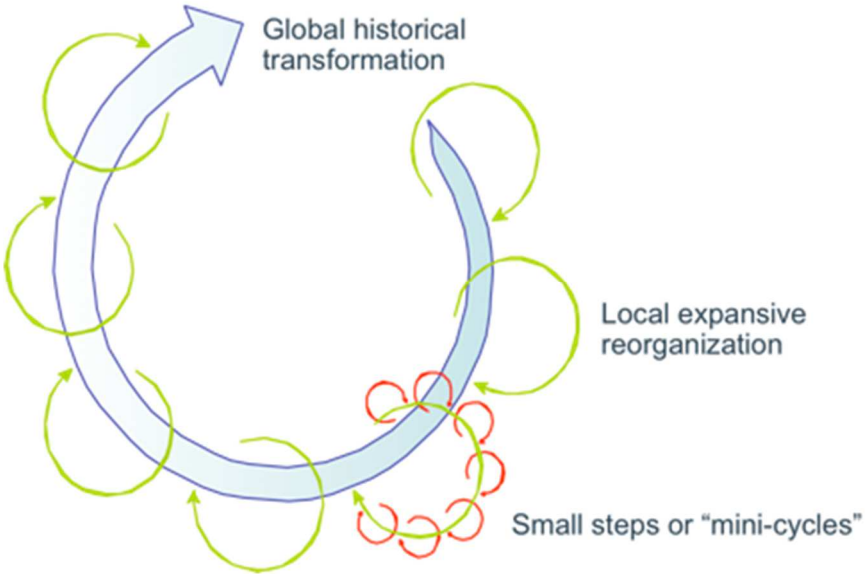
Figure 22 – Sequence of learning actions in an expansive learning cycle



Source: Engeström (2010).

The expansive learning cycle presented in Figure 22 refers to the large-scale cycle (Engeström et al., 2013). However, one large-scale cycle involves numerous smaller cycles of learning actions (Engeström, 2010). “A smaller cycle may take place within a few days or even hours of intensive collaborative analysis and problem-solving” (Engeström, 2010, p.82). As the large cycle of expansive learning is composed of smaller cycles of learning, then, whether the smaller cycles are isolated events, the large-scale cycle can remain stagnant (Engeström et al., 1999). Besides, as affirmed by Engeström et al. (1999) the completion of a large-scale cycle of expansive learning is not so common since a great effort, devotion and commitment of the participants are required. Figure 23 illustrates the occurrence of the large and small cycles of expansive learning.

Figure 23 – Large and small cycles of expansive learning



Source: Engeström (1996b).

The third generation of AT and Expansive Learning have been used in researches that involve learning, knowledge creation and knowledge sharing in organisational settings, especially those related to education, health, and communication (Engeström, 2005). Based on AT and Expansive Learning, it is possible, for those involved in the activity system, to discuss and identify solutions, as well as new and better ways of working. By solving the problems and evolving the way of working, knowledge is shared and created and problems are mitigated.

For this reason, this research intends to use these concepts to analyse how knowledge creation and knowledge sharing occur in the mobile workers' context, especially in problem-solving situations. Moreover, the study also aims to contribute to the expansion of these approaches to the area of Information Systems (IS), more specifically, on the use of mobile ICT in the context of mobile workers. The following section presents the conceptual model elaborated based on this purpose.

3.5 THE CONCEPTUAL MODEL OF RESEARCH

Before presenting and discussing the conceptual model it is important to reinforce the key concepts used in this research. Figure 24 highlights them.

Figure 24 – Key research concepts

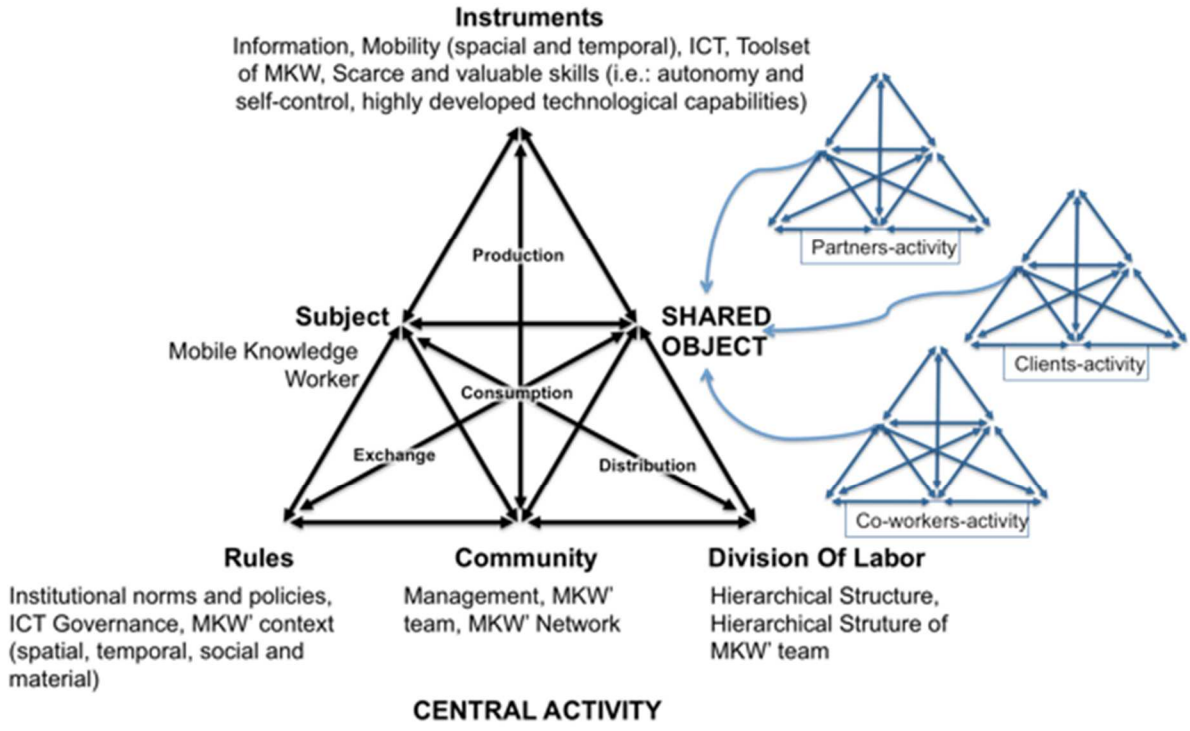
Concept	Definition

Mobile knowledge worker	Professionals who frequently work on the move (at least 20% of their work time), far from their fixed organisation, often performing knowledge-intensive activities (Sørensen, 2011; Vartiainen, 2008)
Knowledge creation	Creation of something that was not there. In the individual dimension, the creation of new ideas, beliefs (Engeström, 1987) or skills (Lundin & Magnusson, 2003). In the organisational dimension, the creation of new contents, new rules or new ways of working (Engeström, 1987).
Knowledge sharing	The knowledge assets (existing knowledge) are shared with others through learning actions (learning in doing) and participation of individuals of the Activity Systems in collaborative/problem-solving situations (Engeström, 1987)
ZPD (Zone of Proximal Development)	Process that involves individuals who are learning, individuals who are teaching and the relationship between them (Engeström, 1987)
Expansive learning	Participants, through collectives' zones of proximal development, provoke transformations and development in their activities. This result in knowledge creation and sharing both in the individual and in the organisational dimensions (Engeström, 1987)
Collaborative problem-solving	The isolated individual interacts with his community either to get help or to collaborate in problem-solving situations (Engeström, 1987)

Source: The author.

The unit of analysis of this research is the MKW (Mobile Knowledge Worker). Based on AT, each MKW can be understood as one activity system since they perform their central activities independently. As mentioned by many authors, these professionals have high levels of autonomy (Koroma et al., 2014; Mazmanian et al., 2013), flexibility (Chen, 2015; Pauleen et al., 2015), freedom to work at convenient times (Dal Fiore et al., 2014; Kietzmann et al., 2013) and personal empowerment (Cavazotte et al., 2014; Kietzmann et al., 2013). However, considering that the main reason to work on the move for the MKW is to meet people: co-workers, partners and clients (Vartiainen, 2008), the activity system of the MKW interacts with others activities systems, the central activities of the people who they have work relations. This scenario can be represented via the framework of the AT proposed in the third generation by Engeström (1987). Figure 25 illustrates an activity system based on the context of the MKW.

Figure 25 – An activity system in the context of mobile knowledge workers



Source: The author.

As illustrated in Figure 25 and observed in the literature review, knowledge work often requires collaboration due to the complexity to individuals to perform it alone (Schultze, 2000; Vartiainen et al., 2007). Because the work activities of MKWs tend to be more complex (Karanasios & Allen, 2014; Kietzmann et al., 2013), to perform them a considerable amount of information is demanded. This also is due to the fact that the MKW is part of several different work relations (with, for example, co-workers, clients and partners).

On the other hand, they are more independent, self-organised and devoted to their work performance (Dal Fiore et al., 2014; Harmer & Pauleen, 2012; Mazmanian et al., 2013). Therefore, they often tend to search for knowledge and information to better carry out their work using, first, their own instruments and second (if necessary) they access their community asking for help. Considering this, the first proposition of this research emerges, which is:

Proposition 1. The need for knowledge and information in the Mobile Knowledge Workers' context steers the adoption of new instruments based on collaborative practices with their community.

In addition, since MKWs have a high degree of mobility, and this characteristic reduces the opportunity for formal training (Koroma et al., 2014), they tend to engage in collaborative practices to learn from others (Kietzmann et al., 2013; Lundin & Magnusson, 2003).

> In a shared problem-solving process, agents who have partial but different information about the problem in question appear to improve their understanding collectively through social interaction. Accordingly, new ideas and innovations emerge between rather than within people (Paavola & Hakkarainen, 2005, p.564).

Another interesting characteristic that contributes to this engagement with their community is related to the pressure the MKWs tend to feel to prove their commitments in help others (Cavazotte et al., 2014; Pauleen et al., 2015). To prove their loyalty, they tend to engage in collaboration with others (Pauleen et al., 2015). This characteristic brings the idea of the ZPD and Expansive Learning concepts (Engeström, 1987), that allows participants learn with each other in problem-solving situations. Moreover, considering they rarely have repetitive work tasks (Yuan & Zheng, 2009), they tend to be involved in either new situations or disturbances and contradictions in their work activities (see Figure 8 – Challenges in the mobile workers context). So, the interaction with their community in problem-solving situations becomes much more important. Hence, the second proposition arises,

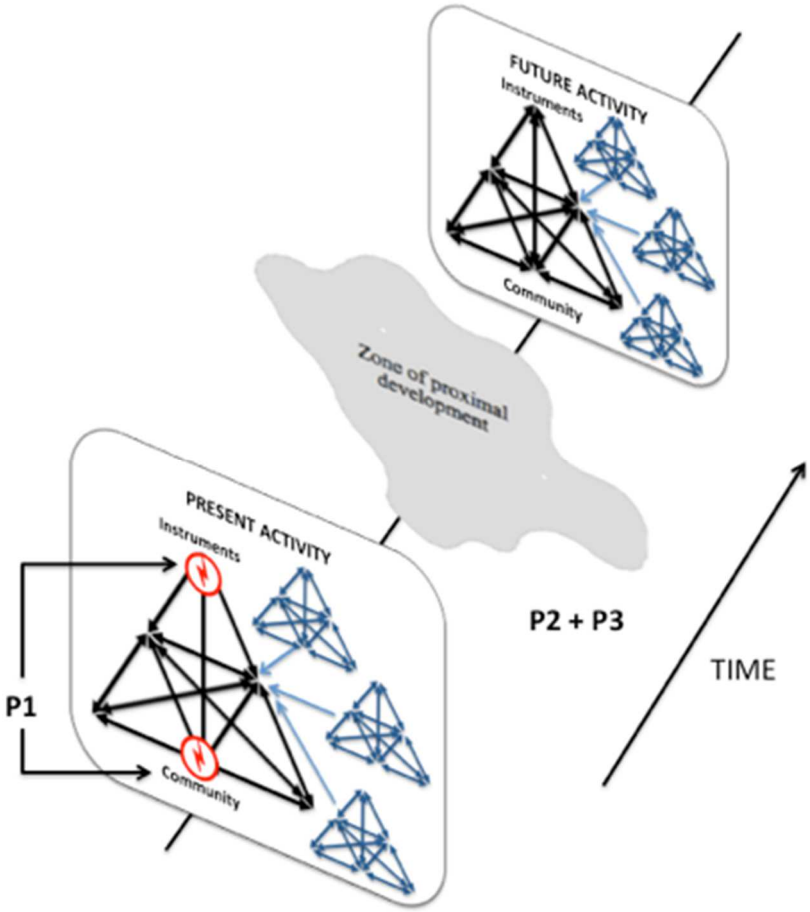
Proposition 2. The adoption of collaborative practices for problem-solving in the Mobile Knowledge Workers' context is made through learning actions and keeps them engaged in knowledge creation and sharing.

Furthermore, because MKWs make frequently use of mobile ICT (Mazmanian et al., 2013) to have easy access to people and information (Koroma et al., 2014), it is common that the interactions with their community are made via these technologies. One advantage of this is to have access to information and contact people anytime, anywhere (Koroma et al., 2014), one of the disadvantages is the need of a great variety of abilities and resources to accomplish all their commitments (Mazmanian et al., 2013; Pauleen et al., 2015). Thus, considering that these professionals tend to work in virtual workspaces, the third and last research proposition emerges:

Proposition 3. The collaborative problem-solving in the Mobile Knowledge Workers' context is mainly mediated by mobile ICT.

Figure 26 illustrates the conceptual model and the research propositions. The present activity illustrated in Figure 26 represents the actual activity of the MKWs that has contradictions related to his instruments and his community (P1). To solve these contradictions, the MKWs need to participate in collaborative problem-solving with their community (P2) via mobile ICT (P3). Then, in the individual dimension, these workers create new concepts and knowledge and, in the organisational dimension, new ways of work can emerge. Therefore, a new form of activity is created, the future activity system of these workers results from new or changed elements.

Figure 26 – Conceptual model



Source: The author

To carry out the research and evaluate these propositions, the method chosen was the Design Science Research (DSR). More details about the research method and the procedures adopted are presented in the next chapter.

4 RESEARCH METHOD

The current research is classified as exploratory, and its empirical study was carried out using the Design Science Research (DSR) method. Considering the challenge to study the mobile workers in a situated way and the exploratory characteristics of this research, DSR proved to be the best method to reach the research goals. According to Gregor & Hevner (2013, p.337) “DSR involves the construction of a wide range of sociotechnical artefacts such as decision support systems, modelling tools, governance strategies, methods for IS evaluation, and IS change interventions”. These authors mention that DSR is based on design theory which “gives prescriptions for design and action: it says how to do something” (Gregor & Hevner, 2013, p.339). In this sense, the descriptive knowledge can be tested and refined during the creation of a design theory.

Gregor & Hevner (2013) also state that the DSR method permits to solve research problems in more effective or efficient ways. The DSR tends to make real and practical contributions, thus, this study seeks to analyse how knowledge creation and knowledge sharing are carried out in collaborative problem-solving situations in the mobile workers’ context and, at the same time, to contribute to the improvement of these processes. Therefore, the research was conducted with individuals and also teams of mobile workers, such as IT Professionals, IT and Business consultants and professors and tutors of distance learning, all of them characterized as mobile knowledge workers. As a result of this research method, an artifact was developed, an approach to stimulate the expansive learning in the mobile workers’ context. This artefact is composed of two items: (1) a method to stimulate expansive learning in the mobile worker’ context and (2) a mobile app to support this method. The details of the artefact and its components are presented in the next chapter.

This DSR followed the steps proposed by Peffers et al. (2007) and Gregor & Hevner (2013): (1) identify the problem; (2) define the solution objectives; (3) design and development of the artifact; (4) demonstration; (5) evaluation; and (6) communication. Figure 27 presents the description of each step.

Figure 27 – Steps of the DSR method

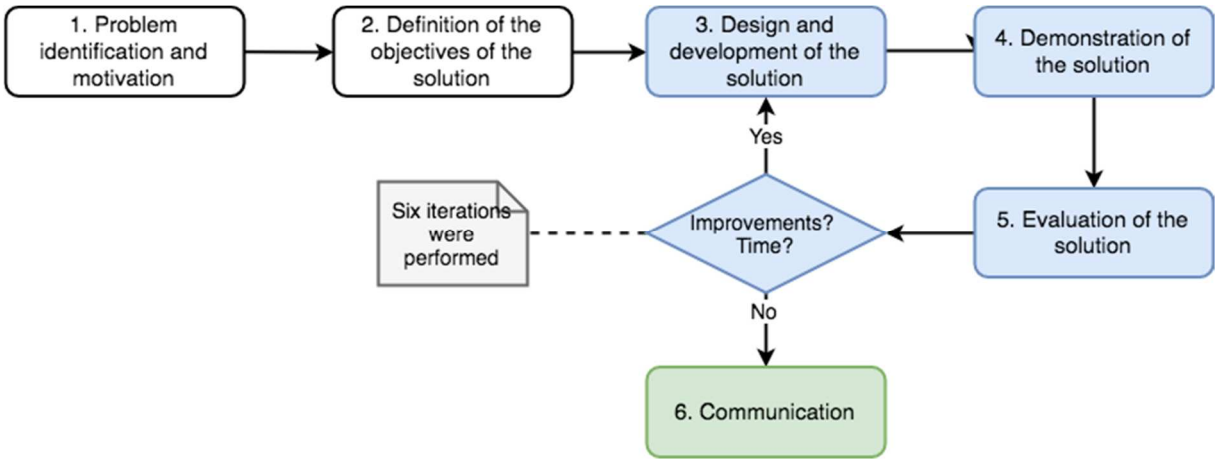
Activity	Description
Activity 1. Problem identification and motivation	Define the specific research problem and justify the value of a solution.
Activity 2. Define the objectives for a solution	Infer the objectives of a solution from the problem definition and knowledge of what is possible and feasible.
Activity 3. Design and development	Create the artifact. Such artifacts are potentially constructs, models, methods, or instantiations (each defined broadly) or new properties of technical, social, and/or informational resources. A design research artifact can be any designed object in which a research contribution is embedded in the design.
Activity 4. Demonstration	Demonstrate the use of the artifact to solve one or more instances of the problem. This could involve its use in experimentation, simulation, case study, proof, or other appropriate activity. Resources required for the demonstration include effective knowledge of how to use the artifact to solve the problem.
Activity 5. Evaluation	Observe and measure how well the artifact supports a solution to the problem. This activity involves comparing the objectives of a solution to actual observed results from use of the artifact in the demonstration. At the end of this activity the researchers can decide whether to iterate back to step three to try to improve the effectiveness of the artifact or to continue on to communication and leave further improvement to subsequent projects.
Activity 6. Communication	Communicate the problem and its importance, the artifact, its utility and novelty, the rigor of its design, and its effectiveness to researchers and other relevant audiences, such as practicing professionals, when appropriate.

Source: Elaborated based on Peffers et al. (2007).

Based on these six steps, presented in Figure 27, this DSR was carried out. First, the problem identification and motivation were completed. Then, in the second step, the objectives of the solution were defined. Afterwards, in the third step, the approach to stimulate the expansive learning in the mobile workers' context was designed and developed based on the findings of the previous steps. Following that, the demonstration and evaluation of the approach were performed, in the fourth and fifth

steps respectively. It is important to highlight that the DSR allows iterating back to steps to try to improve the effectiveness of the solution (Peffers et al., 2007). In this research six iterations were made, considering the following criteria: (a) any improvements was identified for the solution? (b) Is there enough time to design and develop the improvements? Finally, the six and last step was performed, the communication of the results of this research. Figure 28 illustrates the six steps, detailed in the subsequent sections.

Figure 28 – Activities of this DSR



Source: The author.

4.1 PROBLEM IDENTIFICATION AND MOTIVATION

The problem identification and motivation phase was performed based on four research activities: (1) a participant observation during January 2013 until January 2015, (2) a systematic literature review, (3) a bibliometric study, and (4) semi-structured interviews with practitioners.

The main activity used to identify the problem was the participant observation. Based on this method it was possible to observe mobile knowledge workers of an IT Company. The others three activities were used to validate the problem identification both in practice and in the literature. The participant observation was an important step because, as mentioned by Schultze (2000), to study knowledge workers it is necessary to focus on what these professionals do (their work practices), rather than what they say they do. The participant observer gathers data by participating in the daily life of

those people he/she studies, understanding the issues from their perspective (Becker, 1958; Spradley, 2016).

The participant observation was carried out in an IT Company established in the South of Brazil. To preserve the anonymity of the company, the name ITCom is used to identify it. This organization has more than 20 years, and it is one of the main Brazilian IT groups in IT services outsourcing and consulting. During the period of the participant observation, the ITCom had branches in four Brazilian states, attending a variety of industries, such as metal mechanic companies and agribusinesses, in Brazil as in other countries, such as the United States.

This author already worked at ITCom since 2010, first as a Systems Analyst and after, in 2011, as a Systems Analyst Leader of one of its Outsourcing operations. In September of 2012, the vice president of the ITCom invited the researcher to participate in a research and development initiative called PTD (Program of Technological Development). The entrance of the researcher in the PhD program was one of the requirements of this initiative because she supposed to carry out research activities in the company. Thus, in January 2013, this researcher started a new position in the ITCom, and the research project she worked had as primary objective to create a virtual place to improve the communication and keep the organisational knowledge in a single repository. To achieve this goal, a tool was developed, based on Web 2.0 and SharePoint technology, and the premise of it was to stimulate and allow collaboration between employees.

Although the project and tool were developed for all the company, the main attention was focused on the managers, because the company wanted to standardise better practices of management and consequently, improve the services provided for their customers. For this reason, many interactions with these managers were made to identify their main characteristics and their ways of working. Mapping their processes and their responsibilities gave the researcher the chance to ask questions about their work practices and issues faced. Three groups of these managers were identified as mobile knowledge workers – IT Operation Managers, IT Services Managers and IT Relationship Managers. Figure 29 presents the main responsibilities of each one of these managers.

Figure 29 – Managers' responsibilities

Role	Responsibilities
IT Relationship Manager	Sales, Customer relations and prospects, Account management. He/She is responsible for the result (Billing and Margin) of the Client and the Portfolio. Emits, control and charge customer invoices.
IT Services Manager	Perform technical pre-sales by maintaining the established service standards and seeks solutions that help to create competitiveness. He/She delivers, via the IT Project/Operation Manager, the service contracts within the scope, term, quality and contracted margin, guaranteeing the charge of services provided to the client. Responsible for the management, selection and training of IT Project/Operation Manager. Must ensure the standardised delivery of services according to the defined standards. Has the IT Relationship Manager as his internal client to whom he/she responds by the outcome of the contracts and with whom he/she must define the strategies for the clients.
IT Project/Operation Manager	Delivery of the Service Contracts within the scope, term, quality and contracted margin, guaranteeing the charge of the services provided to the client. The acceptance of the service by the customer is his/her responsibility and also the management, selection and training of operation/project people. He/She is subordinate to an IT Services Manager and has the IT Relationship Manager as his/her internal customer.

Source: The author.

The interaction made with these managers was used as motivation and identification of the research problem of this study. The script used to collect and organise data is presented in Figure 30. Table 1 shows the distribution of the participants observed during the participant observation.

Figure 30 – Script for the participant observation data gathering

For each manager, the following questions were asked to know their practices:

- What activities do you perform?
- What is needed to start the activity (inputs)?
- What is needed to end the activity (outputs/evidence)?
- When does the activity need to be performed (deadline)?
- Who provides the inputs (provider)?
- Who receives the outputs (customer)?
- What are the related activities (predecessors)?
- What are the main resources to perform the activity?

Source: The author.

Table 1 - Distribution of the 39 participants observed

Role	IT Relationship Manager	14
	IT Service Manager	11
	IT Operation/Project Manager	14
Gender	Male	33

	Female	6
Type of Mobility	Alternating between two fixed locations	14
	Working at three or more places and constantly moving	25

Source: The author.

Participant observation requires the researcher to spend considerable time in the field, adopting various roles in order to gain more understanding of the people and the context studied (Baker, 2006; Becker, 1958). As already mentioned, the observation was made between January 2013 and January 2015. During 2013 the researcher performed a moderate participation that, according to Spradley (2016) has the role of maintaining a balance between participation and observation. During 2014 a role of active participation with the IT Relationship Managers and the IT Services Managers was performed, because the researcher was more involved with their central activities (Spradley, 2016). In the same year of 2014, the role of complete participation with the IT Operation/Project Managers group was performed since the researcher became a member of this group (Spradley, 2016) assuming an IT Operation/Project Manager position. The main objective of this was to experiment the methodology and tool created to help new managers and understand in practice (empathize) what problems can be occurred during the daily tasks.

The observations were made face to face and also inside the virtual community (Nørskov & Rask, 2011), because many of the interactions were in a virtual form, such as instant messages and virtual meetings. This characteristic allowed recording the data for future analysis, and the triangulation with the written field notes made by the researcher, since the social interaction was done by written (Angrosino & Pérez, 2001). The participant observation during January of 2013 and January of 2015 allowed gathering more than 1GB of digital files and records. As observed by Becker (1958) this method produces an immense amount of data, and the researcher needs to handle the problem of how to analyze it systematically.

For the qualitative analysis, 301 files were considered: 108 fieldnotes, 75 emails and 118 instant messages conversations. Besides the online social interaction data, it was also collected a variety of documents such as power point presentations, minutes of meetings, reports and others. To organize these files and its analysis, it was used the NVivo software. The systematic data analysis began after the researcher had left the company in January 2015. However, nine participants of this observation were

interviewed later, between November 2015 and March 2016. Also, because of the strong relationship constructed during the participant observation with some of these workers, the current researcher still maintain contact with them via social media (LinkedIn and Facebook).

As already mentioned, also to understand the research problem identified in the participant observation the following techniques were used: (a) a systematic literature review, (b) a bibliometric study, and (c) semi-structured interviews with practitioners. The details and procedures used in the systematic literature review are presented in APPENDIX A – SYSTEMATIC LITERATURE REVIEW and the details of procedures utilised in the bibliometric study is shown in APPENDIX B – BIBLIOMETRIC STUDY. The findings from the literature were used to define the guideline for the semi-structured interviews with the mobile knowledge workers. The script used is available in APPENDIX C – INTERVIEW QUESTIONS: UNDERSTANDING THE PROBLEM. Thirty-one MKWs were interviewed; nine of them already had taken part in the participant observation. Table 2 shows the distribution of the interviewees. The complete demographic information about them is available in APPENDIX D – PARTICIPANTS IN THE INTERVIEW: UNDERSTANDING THE PROBLEM.

Table 2 - Distribution of the 31 participants interviewed

Position	IT Relationship Manager	4
	IT Project/Services/Systems Manager	6
	Business Consultant	8
	Account executive	5
	CMO – Chief Marketing Officer	1
	Lecturer	5
	Lawyer	2
Gender	Male	25
	Female	6
Age	20-30	7
	30-40	19
	40-50	3
	Over 50	2
Type of Mobility	Alternating between two fixed locations	14
	Working at three or more places and constantly moving	17
Type of Interview	Face to face (coffee shop, company site, home)	3
	Online (Skype, Google Hangouts, WhatsApp, Appear.in, WebEx)	28

Source: The author.

Participants were identified through the researcher's contacts in the local IT community, online searches in the LinkedIn website, personal recommendations of interviewees, and also recommendations from the author's social network. The interviews were either conducted remotely or in-person, at a location chose by the participants. The interviews lasted between 30 minutes to 1 hour and 40 minutes, and all of them were recorded. Interviewees expressed a preference for undertaking the interviews using video conference, audio conference and instant messages applications such as Skype, WhatsApp, Google Hangouts, Appear.in and WebEx, because it was difficult to perform the interviews face-to-face, due to the mobile nature of their work. Interviewees also relied heavily on these tools in their day-to-day operations. The use of these tools has the advantage of being less obtrusive in the work of respondents (Cavana, Sekaran & Delahaye, 2001).

The analysis of the interviews examined how the mobile workers performed their activities and also which factors affected knowledge creation and knowledge sharing in their context, especially for problem-solving situations. The analysis was performed as follows. First, the activity system was used as a framework to determine the artifacts – the object-tools – involved in the context of mobile workers. Second, in order to identify the challenges, an examination was made focusing on disturbances and tensions in the context of mobile workers.

As a result of these steps the current research objectives was achieved: (a) to identify the main characteristics and challenges of mobile knowledge work context, (b) to identify what factors are involved in the processes of knowledge creation and sharing in the context of mobile workers and (c) to analyse the way by which mobile workers create and share knowledge, especially during problem-solving situations. The next section presents how the definition of the objectives of the solution developed in this DSR was carried out.

4.2 DEFINITION OF THE OBJECTIVES OF THE ARTIFACT

To define the objectives for the artifact to be designed according to the DSR method, the data from the literature and practice was analysed. The systematic literature review disclosed a lack of studies considering the intersection of knowledge

creation, knowledge sharing and mobile workers. Only two were found (Kietzmann et al., 2013; Lundin & Magnusson, 2003) that addressed, respectively, knowledge sharing and mobile workers and collaborative learning in mobile work.

Due to the characteristics of the work of MKWs (as identified in the first step of DSR) they have unique needs, formal training and a knowledge-based system are not enough to support their knowledge creation and sharing. Furthermore, the urgency to solve problems, to achieve their activity's goals, anytime and anywhere, made them to adopt virtual communities, like WhatsApp and Facebook groups, as an attempt to strengthen the work relations, create and share knowledge. Thus, based on these results, the requirements of the artifact were derived.

The artifact was composed of two elements: (1) a method and (2) a mobile app. They were developed to achieve the research specific objective: to propose an approach to stimulate collaborative problem-solving through knowledge creation and sharing in the mobile knowledge workers' context. Therefore, to accomplish this specific objective, the artifact needed to: (a) stimulate collaborative problem-solving in the mobile workers' context through the promotion of knowledge creation and knowledge sharing and (b) allows the online observation of the mobile worker's context and their knowledge creation and knowledge sharing practices.

To identify these requirements and the basic idea of the artifact, informal conversations were also made with experts and practitioners. The experts consulted were the researcher's contacts in the CRADLE Research Group (see APPENDIX N – FINAL REPORT OF STUDIES IN CRADLE). According to one of them, even the researchers could use an artifact like this to conduct the original Change Laboratory Method (field note from the informal conversation with an expert from CRADLE Research Group – see the email interaction occurred before this conversation in APPENDIX J – CROSS-CHECK WITH EXPERTS: EVALUATION). More details about the Change Laboratory Method are presented in the section 5.2 ARTIFACT DEVELOPMENT.

In an informal conversation with practitioners from the researcher's personal network, also the idea of using the artifact for other kinds of workers appeared, for instance, distributed teams who are not mobile workers but work physically in other locations. Based on this feedback the design and development of the solution started. More details about the artifact developed are presented in the section 5.2 ARTIFACT

DEVELOPMENT. The procedures to conduct the development step are presented in the next section.

4.3 DESIGN AND DEVELOPMENT OF THE ARTIFACT

The ideas identified in the previous steps were used to define the requirements of the design and helped in the development of the artifact. In this step, the following specific research objective was considered: to analyse how mobile technologies are used to support collaborative problem-solving in the mobile work context. Thus, a mobile app was designed and developed with the aim to stimulate collaborative problem-solving through knowledge creation and sharing in the mobile knowledge workers' context. The method on how to use the app was inspired by the Change Laboratory Method (Engeström et al., 1996; Virkkunen & Newnham, 2013), Experience Sampling Method (Larson & Csikszentmihalyi, 2014) and Self-Report Method (Muukkonen et al., 2014; Palomäki et al., 2014).

Based on the best practices of Software Engineering and Agile Development, the mobile app was designed and developed. First, the requirements were elicited, and the ontology of the application was defined. Second, the technologies, architecture and infrastructure for the tool were established. Finally, the mobile app was prototyped and after developed. Many tools were used in this step to support the design and the development. The primary tools were: (a) to model the method and the tool: Pencil[1] and Astah Professional[2], (b) to define the ontology: Protégé[3] and (3) to prototype the tool: Ionic Framework[4]. The mobile app was developed for both iOS and Android platforms. More details about the method and the mobile app developed are presented in the section 5.2 ARTIFACT DEVELOPMENT.

The design and the development of the solution started in December 2015 and finished in November 2016. The first deployment of the mobile app in Apple Store and in the Google Play Store was in 29th of August of 2016[5]. The last update of the solution

[1] Pencil is a free prototyping tool that allows to create mockups: http://pencil.evolus.vn/
[2] Astah is a modelling tool that allows defining the systems architecture: http://astah.net/editions/professional
[3] Protégé is a free ontology editor and framework for building intelligent systems: http://protege.stanford.edu/
[4] Ionic Framework is an open source framework for building mobile apps: https://ionicframework.com/
[5] Mobile app publication in Apple Store: https://itunes.apple.com/br/app/mobchangelab/id1122683613?l=en&mt=8 and Play Store: https://play.google.com/store/apps/details?id=com.ionicframework.mobchangelab176579&hl=pt_BR

was deployed in in 8th of November of 2016. To have a first assessment of the artifact developed before testing, informal conversations were made with experts and practitioners.

Besides the informal conversations, a presentation of the solution was made to the UBI (Ubiquitous) Business Research Group at UNISINOS in 19th of May 2016. The presentation had the duration of 1 hour and 30 minutes: 30 minutes for presentation and 1 hour for discussion about the method and the app. Six participants attended the presentation: the professor and researcher coordinator of the group, one PhD who is also a Commercial Director in an IT Company, and four PhD students who also have IS experience. The feedback provided by the group was very useful both to validate the idea and to improve it.

Some issues occurred during the development of the mobile app. First, two undergraduate students demonstrated interest in helping in the development, but only one effectively could help and in a restricted manner, time and technical skills were impediments for him. Therefore, this author needed to learn the technologies and develop 80% of the app. The others 20% were produced with the help of the student as a part of his research work in the undergraduate degree program with the supervision of the researcher. This 20% refers to the development of the feature to adapt the Experience Sampling Method in the tool. More details about the method and mobile app are presented in section 5.2 ARTIFACT DEVELOPMENT. Next section presents how the demonstration of the solution developed was made.

4.4 DEMONSTRATION OF THE SOLUTION

The demonstration of the solution was performed using four procedures: (1) online observation from two experimentations of the app with mobile knowledge workers, (2) deployment of the website of the project (see APPENDIX F – PROJECT WEBSITE: DEMONSTRATION) and advertising of the mobile app via informal conversations, email communications and social media messages, (3) posts in social medias such as LinkedIn and Facebook, and (4) demonstration of the artefact to experts and practitioners (see APPENDIX H – MEETING SCRIPT: DEMONSTRATION).

Many MKWs were invited to try the mobile app. The invitations were made via informal conversations, meetings, emails, WhatsApp messages, and posts in social

media. As a result of the invitations, 37 MKWs requested access to the mobile app. However, only 21 used the app with a work group, which was a need according to the method of use (based on Activity Theory). The other 16 people had an initial interest, requested the access to the mobile app, accessed the app and reported data, but have not used it as intended (with a community). Table 3 presents the distribution of participants who had access to the mobile app.

Table 3 - Distribution of participants 37 people registered in the app

Role	IT and Business Consultant	8
	IT Professional	19
	Lecturer	10
Gender	Male	25
	Female	12
Type of Mobility	Alternating between two fixed locations	22
	Working at three or more places and constantly moving	15

Source: The author.

Based on two segments: education and business, the 21 participants, divided into four groups (cases), took part in the first trial of the solution between September 2016 and December 2016. During the trial, online observation was used. According to Nørskov & Rask (2011) online observation can be defined as a "textual exchange that can have both a synchronous (i.e. simultaneous such as chat) and a asynchronous nature (i.e. non-simultaneous such as email)". These authors also mention that online observation can take place within mailing list, chat, wikis, blogs and other interactive social media platforms. In the case of this research, the solution developed is a type of mobile social media platform, and its use by the practitioners permitted to perform the online observation. Table 4 presents the cases summary. Case A and case B are from the same organisation, an University established in São Leopoldo, RS, Brazil; case C is from another organisation, a technology company specialized in the development of business solutions established in Joinville, SC, Brazil; finally case D is composed of a network of IT Professionals who do not work in the same company but have a close and active relationship.

Table 4 - Distribution of the cases in the first trial of the artifact

Education segment – the two cases are from the same organisation (University)	Case A, named as EDU_A, was a team of four lecturers and one course coordinator. The team's activity was to coordinate and to help and support students in learning Java Programming in an e-learning undergraduate degree program. The participants are from the University established in São Leopoldo, RS, Brazil.	5
	Case B, named as EDU_B, was a team of two lecturers. The team's activity was to coordinate and to help and support students in the learning of Costs and Budget for Decision Making in an e-learning undergraduate degree program. The participants are from the University established in São Leopoldo, RS, Brazil.	2
Business segment	Case C, named as ITCON, was a team of four IT and Business Consultants from an IT company established in Joinville, SC, Brazil. The team's activity involves "thinking clients' processes" and support clients' processes needs. They need to understand the processes from their clients considering their business objectives and identifying process improvements.	4
	Case D, named as ITPRO, was a team of IT Professionals. Each professional works in different companies, but they have similar attributions. They support their client's processes needs. They are also part of a strong network of contacts. The primary objective of this group was to use the app to share common issues and to collaborate in their solution and consequently in their learning expansion.	10
TOTAL OF PARTICIPANTS		**21**

Source: The author.

In this first trial the researcher played the following roles as an observer, based on the observation roles presented in Baker (2006): (a) nonparticipation: in cases B, C e D the researcher only observed the use of the solution based on the records inside the tool, thus, without involvement with participants; (b) complete participation: the researcher act as a full group member in case A.

The second trial of the artifact was carried out through the application of the *experience sampling method* developed in the mobile app. This application was inspired by the research of Muukkonen et al. (2014) that used this approach to collect contextualised data on professionals' daily working activities. Thus, this study adapted the methodology developed by these authors and applied it with 6 IT Professionals considered MKWs who work at three or more places. During 4 days of data collection, participants answered queries received via the mobile app three times a day, resulting

in 72 responses in the database. The methods and instruments developed enabled to trace aspects of the mobile workers' ways to collaborate with others via knowledge creation and knowledge sharing, as well as their activities and challenges. As already mentioned, this application was made with the help of one undergraduate student; the queries and script of the experience sampling were elaborated by the researcher and are available in APPENDIX E – SAMPLES OF THE EXPERIENCE SAMPLING.

In parallel with the two trials, other approaches were used to demonstrate the solution developed. First, the deployment of the project website helped in explain the research and to invite people to participate. The link and image of the site are available in APPENDIX F – PROJECT WEBSITE: DEMONSTRATION. Then, a variety of posts in social media were made to explain the objectives and benefits of the artifact. These posts were made on LinkedIn and Facebook, and all of them are available on the fan page created for the project[6]. Also, a series of meetings/presentations, emails and informal conversations about the artifact were made with experts and practitioners. The script used in the meetings is available in APPENDIX H – MEETING SCRIPT: DEMONSTRATION.

A total of 15 meetings/presentations were made: (a) 4 meetings with one CTO of an enterprise mobility company who had interest in the research project, (b) 2 presentations to entrepreneurship specialists and practitioners during the participation in an entrepreneurship competition[7], and (c) 9 meetings with professionals and managers of mobile workers in different types of organisation businesses (IT Services, Business, Education and Industry). Finally, in the entrepreneurship competition, one of the tasks was to carry out a test of the artifact inscribed. The aim of the test was to validate three hypotheses generated in the competition and this validation was made via one survey, which was available via Google Forms during twenty-four hours. The details of the test plan and the survey are available in APPENDIX I – TEST PLAN FOR THE ARTIFACT: DEMONSTRATION.

The data gathered in the two trials were analysed via qualitative text analysis based on the conceptual framework of Activity Theory and its key concepts and the Expansive Learning steps. The guideline used for the analysis of the Expansive

[6] Project fan page: https://www.facebook.com/mobChangeLab/

[7] This author inscribed the solution for an entrepreneurial competition called: Roser Award (http://www.tecnosinos.com.br/premio-roser/sobre/). The solution was accepted to participate in the competition that took place during three days between 13th and 15th of October of 2016.

Learning steps is available in APPENDIX L – EXPANSIVE LEARNING ANALYSIS: EVALUATION. Other data collected were analysed in a quantitative way via Minitab tool[8]: (1) logs and information registered in the mobile app; (2) statistics of the project website access (see APPENDIX G – PROJECT WEBSITE STATISTICS: DEMONSTRATION) and (3) logs and information registered from the posts in social medias and the survey carried out. All the data collected in this step helped to understand the validity of the artifact developed and also contributed to improving it. Next section describes how the evaluation step was carried out.

4.5 EVALUATION OF THE ARTIFACT

The advantage of carrying out 6 iterations during the study is that the solution could be evaluated and improved by experts and practitioners and a list of new ideas and insights was created for future improvements.

The final evaluation of the artifact was carried out between December 2016 and January 2017 and used the following procedures: (a) analysis of the empirical data collected in the demonstration activity, (b) 20 semi-structured interviews with MKWs participants of the first trial (see Table 4 - Distribution of the cases in the first trial and the script of the interview in APPENDIX K – INTERVIEW QUESTIONS: EVALUATION), (c) two focus groups with MKWs participants of the first trial – cases A and D (see Table 4 - Distribution of the cases in the first trial), and (d) informal conversation with practitioners and experts via emails, social media and WhatsApp conversations.

It was hard to perform this last evaluation considering that many participants were already involved in summer holiday. Consequently, the majority of the interviews (17 interviews) were made via phone call and lasted between 5 and 10 minutes. The two focus groups were made one in person, with participants of case A and the other via Skype, with the members of case D. Both were recorded and transcribed for analysis. The data from the interviews and focus group were analysed via qualitative text analysis based on the conceptual framework of Activity Theory and its key concepts, and the Expansive Learning steps. The guideline used for the analysis of the Expansive Learning steps is available in APPENDIX L – EXPANSIVE LEARNING

[8] Minitab is a statistical software: https://www.minitab.com/en-us/

ANALYSIS: EVALUATION. The other data collected, as already mentioned in the previous step, was analysed in a quantitative way: (1) logs and information registered in the mobile app; (2) statistics of the project website access (see APPENDIX G – PROJECT WEBSITE STATISTICS: DEMONSTRATION) and (3) logs and information registered from the posts in social medias. In parallel with the analysis of the results, the communication step was started. The details of this phase are presented in the next section.

4.6 COMMUNICATION

The last phase of this DSR was the communication activity. The goal of this activity is to communicate to researchers and professionals the problem studied and the artifact provided (Peffers et al., 2007) by this study. Therefore, this activity started with the writing of this thesis but will carry out future developments, presented as follows.

Thus, for the academic field, three levels of communication were already planned: (a) the writing and publication of this thesis, (b) the writing of a chapter book in collaboration with Professor Yrjö Engeström and Professor Annalisa Sannino from CRADLE Research Group (ongoing – see ANNEX A – CHAPTER PROPOSAL APPROVED), and (c) the writing of articles in collaboration with Professor Stan Karanasios from RMIT University (planned). Other articles and publications will be prepared according to the feedbacks to these first ones.

Finally, for the empirical field, two levels of communication were already planned: (a) the development of a landing page of the new product in development (ongoing) - the artifact developed in the DSR is becoming a commercial product (see APPENDIX M – PRODUCT VISION), and (b) the writing of articles in practitioners' outlets (planned). Figure 31 summarises the steps carried out in this DSR and the specific objectives achieved with them. Figure 32 presents the consolidation of all empirical data gathered during this research.

Figure 31 – Research method summary, according to the steps of DSR

Step of DSR	Activities performed	Research Specific Goals
Problem identification and motivation (January of 2013 until October of 2016)	• Real-world observations with 39 participants during January of 2013 and January of 2015 revealed the main characteristics of mobile workers in practice and the difficulty to create and share knowledge in the mobile workers' context • Literature review (see APPENDIX A – SYSTEMATIC LITERATURE REVIEW); • Bibliometric study (see APPENDIX B – BIBLIOMETRIC STUDY); • Semi-structured interviews with 31 practitioners (see APPENDIX C – INTERVIEW QUESTIONS: UNDERSTANDING THE PROBLEM); • Qualitative analysis based on Activity Theory using NVivo. **Total of Participants in this step: 61** • 39 participants observed • 31 participants interviewed (nine of them were also observed)	• To identify the main characteristics and challenges of the mobile work context • To identify what factors are involved in the processes of knowledge creation and sharing in the context of mobile workers
Definition of the objectives of the artifact (November of 2015 until June of 2016)	• Review of the literature at the intersection of knowledge creation, knowledge sharing and mobile workers • Qualitative analysis of the empirical data from the previous step in NVivo • Derivation of requirements from theory and practice • Cross-check with experts and practitioners	• To identify the main characteristics and challenges of the mobile work context • To identify what factors are involved in the processes of knowledge creation and sharing in the context of mobile workers
Design and development of the artifact (March of 2016 until November of 2016)	• Definition of the method to model the app • Definition of the ontology (knowledge representation) • Definition of the architecture and infrastructure for the app • Definitions of the technologies used to develop the app • Prototyping the app • Development and deployment of the tool • Cross-check of the prototype with experts and practitioners • Meeting with research group (1 meeting with UBI Research Group) **Total of Participants in this step: 6** • 6 participants in the meeting	• To analyse the way by which mobile workers create and share knowledge, especially during problem-solving situations • To analyse how mobile ICT are used by mobile workers in the processes of knowledge creation and sharing • To propose an approach to stimulate knowledge creation and sharing through collaborative problem-solving in the mobile knowledge workers' context
Demonstration of the artifact (July of 2016	**Method**: • Online observation from two trials with mobile workers: IT professionals, IT and business consultants and lecturers	• To identify what factors are involved in the processes of knowledge creation and sharing in the context of mobile workers

until January of 2017)	• Deployment of the project website (see APPENDIX F – PROJECT WEBSITE: DEMONSTRATION) • Posts in social medias such as LinkedIn and Facebook • Demonstration of the app to specialists and practitioners via: (1) meetings/presentations to experts in the mobility field and entrepreneurship and to practitioners (15 meetings see APPENDIX H – MEETING SCRIPT: DEMONSTRATION); (2) emails and informal conversation with practitioners and experts; (3) survey with practitioners (56 participants – see APPENDIX I – TEST PLAN FOR THE ARTIFACT: DEMONSTRATION) **The processual evaluation started in this phase**: • Qualitative analysis of the data recorded from the trials with mobile workers. The analysis was based on the Activity Theory framework and the Expansive Learning steps (see APPENDIX L – EXPANSIVE LEARNING ANALYSIS: EVALUATION) • Quantitative analysis of: (1) logs and information registered in the mobile app; (2) statistics of the project website access (see APPENDIX G – PROJECT WEBSITE STATISTICS: DEMONSTRATION) and (3) logs and information from posts in social medias and the survey applied **Total of Participants in this step: 105** • 37 participants registered in the app but only 21 used the app in the first trial. 4 of these participants were observed and interviewed. • 6 participants used the app in the second trial (the experience sampling) • 56 participants in the survey, 5 of them registered in the app • 3 participants in the meeting with the Enterprise Mobility experts, 1 of them registered in the app • 11 participants in the meetings with practitioners, 2 of them registered in the app	• To analyse the way by which mobile workers create and share knowledge, especially during problem-solving situations • To analyse how mobile ICT are used by mobile workers in the processes of knowledge creation and sharing • To propose an approach to stimulate knowledge creation and sharing through collaborative problem-solving in the mobile knowledge workers' context
Final evaluation of the artifact (December of 2016 until January of 2017)	**Method**: • Qualitative and quantitative analysis of the empirical data from the previous step • Semi-structured interviews with the 20 participants/testers - mobile workers - IT professionals, IT and Business consultants, lecturers (see APPENDIX K – INTERVIEW QUESTIONS: EVALUATION) • Focus group with 2 groups of participants (Business and Education) • Informal conversation with practitioners and specialists via emails, social media and WhatsApp	• To identify what factors are involved in the processes of knowledge creation and sharing in the context of mobile workers • To analyse the way by which mobile workers create and share knowledge, especially during problem-solving situations • To analyse how mobile ICT are used by mobile workers in the processes of knowledge creation and sharing

	Evaluation: • Qualitative analysis of the data interviews and focus group. The analysis was based on the Expansive Learning steps (see APPENDIX L – EXPANSIVE LEARNING ANALYSIS: EVALUATION) • Quantitative analysis of the: (1) logs and information registered in the mobile app; (2) statistics of the project website access (see APPENDIX G – PROJECT WEBSITE STATISTICS: DEMONSTRATION) and (3) logs and information registered from the posts in social medias **Total of Participants in this step: 20** • 20 participants interviewed	• To propose an approach to stimulate knowledge creation and sharing through collaborative problem-solving in the mobile knowledge workers' context
Communication (after January of 2017)	• **To communicate research results and generated knowledge**	• Academic and professional publications
TOTAL OF PARTICIPANTS IN THE DSR: 168[1]		

Source: The author.

[1] This total does not include the participants from the Entrepreneurship Competition and the informal conversations via email, WhatsApp and social medias

Figure 32 – Summary of data collected during the research

Types of data	Amount and contents of the data
Observations	• The participant observation during January of 2013 and January of 2015 allows gathered more than 1GB of digital files and records. For the qualitative analysis was considered 301 files among: 108 records of field notes, 75 emails and 118 instant message conversations. • Online observations through the first trial of the mobile app with practitioners: 37 participants during September of 2016 and December of 2016. • Online observations through the second trial of the mobile app (application of the experience sampling method) with practitioners: 6 participants, 3 samples per day during four days = 72 observations. This data collection was made with the help of one undergraduate student, supervised by the author.
Interviews	• 31 semi-structured interviews to understand the problem. Three face-to-face interviews, and the others online (via Skype, Google Hangouts, WhatsApp, Appear.in, and WebEx). • 20 semi-structured interviews to evaluate the solution. Three were done via Skype and the others via phone calls. • 2 focus groups to evaluate the solution. One was via Skype and one was via face-to-face in a coffee shop.
Meetings/presentations with specialists and practitioners	16 meetings: • Meeting with UBI_Business Research Group: 1 face-to-face meeting with 6 participants. • Enterprise Mobility experts: 4 meetings = 1 face-to-face and 3 online meetings via Skype. • Entrepreneurship experts: 2 presentations in the entrepreneurship competition. • Practitioners: 9 meetings = 3 face-to-face, 1 phone call and 5 online meetings via Skype.
E-mails, messages in social media LinkedIn and WhatsApp conversations	254 thread of emails, 58 messages conversations in LinkedIn, and 18 WhatsApp conversations
Survey	Carried out as one task of an entrepreneurship competition. The survey was published in 15th of October of 2016 and was available during 24 hours. 56 participants answered the survey.
Statistical data	• Logs from the use of the mobile app with practitioners. • Data interaction from social media posts in fan page: 9 posts in Facebook and LinkedIn. • Project Website statistics since July/2016

Source: Research data.

5 RESULTS

The goal of this chapter is to show in detail the research results following the steps of DSR, explaining how the problem was understood, how it was addressed and what are the main results achieved. As already mentioned, to understand the problem the empirical data was collected via participant observation and interviews. After, the data was compared to the literature review and finally they were analysed at the light of the Activity Theory (AT) and Expansive Learning. Following that, the principles of design were identified, and the artifact development was carried out. Subsequently, the evaluation of the artifact was made based on (a) the trials of the artifact and also on (b) demonstrations to experts and practitioners. The details of these steps and the research results are presented in the sections as follows.

5.1 UNDERSTANDING THE PROBLEM

To better understand the research problem, the data collected in the participant observation and interviews were analysed using the framework of AT and the cycle of Expansive Learning. Thus, the activity system illustrated in Figure 25 – An activity system in the context of and the conceptual model showed in Figure 26 helped to guide this analysis. First the main characteristics of the subject – the MKWs were identified. Next, the central activity and the object of the subject were determined. Then, the instruments used to perform the central activity; the rules and division of labour that respectively, regulate and organise the activity were identified. Subsequently, the members of the MKWs community and their interrelated activities were identified. Finally, it was looked for the main disturbances and contradictions in the activity systems and how these workers usually address them. In this phase, the ZPD concept allied with the cycles of Expansive Learning, the small and large-scale, and collaborative problem-solving concept, were also used to better understand the learning actions carried out by the MKWs. Based on these steps it was possible to compare the empirical data with the literature and understand the problem as it occurs in practice. Next section presents the results of this step.

5.1.1 The Mobile Knowledge Workers' context

Regarding the subject, the three groups of the participant observations were hired to work 40 hours a week, but it is very common for then to work more than 40 hours. As they are contracted as managers, they do not need to register the hours they have worked, and they have more flexibility to start and finish their work whenever they want. It was very common to find them working online in the virtual spaces such as Skype or Microsoft Lync[1] early in the morning, late at night or even on weekends. This situation was also confirmed in the interviews, "I'm connected 24 hours, it is difficult to hang up, and then we work much more" (Interviewed 4).

The participants observed often worked at home, in the company sites and at client sites. Some of them, mainly the IT Relationship Managers need to travel a lot. They often use their cars or, when the customer is far from the company site, they travel by airplane. But even having a high mobility, as observed in the literature (Harmer & Pauleen, 2012), they generally enjoyed the variety of organisations, situations, people and challenges to which they were exposed. Later, in the interviews, this situation was also confirmed,

> I feel better being a mobile worker because usually as you are on the move and working in different places all the time, you end up, as I said before, experiencing different realities, different cultures, different habits, knowing different people, you know. And I like this one, this particularity of being a mobile worker (Interviewed 10).

One common situation observed was that the professionals who worked most of the time at client's sites have a feeling to be "invisible". This circumstance also was mention in the literature (Koroma et al., 2014), and was one of the main reasons for the ITCom to develop the social media network, to group these professionals who feel like being more employees of their clients. This situation was evidenced in the speech of the Interviewed 8, who also took part in the participant observation,

> Another point is that when you go back to the base […] your relationship with the base people are, it is weaker because you're not much there. You spend 50% of your time off, a week in the headquarters and a week on the move, you, ah, many times the people who spend more time at the headquarters, they have some routines that usually those who are not there all the time do not participate of, because people do not even remember to invite them. For example, the people are going to have lunch every day at the same hour, and then because you always are not there, they do not remember to invite you. So if you do not go there and say, "oh let's have

[1] The instant messaging formalised by the ITCom and used by these workers to communicate with others

> lunch", they do not invite you. You also have this loss of relationship with the headquarters staff. It's another aspect (Interviewed 8).

About the rules of work, because there is little standardisation across the different ways of working and attending their clients and teams, MKWs need to deal with many intricacies between the ways performed by their clients and the methods used in their own company. As a result, they often adopt a mix of procedures and methods, but this brings the difficulty to achieve the deadlines and the quality in the clients' attendance expected by the ITCom. Besides, they need to deal with many challenges during the interactions with their community, mainly with those that are working at the headquarters and need to support them. Hence, organisation, time management and self-management are some of the required skills for MKWs. The interviewees also pointed these situations,

> I'm changing from the line of mentoring and going to a coaching line with the client, for example ... starting with the briefing, do the construction together with the clients, the material, defining activities that the client will have to execute, and then I come back to check how the progress of these actions was, and so on ... coaching activity, you know ... what is improving, in the case improves the quality of what I do and has a greater participation of the client... but this is my attitude and not from my organisation... (Interviewed 28).

> We have some clients with very rigid norms that cause a lot of impact in our lives (e.g., clients that do not let us access their environment). So we need to adapt and keep in touch with everything and many times we need help from someone from the headquarters. However, it is common that the people from the headquarters do not understand our "urgency" due to clients with restrict access to the Internet, access to their network with our notebooks, etc. (Interviewed 14).

Regarding the MKWs responsibilities in the participant observation, the workers complained about the many attributions and information they need to deal with. In the activity system representation, this refers to disturbances between the rules and the object. According to them, the several attributions they have make the accomplishment of the clients' needs very difficult. "Many times I need to choose between the client's needs and the procedures of our company… It is tough to perform the procedures as defined and achieve the client's needs" (IT Operation Manager, Field Notes, February 22, 2013). But, many times, it was observed that they did not understand all the attributions they have or did not have enough knowledge about how to do to perform the task. Thus, they typically were circling in cycles of trial and error until they reach a solution. As mentioned by one IT Project Manager in the participant observation, "There are a lot of things to adjust that I have no idea how to do it and the time for me

is very short, so I end up prioritizing the work with the team" (IT Project Manager, Instant Message, April 12, 2013).

About the instruments, as mentioned in the literature, these workers use an immense variety of instruments. Since they need to be ready for anything, anywhere, they carry a vast toolset such as notebooks, tablets, 3G/4G modem, extra batteries, more than one smartphone and so on. It was observed that these workers like technology and they are always aware of technological innovations that could help them to work. It is very common to witness informal chats related to new devices that someone bought to better perform their activities.

One disturbance related to the instruments observed was related to the constant infrastructure problems faced by these workers. Because they are very dependent on the ICT tools to perform their work and interact with their community, these tools have a significant influence on the work results. This situation also was mentioned in the literature (Cavazotte et al., 2014; Koroma et al., 2014) and perceived by the researcher (more than once) in the participant observation,

Excerpt 1: Instant message conversation April 05, 2013, Infrastructure problem

Participant researcher [15:31]: hi […], can you talk now?
IT Operation Manager [15:32]: yes!
Participant researcher [15:33]: do you have the details of the contract?
[15:34] This message has not been delivered to IT Operation Manager because that person is not available or is offline.
IT Operation Manager [15:36]: I came back, the 3G was down
Participant researcher [15:36]: yeah, i got it

Still about disturbances related to instruments, but in this case, a new instrument used to work – this instrument is not "a formal work tool", and it is adopted for some but not so much by others. In the interviews this became clear with the speech of the Interviewed 7, when she talked about the WhatsApp tool,

> WhatsApp was being used a lot, until I had to give some breaking. So I talked to my leader and said:"wait, WhatsApp is not a work tool, I understand that we need to have agility for some things, but we have to handle it, to". I said,"No, it's enough" WhatsApp for work is strictly to the necessary, right. And I've been trying to control me more because otherwise, I will not stop to work (Interviewed 7).

Both in the observation and in the interviews many disturbances were also identified among the central activity of MKWs and their other activities. Therefore, many times these workers need to prioritise what they need to do next.

> The question of many bureaucratic activities that are in our hands [...] we need a staff support who can do that boring but necessary part that takes our valuable time (which is being on the move selling, attending the team and the client and anticipating problems) (Interviewed 3).

As presented in the literature review and observed in this empirical data, the context of MKW is very complex. They need to deal with many intricacies related to people they need to work with, the many instruments they need to use and the rules (from their own company and from the client's company) they need to follow to deal with their object and achieve their best results. Therefore, to create and share knowledge in this context is not a trivial task. More about this is presented in the next section.

5.1.2 Knowledge creation and sharing in the Mobile Knowledge Workers' context

Considering the idiosyncrasies of the MKW's context, it is not so simple to become one of them. As questioned about how someone can prepare himself to become a MKW the Interviewed 6 six stated,

> You cannot, you cannot start alone. The best way for you to do this is to start there at the beginning, as a trainee, as a commercial assistant and after a few years, you will be able to get to the point of becoming one (Interviewed 6).

This reinforces the key concept of ZPD and the importance to have someone helping these workers to create knowledge and developing themselves. All the professionals interviewed highlighted that they started as a trainee; thus they learned the first steps with someone, and after some time, they could continue to work alone. Besides, as identified in the literature (Harmer & Pauleen, 2012), it is common that the MKWs are the main responsible for their own knowledge improvement. This was observed both in the participant observation and in the interviews. All participants expressed concerns about their knowledge and skills. All participants have specialisations or MBA, and many of them were studying in the period of the data collection.

When asked about the decision to take formal education or training during their professional careers, the Interviewed 10 reinforced that they took the decision alone.

> Quality management specialisation was because I was, it was also a decision of mine, I was developing a quality system as software within [Name of the company], so I chose to take a

> particular course to understand the quality, not only understand the process but to understand the concepts and all the related things. So when I chose to do, nobody suggested to me like a career plan, like that. Today I want to do an MBA again now, you know. The doubt is between this, or I specialise in something that I can use for my daily life (Interviewed 10).

However, sometimes it is hard to take academic education or training due to the high mobility of the workers. For instance, as mentioned by the Interview 18, he prefers to study in face-to-face courses rather than via distance learning; however, it is very difficult to synchronise his work activities and educational activities. He already started an MBA via distance learning, but he gave up because he did not like the modality. “The greatest thing about doing an MBA is to exchange ideas with other colleagues in a face to face way” (Interviewed 18).

Regarding the sources used to look for knowledge, they often tend to use the Internet to explore and after they use others sources such as books, materials from their formal education and their community. Their community is not only composed of the colleagues from the company but also of their social network.

> I would say the Internet is one of the sources, but it is not the main one. I think, let me see here ... let me think here (pause) ... I have, I search a lot on the Internet, but I also use a lot the MBA material. Articles, books, hmm ... regarding knowledge, so, for me, I use the undergraduate material, the MBA material and the exchange with my co-workers (Interviewed 1).

> I'll give you a very classic example when I use my social network, for instance when I need to define the sales price because I'm competing with other companies [...], I have to study these companies, see if I can get their sales price elsewhere, and then I have to call 3 or 4 people who have already worked there to help me with this information (Interviewed 22).

In the participant observation it was very frequent to witness the commitment of these workers with their community in practices of knowledge sharing. As observed in the Excerpt 2, they tend to help their colleagues anytime, mainly those ones who are starting in their attributions for the first time. Therefore, in these collaborative problem-solving situations, the more skilled workers in the situation help the less skilled in achieving their task or objective (ZPD key concept). In the Excerpt 2, a kind of task force was informally created, on the last day of December, to help a new IT Project Manager to finalise his tasks.

Excerpt 2: Instant message conversation December 31, 2013, Collaborative problem-solving to help a new IT Project Manager in the monthly invoicing

> IT Project Manager [12:22]: hi
> Participant Researcher [12:22]: hi
> IT Project Manager [12:23]: Of all requests of my clients, 28 have to bill in this month

> Participant Researcher [12:23]: ok, got it. Do you need help?
> IT Project Manager [12:25]: maybe, [Person 1] and [Person 2] can help me with this, they already give some tips about it
> Participant Researcher [12:25]: ok, so let's involve them in it ...then write the email to them while I call to [Person 1]
> IT Project Manager [12:25]: ok
> Participant Researcher [12:30]: hi, I already spoke with [Person 1] he is having lunch right now but he will help you later
> IT Project Manager [12:33]: ok

An interesting point about these collaborative problem-solving processes among MKWs is that they occur mainly through ICT tools. The most used ICT tools in these situations are instant messages such as WhatsApp, Microsoft Lync or Skype. Email and phone calls are also used, but the first three ones are more used since it is easier (fast) and cheaper (phone calls can generate high bills) to access the person who could help. Another interesting situation that disagrees with what was presented in the literature is about the use of the Facebook. According to Jarrahi & Thomson (2016) these workers use Facebook only for personal activities, but in the data collected the MKWs use Facebook to work activities too. It was observed the use of Facebook for two main reasons. The first reason is related to better know the personal interests of the people they have to work with, mainly clients and support team members. The main idea of this is to strengthen the relationship with these people. As mentioned by the Interviewed 2, “I use Facebook to understand what's happening to my clients. So for example, I see that my client, he likes to run, he likes to do a marathon, so when I know that, I talk to him about things that are related to that” (Interviewed 2).

The second reason is related to have easy access to the people they need to interact. Because many times they have infrastructure problems inside the client’s site or in other places, they often use their smartphones, with 3G or 4G connection and the Facebook mobile app to contact the people they need to talk via Facebook messenger. Also, when they want to contact someone who makes part of its network of relations but they do not have his contact details, they use Facebook and LinkedIn to reach the person. As mentioned by the Interviewed 11, “We use Facebook a lot also to connect with people; where the guy is plugged we call him (laughs)” (Interviewed 11). Although, it was observed, during the year of 2016 a migration of some part of this kind of communication from Facebook and LinkedIn messenger to WhatsApp. However, according to some participants, the main disadvantage of using WhatsApp instead of others tools is that the messages disappear and they lose the conversations records.

During the participant observation, a case of expansive learning among the mobile workers was observed. Because of the new tool, based on a social media platform created by ITCom, the managers observed started an informal teamwork to use the new instrument for their benefit. Then, they began to organise themselves to create a new instrument that could help them to define a sort of best practices guide to perform their work activities. Due to the longitudinal participant observation, it was possible to observe one large-scale cycle of expansive learning, initiated by these workers. Because the large-scale cycle of expansive learning is composed of many smaller cycles and requires intensive collaboration, it can take years, then is not so common to observe this situation empirically (Engeström, 2010).

Figure 33 illustrates the Expansive Learning among the MKWs observed. The first step of Expansive Learning, the need state, started in February 2013. In this step, the questioning and identification of needs are carried out. The second step is analysing the historical and actual situation where the learners are involved. This step started in parallel with the first step and was carried out until April 2013, when the third step was started. The main conflict situation stated by the MKWs was about their responsibilities. They complained about the many attributions and information they had to deal with every day.

The third step is modelling the new idea that can offer a solution to the problematic situation observed in the second step. In the case of mobile workers, the first idea was to create a mind map with all the main activities that needed to be performed by them. However, some problems happened in the mind map construction. The main issue was to use the mind map tool[2] in a collaborative way. First, some of the managers, that had never used the mind map tool before, had some problems to use it. After, because only one person could use the mind map file at a time, this task became unproductive. Then, they started a new idea, a second idea, to make an experience using the SharePoint resources available on the ITCom Social Media, because that could be possible to update by everyone anytime, anywhere. Due to the format of this list and its content (all the managers' tasks and roles), the participants started to call it "responsibility matrix".

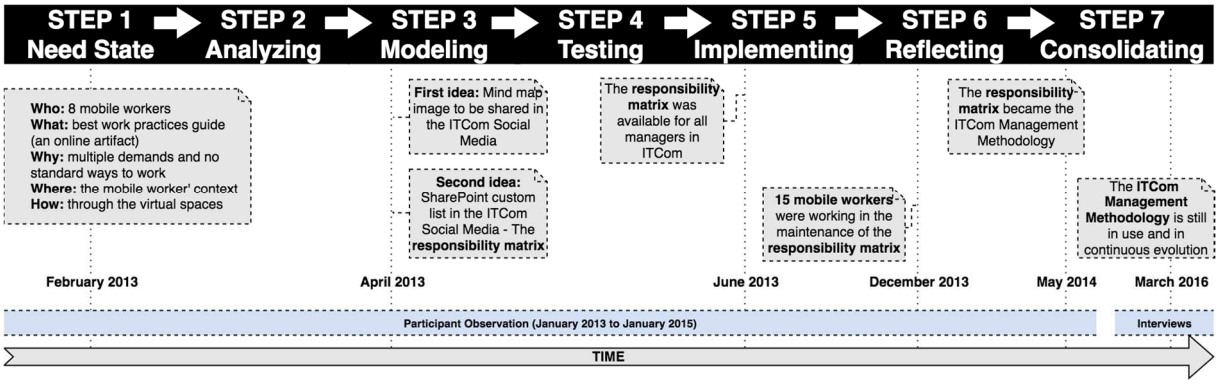
In the fourth step, more MKWs started to experiment and to help in the maintenance of the responsibility matrix. Some of these new participants were invited

[2] The tool used was the XMind (http://www.xmind.net/)

by the matrix' creators while others offered their help in the initiative. At the end of 2013, fifteen participants were already working in the maintenance of the information in the responsibility matrix. The fifth step is implementing the new model. In June 2013, the responsibility matrix was available for all managers in ITCom. However, only the group who started the artifact continued responsible for its maintenance, with the sponsorship from the company. Also, the company provided autonomy to this team to work and get more participants to help.

Despite some resistances, the responsibility matrix was consolidated in the company at early 2014. The board of ITCom decided to change the name of the artifact to ITCom Management Methodology. The ITCom Management Methodology continued to be improved and, according to the nine interviewees, also participants in the participant observation, it is still used nowadays. As these workers have always complained about the many activities they needed to deal with, this instrument, created by them, helped them to deal with these situations. Figure 33 summarises the learning steps took by the MKWs observed.

Figure 33 – The Expansive Learning among the MKWs observed



Source: The author.

Therefore, based on the literature review and these results from the participant observation and interviews, it was possible to identify the main characteristics and challenges of the MKW's context and also to identify what factors are involved in the processes of knowledge creation and sharing in this context. Figure 34 shows the summary of the results of this step of DSR, mainly related to the understanding of the MKW' context.

Figure 34 – Summary of results - understanding the MKW' context

Theoretical Element	Research results	Sources[3]
Instruments (Tools and Signs)	Virtual spaces to work and communicate with others such as E-mail, Skype, Microsoft Lync, WhatsApp, Facebook, LinkedIn, DropBox, Google Drive etc.	LR, PO, AI
	Required skills: organisation, time management and self-management	LR, PO, AI
	Variety of instruments to carry on and deal with: mobile devices (notebooks, tablets, kindle), 3G/4G modem, extra batteries, portable battery charger, more than one smartphone, projectors, earphones, external hard drive, cars	LR, PO, AI
	Very dependent on the ICT tools to perform their work and interact with their community	LR, PO, AI
	Need of dealing with constant infrastructure problems	LR, PO, AI
	Most of them like ICT tools, adopting brand new ones informally	PO, I2, I6, I7, I8, I9, I19
	Often they use their own devices to work (BYOD)	PO, I1, I2, I3, I4, I6, I7, I8, I19, I22
Subject	Diverse MKWs roles. In this research: IT Relationship Managers, IT Project/Services/Systems Managers, Business Consultants, Account Executives, CMO – Chief Marketing Officers, Lecturers, Lawyers.	LR, PO, AI
	Most of them enjoy being a mobile worker	LR, PO, I8, I10, I11, I16
	Feeling of being “invisible”	LR, PO, I8
	Most of them like technology and they are always aware of technological innovations	PO, I6, I9
	Need to be able to deal quickly with the day-to-day impediments such as cancelled meetings, cancelled flights etc.	LR, PO, AI
	Need to deal with different time zones	LR, I5, I20, I21
Object	MKWs have a high mobility and work at home, in the company site, at client sites and public spaces such restaurants, coffee places, airports etc.	LR, PO, AI
	They use to work anytime, anywhere and beyond the contracted hours	LR, PO, AI

[3] The abbreviations represents: LR = Literature review, PO = Participant observation, AI = All interviewees (31), I# = Interviewed number

	They usually work alone most of the time	LR, PO, AI
	They travel a lot (by car, by bus, by airplane) and complained about the time lost in displacement and traffic	LR, PO, AI
	The main reason of their high mobility is to meet people (clients, team etc.).	LR, PO, AI
	Different ways of working, many times conflicting with the client's needs and the company's procedures	PO, I28
	Adoption of a mix of instruments, procedures and methods to reach the activity goal, which sometimes brings difficulties to achieve the deadlines and quality expected by the clients or the company	PO, I1, I2, I3, I28
	They need to deal with many attributions and information	LR, PO, I1, I2, I3, I5, I6, I7, I8
	Difficult to deal with their object since they do not recognise the object as theirs (why can I need to do that? – such as bureaucratic activities from their company)	PO, I1, I2, I3, I6, I8, I11
	Routine almost does not exists, they often work with a diversity of things	LR, PO, I1, I2, I6, I7, I8, I11
	They are more exposed to personal security risks	LR, PO, I6
	Difficulties in getting balance between work life and social/personal life	LR, PO, I2, I6, I7, I8
Community	They need to deal with different people (new clients, new team, new co-worker etc.)	LR, PO, AI
	Challenges to interact with the support team or staff at the company base	LR, PO, I1, I3, I5, I6, I8, I11, I14
	The mobility weakens relations with co-workers, but increases the access to diverse people and information (new ideas and new cultures)	LR, PO, I2, I8, I10, I11
Division of Labour	Teams at the company base often do not understand the urgencies and needs of MKWs	PO, I3, I6, I8, I10, I14
Rules	Working time is flexible	LR, PO, AI
	Autonomy to work	LR, PO, AI
	Little standardisation across the different ways of working and attending clients and teams	PO, I1, I2, I3, I6
	Conflicts between the ways performed by their clients and the methods used in their own company	PO, I3, I7, I8, I14
	Difficulties between the company's rules and the context of MKWs	PO, I2, I3, I4, I6, I7, I8

Source: Research data.

The summary results of this step of DSR, mainly related to the understanding of knowledge creation and sharing of the MKW' context, is presented in Figure 35. In this summary, the primary factors observed that are involved in the processes of knowledge creation and sharing in the MKW' context are described.

Figure 35 – Summary of results - understanding knowledge creation and sharing in the MKW' context

Theoretical Element	Research results	Sources[4]
Knowledge creation	The MKW is the main responsible for their own knowledge improvement	LR, PO, AI
	Learning by doing is frequent	LR, PO, I1, I2, I3, I6, I7, I8, I15, I27
	It is hard to take academic education or formal training courses	PO, I1, I2, I6, I8, I10, I18
	They often tend to use the Internet to explore an issue and after they use others sources such as books, materials from their formal education and after, their community	PO, I1, I2, I3, I6, I8, I11
Knowledge sharing	High commitment of these workers with their community in practices of knowledge sharing, even more frequently in problem-solving situations	LR, PO, I1, I2, I3, I4, I5, I7, I8, I11
ZPD	MKWs usually start their career following an experienced professional	PO, AI
	Usually contact and help their community in problem-solving situations through mobile ICT tools	PO, I1, I2, I3, I4, I5, I6, I7, I8, I11, I22
Expansive Learning	Learning actions based on collaborative problem-solving situations with their community were observed (large and small cycles of Expansive Learning)	PO, I2, I8
	Collaborative problem-solving practices through mobile ICT tools make it possible to generate expansive learning	PO, I1, I2, I6, I7, I8

Source: Research data.

[4] The abbreviations represents: LR = Literature review, PO = Participant observation, AI = All interviewees (31), I# = Interviewed number

Following the DSR method, the next step was to start the design and development of the artifact. The details of this step are presented in the next section.

5.2 ARTIFACT DEVELOPMENT

After understanding the problem through the analysis of the literature review and the empirical data, the design of the artifact proposed in this research started. In the next section, the methods that inspired the design and development phase are discussed. Following that, the details of the artifact development are presented.

5.2.1 Methods used for the artifact design

According to Jarrahi & Thomson (2016), Muukkonen et al. (2014) and Palomäki et al. (2014) there is a need for new methods that allows studying the mobile workers in their own contexts. Because of the high mobility of these professionals, the application of traditional research methods such as interviews implies in non-trivial limitations to the researcher's ability.

Originally, observation methods are options to capture behavioural events in natural settings. However, as presented in the literature review and in the previous section, mobile work can be performed in multiple locations at evenings, weekends and also during vacations, making it difficult or expensive to observe or capture using recording devices (Muukkonen et al., 2014; Palomäki et al., 2014). Thus, one alternative to conduct studies with MKWs is to observe them online. To make that, it is possible to adopt methods such as Experience Sampling Method (ESM) and Self-Report Method (SRM).

> The Experience Sampling Method (ESM) is a research procedure for studying what people do, feel, and think during their daily lives. It consists of asking individuals to provide systematic self-reports at random occasions during the waking hours of a typical week (Larson & Csikszentmihalyi, 2014, p. 21).

The ESM involves sending repeated assessments to people to gather their current experiences and behaviours in their natural environments without latency or only with minimal latency (Palomäki et al., 2014). The duration of these studies can vary from days to months and smartphones are often used as an instrument of ESM since they have a number of sensors such as GPS for collecting location information,

Bluetooth for tracing proximity of team members, notification messages to stimulate the application access and others (Palomäki et al., 2014).

The SRM, in turn, is an approach related to “Daily diary methods” in which the subjects record data from their daily events (Muukkonen et al., 2014; Palomäki et al., 2014). The data recorded can be structured and guided by questionnaires or can be open-ended. This last type is used when the individual need to report his feelings and thoughts about the day as a diary (Muukkonen et al., 2014). The SRM is interesting since the data reflects the experiences of the subjects (Palomäki et al., 2014) and it involves collecting both qualitative and quantitative data on users’ naturally occurring activities (Muukkonen et al., 2014). Furthermore, the advances in technology and mobile devices permit to conduct more automatic data collection to trace the professionals’ work activities (Palomäki et al., 2014).

Thus, these two methods, ESM and SRM, were used as an inspiration to design the method and the tool developed in the present research mainly to allow collect data in the mobile knowledge workers’ context. However, these two methods alone cannot stimulate the knowledge creation and knowledge sharing in the mobile knowledge workers’ context. Then, considering one of the specific objectives of this research, to propose an approach to stimulate collaborative problem-solving through knowledge creation and sharing in the mobile knowledge workers’ context, another method was studied, adapted and used for this reason.

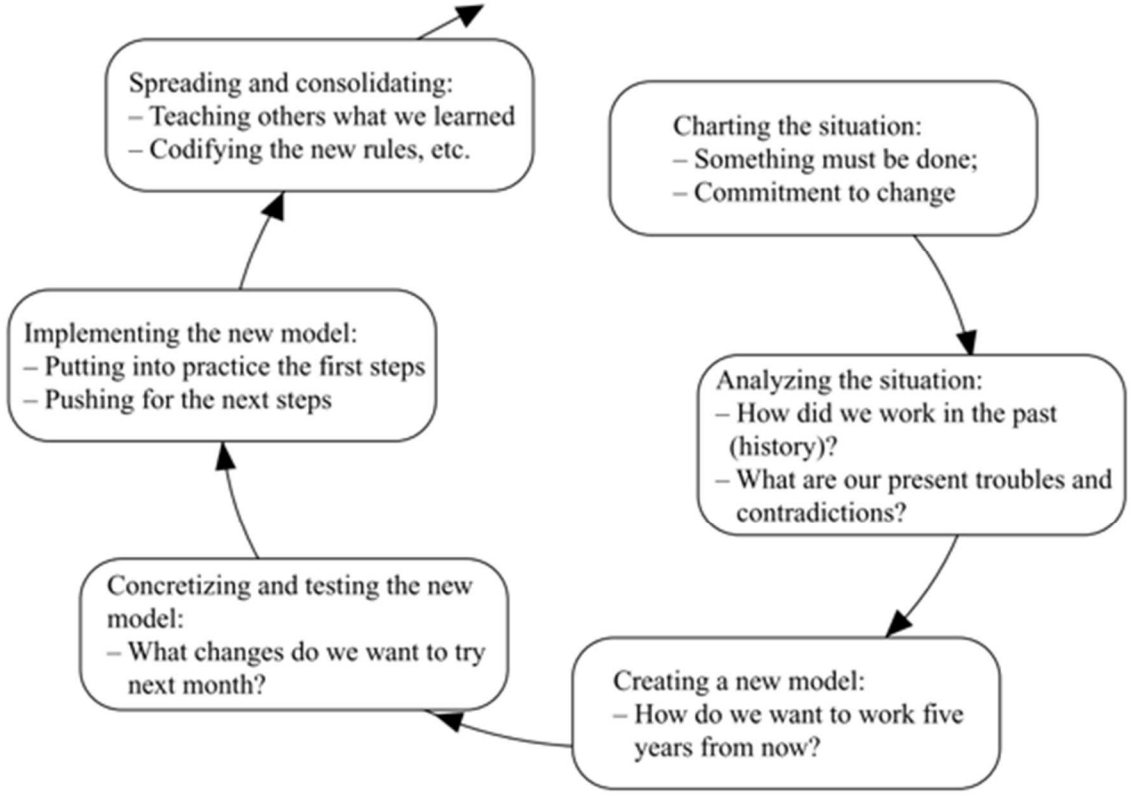
Therefore, the third method that inspired the artifact design was the Change Laboratory Method (CLM). “Change Laboratory is a method and set of instruments for developmental intervention to support collaborative learning and transformation of work activities” (Virkkunen & Newnham, 2013, p. xix). CLM is based on the Expansive Learning (Engeström et al., 1996; Virkkunen & Newnham, 2013) and enables the development of work practices through dialogue and debate between the participants, their management, their clients, and the interventionist researchers (Engeström, 2007). The original idea of this method is to organise a physical room or space in the work environment where there is a rich set of tools available for the analysis of disturbances and the construction of new models of work activity through knowledge creation and knowledge sharing processes (Engeström, 2007).

> The change laboratory is a space situated in the vicinity of the daily work of a work team or community. It comprises instruments for taking epistemic actions to analyse and develop the

> activity. Its central tools are whiteboards for representing the practitioners' activity system in different ways (Virkkunen & Ahonen, 2011, p. 236).

According to Virkkunen & Newnham (2013), the end results of learning are not predetermined by the interventionists or researchers since they are designed by the participants as they work out expansive solutions to the contradictions in their activity systems. The authors also state that Expansive Learning crosses the domains of individual learning and organisational learning that allows material changes in objects, instruments, rules and divisions of labour within and between the activities systems. Besides, the CLM does not aim only to produce a solution or change of practice in the activity system but also helps in the practitioners' understanding of the nature and causes of the problems in it (Virkkunen & Newnham, 2013). Figure 36 presents the phases of the CLM. These phases are base on the cycle of Expansive Learning.

Figure 36 – The phases of a CLM



Source: Virkkunen & Ahonen (2011, p. 238).

According to Engeström & Sannino (2010), Expansive Learning occurs when the isolated individual interacts with his community, to solve contradictions that permeate the activity and, collectively, based on sensemaking, they create a new goal or object

for the collective activity, with a new principle of operation or organisation. Therefore, to stimulate the Expansive Learning in organisations and teams, it is recommended the use of the CLM (Engeström, 2007). Based on this, these three methods were used to inspire the artifact design and development.

The artifact was composed of two elements: (1) a method and (2) a mobile app. They were developed to achieve the research specific objective: to propose an approach to stimulate collaborative problem-solving through knowledge creation and sharing in the mobile knowledge workers' context. Therefore, to accomplish this specific objective, the artifact needed to: (a) stimulate collaborative problem-solving in the mobile workers' context through the promotion of knowledge creation and knowledge sharing and (b) allows the online observation of the mobile worker's context and their knowledge creation and knowledge sharing practices.

Considering the context of mobile workers, who are often in movement and away from a fixed workplace, the ESM and SRM allowed to collect the data and to observe these professionals online. Besides, inspired by the CLM, the artifact designed made it possible for the mobile workers to debate and to solve problems of their work practices in their own context, mediated by the use of mobile ICT. Also, the logging of contextual data allied to the utilisation of these three methods allowed observing the spaces used by these professionals to create and share knowledge, the periods they tended to work on it, and also everything they did, created and shared in the tool (the app developed).

Figure 37 summarises how the three methods were used in this DSR to achieve the research specific objective.

Figure 37 – Summary of the methods used to create the artifact

(a) Stimulate collaborative problem-solving in the mobile workers' context through the promotion of knowledge creation and knowledge sharing		
Method used	**Why was used**	**How it was applied in the artifact**
CLM (Change Laboratory Method)	To stimulate the isolated individuals to interact with their community in problem-solving situations and to collect data from these interactions	Based on the cycle of Expansive Learning and the steps of the CLM two phases were implemented in the method and mobile app: (1) the consciousness phase and (2) the transformation phase (see more in 5.2.3 Artifact features).

(b) Online observation of the mobile worker's context and their knowledge creation and knowledge sharing practices		
Method used	**Why was used**	**How it was applied in the artifact**
ESM (Experience Sampling Method)	To collect data from the context of MKWs based on their answers on random occasions and contextual data from their loggings	Three structured questionnaires were used to collect data about the activity, knowledge creation and knowledge sharing three times a day during four days.
SFM (Self-Report Method)	To collect data from the context of MKWs based on their disturbances reports and contextual data from their loggings	Keeping a disturbance diary allows collecting data about problematic aspects of the activity system (Virkkunen & Newnham, 2013).
CLM (Change Laboratory Method)	To collect data from the context of MKWs based on their interactions with others and and contextual data from their loggings	Based on the key features of the mobile app MKWs could interact to create and share knowledge with others, anytime, anywhere.

Source: The author.

The next section details the main characteristics of the artifact.

5.2.3 Artifact features

The artifact developed in this research was named "mobChangeLab". The idea of this name was to indicate the inspiration of the CLM for application in the context of mobile work. As the original idea of the CLM, the application of the mobChangeLab is triggered based on situations as crisis, problems or needs for change in the activity systems of the MKW. Because MKWs are often autonomous and require new styles of management, it is important that the need situation, which encourages the mobChangeLab application use, is recognising by them. More than their management, the MKWs need to be convicted that something must be changed.

As presented, the mobChangeLab is composed of two elements: (1) a method and (2) a mobile app. The next sections present the main characteristics of them.

5.2.3.1 The mobChangeLab method

The method was divided into two phases: (1) the consciousness phase and (2) the transformation phase. The primary objective of the first phase is to reinforce the

need for change in the work practices of the MKWs. This is made by the creation of a kind of a mirror based on the data collected from the context of the workers such as disturbance self-reports, the logging of their contextual data and their answers on the random questionnaires. It is important that this phase can be realised during at least for four days or more since the consolidation and the presentation of the data collected acts as a first shared stimulus that there are disturbances or problems to be solved and the situation requires expansive learning actions.

After the period defined for the consciousness phase ends, or when the MKWs realise that there is enough evidence to work out in collaborative problem-solving, the transformation phase can be started. This second phase is composed of five steps and, based on the Expansive Learning concept, each step is related to one or more learning actions – steps of the Expansive Learning cycle, see Figure 22 (Engeström & Sannino, 2010):

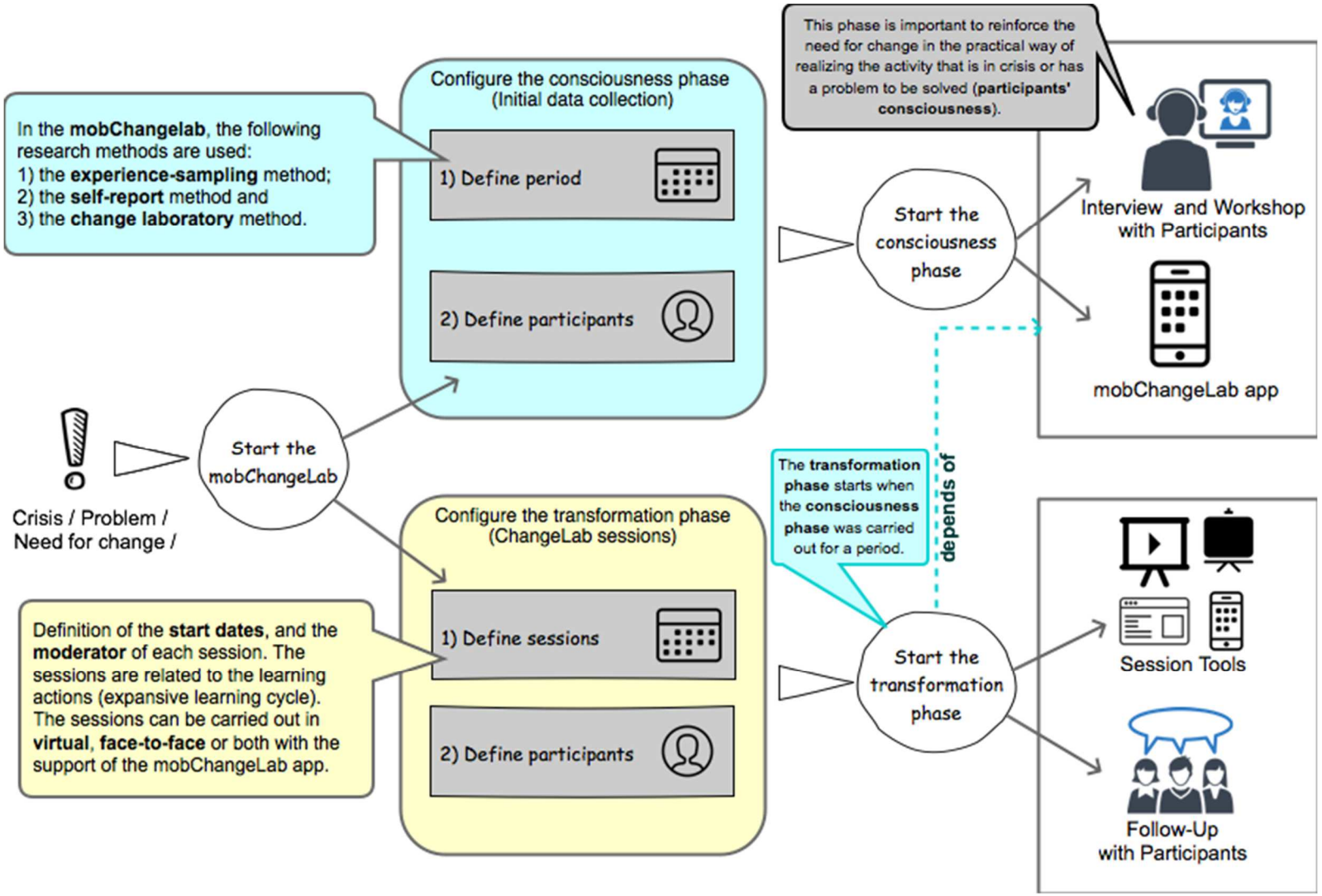
1. **Problems and challenges identification** (based on the first step of the Expansive Learning cycle: Questioning): in this step, a summary of the consciousness phase is presented, which enables the reflection on the data collected. Allied to their recent work experiences, the MKWs can identify the contradictions in their activity systems. Actions of questioning, criticising or rejecting some aspects of the accepted practice and existing wisdom or a current plan are carried out.
2. **Target definition** (based on the second step of the Expansive Learning cycle: Analysing the situation): in this step, the significant problems are identified and prioritised to start the collaborative problem solving. Actions of analysing the situation are carried out and involve a mental, discursive or practical transformation of the situation to discover origins and explanatory mechanisms.
3. **Solution elaboration** (based on the third and fourth step of the Expansive Learning cycle: Modelling the model and Examining the model): in this step, it is elaborated and concretized the ideas of new solutions and planned how to organise the experimentation of them. Actions of modelling are made with the purpose of constructing an explicit, simplified model of the new idea, which explains the problematic situation and offers a perspective for resolving or transforming it. Also, actions of examining the model, running, operating, and

experimenting it are carried out to grasp its dynamics, potential, and limitations.

4. **Solution implementation** (based on the fifth step of the Expansive Learning cycle: Implementing the model): in this step, actions of implementing the model, concretizing it by means of practical applications, enrichments, and conceptual extensions are performed.
5. **Retrospective and follow-up** (based on the sixth step of the Expansive Learning cycle: Reflecting): finally, in this last step, actions of reflecting on and evaluating the expansive learning process to identify needs for further learning and development are carried out.

As already presented in Chapter 3 THEORETICAL BACKGROUND: ACTIVITY THEORY (AT) and in Figure 22, the Expansive Learning is composed of seven learning steps. The seventh step is Consolidation, and in this step, actions of consolidating and generalising the outcomes of the learning process into a new stable form of practice are carried out (Engeström & Sannino, 2010). However, this is a long-term view and can take years (Engeström et al., 1999). This is one of the reasons of the development of the mobChangeLab application. Another reason is to support the mobChangeLab method better, mainly in mobile work' contexts. Because the main data about the disturbances/problems and actions to carried out the expansive learning cycle will be structured in the application, it will be possible for the MKWs and the researchers observe, in a long run, which ideas experimented was consolidated and evolved in time. Figure 38 presents the main view of the mobChangeLab method. The next section details the development of the mobChangeLab app.

Figure 38 – The method developed and implemented in the mobChangeLab app



Source: The author.

5.2.3.2 The mobChangeLab app

The mobChangeLab app was designed and developed following the concepts of the agile software development process. The first phase of the agile software development process is to create an artifact called product vision[1]. In the product vision, the target group of the app, the needs of this target group and the functional and architecture requirements for the app are elicited and organised. Figure 39 presents one part of the product vision.

The target group is the MKWs and their needs were elicited based on the results of the first step of this DSR. Four needs were elicited to be implemented in the mobChangeLab app: (1) to allow the isolated individuals (MKWs) to create and share knowledge by interacting with their community in problem-solving situations; (2) to help MKWs to solve theirs problems in their own context; (3) to help workers to find and know who knows what (collaborative knowledge) in their own context and (4) to create opportunities for interaction anytime, anywhere ("walking around" in a virtual space). Considering these needs, the functional and architecture requirements were derived.

To develop the key features for the first and second needs, it was designed an architecture based on social media features. The aim was to create a kind of a mirror (an instrument of the original CLM) for the practitioners. In the original CLM, the mirror is used to present problematic aspects and situations in their current practice to stimulate them to encounter and construct a shared first stimulus, a consciousness of a problem that needs to be solved (Virkkunen & Newnham, 2013). The main feature used as a mirror was a sort of "social media timeline" (see Figure 40b). In this feature, all the disturbances reported by the practitioners in the disturbance self-report (see Figure 40a) were presented to the community. It was also provided resources for analysing the mirror data (see Figure 40d), the analysis tools. Based on these features, collaborative analysis of problems and development could be performed and can generate a new concept that permits to transform the activity system to overcome the contradictions that cause disturbances, ruptures or conflicts in the daily work activity (Virkkunen & Newnham, 2013).

[1] According to Vlaanderen et al. (2011) the product vision is the starting point for the software development lifecycle. This artifact presents an idea of the requirements of the product to be developed.

For the third need, two main features were created in the app, one to indicate that the disturbance reported was already solved by someone in the community and who is this person, and another to allow participants to comment about it. These features are available on the timeline screen (see Figure 40b). According to the literature, the processes of knowledge creation and sharing are participatory and count on several individuals sharing and acquiring knowledge through transactional memory (von Krogh et al., 2012). Through this memory, it is possible to know the expertise of the participants and to identify who knows what within the group (Lyytinen & Yoo, 2008).

Finally, for the fourth need, a mediated tool for the 'walk around' in the virtual space would have to let the user look at the information inserted by other online users and be able to decide whether or not to engage in the interaction (Lundin & Magnusson, 2003). This can create opportunities for the MKWs to share or collaborate in problem-solving situations anytime, anywhere. Besides, structuring these discussions and making them more focused could help the users create a collective understanding (Blackler, 1995). The main feature related to this is the timeline created in the mobChangeLab app (see Figure 40b). These four needs guided the design and development of the mobChangeLab as depicted in Figure 39.

Figure 39 – The mobChangeLab app product vision

Target Group: Mobile Knowledge Workers		
Needs	**Functional Requirements**	**Architecture Requirements**
(1) To allow the isolated individuals (MKWs) to create and share knowledge interacting with their community in problem-solving situations; (2) To help MKWs to solve theirs problems in their own context; (3) To help workers to find and know who knows what in their own context and (4) To create opportunities for interaction anytime, anywhere	• To report a disturbance/problem • To observe the disturbances/problems reported by others • To interact with the disturbances/problems reported by others • To be aware of new reports/interactions • To know who knows what in the community • To report an idea/solution for disturbances/problems	• iOS and Android platforms • Social media features • NoSQL database to store any media formats • Push Notifications • GPS Location

	• To interact with an idea/solution for disturbances/problems reported by others • To analyse the disturbances/problems reported and the ideas solutions proposed or carried out • To store the disturbances/problems and the ideas/solutions reported for future analysis	

Source: The author.

To allow the analysis of the data gathering in the mobChangeLab app at the light of Activity Theory and to carry out Expansive Learning actions, the ontology (knowledge representation of the application) designed for the tool include the elements of the activity system in the disturbance self-report feature and the steps of the mobChangeLab method. This allows using the explicit knowledge generated during the application of the mobChangeLab method, to further analysis and continuous improvement. Besides, the idea to structure the disturbance self-report in a way that the worker needs to observe and report the type of disturbance he had (see Figure 40a), operates as a first individual stimulus for reflection. In time, and based on the reports, the MKWs can see the quantity of disturbances he had grouped by the elements of the activity system and how he engaged in the transformation phase.

Regarding the mobChangeLab app architecture, considering that it was developed based on the characteristics of a social media application and mobile technology, the application was designed and developed in three layers: (1) the user interface layer, the app developed for iOS and Android platforms; (2) the model layer, where the ontology was implemented and the data was structured; and (3) the control layer which controls the manipulation of the data between the user interface layer and the model layer. The user interface layer was developed using Ionic Framework[2]. The

[2] Ionic Framework is a framework which helps build apps either for iOS and Android platforms (https://ionicframework.com/)

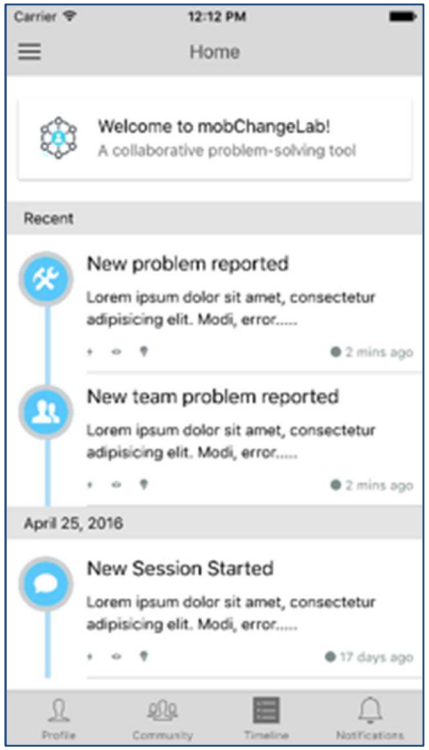
model layer was implemented using a NoSQL[3] database called MongoDB[4]. Finally, the control layer was developed using the NodeJS programming language[5]. An important characteristic of the mobChangeLab app is that it is necessary Internet connection to use it. Due to the three-layer architecture, the second and third layers are hosted on a cloud server contracted by the researcher[6].

The main screens of the mobChangeLab app are presented in Figure 40. These are the original screens designed in step 3 of this DSR. Next section presents the results of the demonstration and use of the artifact (mobChangeLab method and app).

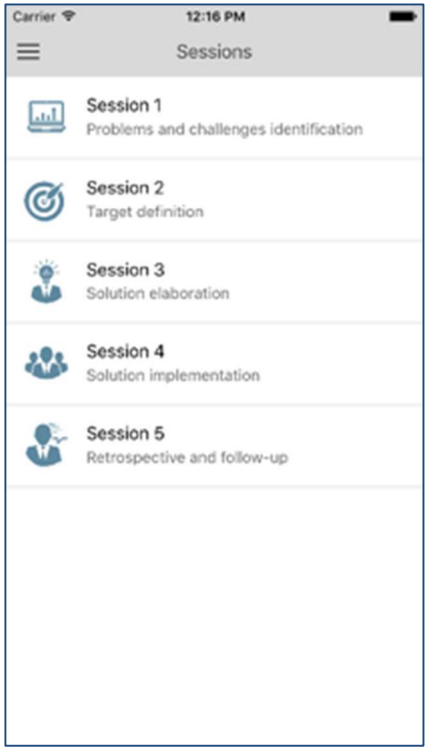
[3] NoSQL means a “no relational database”. This type of database are very used nowadays mainly for social media applications which needs to store data in many formats (i.e.: text, video, audio or image).
[4] MongoDB is recognised as the leading NoSQL database (see https://www.mongodb.com/leading-nosql-database)
[5] https://nodejs.org/en/
[6] The second and third layers of the application are hosted in https://jelastic.com/

Figure 40 – Main features of the mobChangeLab app (screens)

(a) Disturbance/Problem self-report



(b) Timeline



(c) Transformation sessions

(d) Analysis tools

Source: The author.

5.3 DEMONSTRATION AND EVALUATION OF THE ARTIFACT

As presented in Chapter 4 RESEARCH METHOD, the demonstration and evaluation of the artifact was done through different ways. These multiple ways allowed to collect a set of data for analysis of the research problem. The aim of this section is to present the main research results in this step of DSR.

5.3.1 The four cases of the first trial

The first trial was carried out based on two segments of MKWs: education and business. Twenty-one participants, divided into 4 groups (cases) tested the mobChangeLab between September 2016 and December 2016 (see Table 4 - Distribution of the cases in the first trial of the artifact). Before each group starts the test, a meeting was realised with them (online meeting via Skype) to explain the details of the method and the key features of the app. After the meeting, a material in PDF format with these details was also provided to them along with the data to access the app. Then, the online observation started, and the participants could use the app when and how they wanted. The details about the results for each case are discussed in the subsequent sections.

5.3.1.1 Case EDU_A

A team of four lecturers (two of these lecturers act as tutors) and one course coordinator have participated in the case study A. The team's activity is to coordinate and to help undergraduate students in learning Java Programming in distance education – the shared object. The need for change that engaged the team in the trial is related to the high index of evasion of students. Because these students are from the first semester of the degree program, many times they give up of the entire degree program since their performance in this activity is low. Figure 41 presents the participants identification in this case.

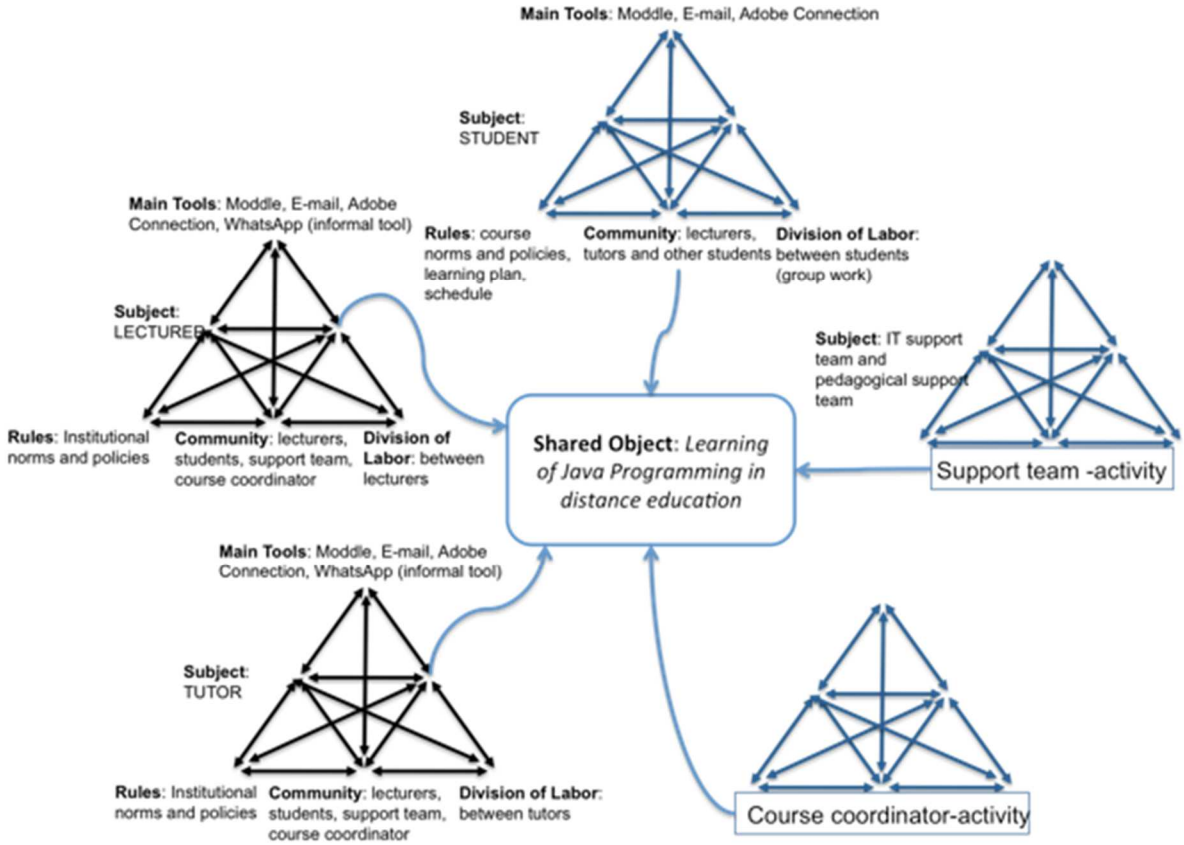
Figure 41 – Participants identification in EDU_A case

		Participants Identification				
		1	2	3	4	5
Position	Lecturer	X			X	
	Tutor		X	X		
	Course Coordinator					X
Gender	Male		X			
	Female	X		X	X	X
Age	20-30		X			
	31-40	X		X		X
	41-50				X	
Type of Mobility	Alternating between two fixed locations	X	X	X	X	X

Source: Research data.

The activity system of this case is presented in Figure 42. The lecturers and tutors are the MKWs who tested the artifact. The course coordinator also had access to it but she only participated as an observer. The lecturers and tutors have particular activities to perform, however, as mentioned, they share the same object. The lecturer is responsible for the definition and elaboration of the content inside the e-learning environment, exercises and assessment instruments. The tutor, in turn, is responsible for students' attendance and the correction of exercises and evaluation activities. The students and the support team of the University, composed of the IT support team and the pedagogical support team, also share the same object of the lecturers and tutors.

Figure 42 – The activity system of the EDU_A case



Source: Research data.

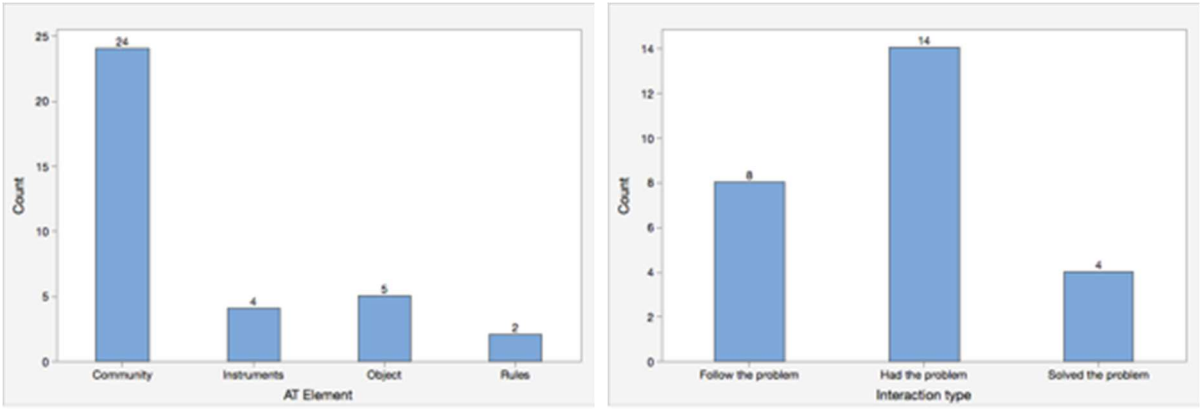
As illustrated in Figure 43, the disturbances reported by the lecturers and tutors were primary related to: 1) Community, 2) Object, 3) Instruments and 4) Rules. About the community and object, the main disturbances were generated by the difficulty to getting feedback and participation from students. As mentioned by the Participant 2 “The greatest problem is to be able to measure, in fact, how is students’ level of learning”. This mainly occurs because the students usually do not participate as expected of the collaborative learning activities such as web conferences, through the Adobe Connection tool, chats or discussion forums, via Moodle tool. Also, the Participant 3 highlights that the main difficulty related to the community is based on the communication. “I think the main difficulty is communication. How to express yourself, plus the time to send a message and to receive feedback. Particularly in situations that you need a fast feedback” (Participant 3).

There were also communication difficulties among the lecturers, tutors, course coordinator and support team. These difficulties were related to the instruments used by these workers, since they mainly use email to interact. Others instruments’ disturbances reported were mostly related to the other ICT tools used to deal with the

object, for instance, in a web conference event, the system used was unavailable for all the users (tutors and students), and the tutor could not warn the students about the problem. Finally, about the Rules, only the Participant 2 reported the disturbances of this kind since he started as tutor in the first semester (it is his second time as tutor). Since he does not have the same experience of the other tutor and lecturers, he reported disturbances related to unknown procedures, such as how to recovery assessment works.

Figure 43 also presents the quantity and type of interactions performed in the app by this team. The “follow interaction” represents the number of disturbances that these participants wanted to follow to know their results. The “had interaction” represents the number of disturbances that some workers did not report but indicated as they also had. This interaction type help to indicate which workers had the same disturbance but not necessarily had the solution for it. Then, the worker, which reported the disturbance, is notified and can start a collaborative problem-solving to search for or create the solution. Finally, the “solved interaction” represents the number of disturbances that the participants solved or helped to solve. As illustrated in Figure 43 the “had interaction” was the feature more used by these team.

Figure 43 – Disturbances and interactions observed in the EDU_A case



(a) Disturbances reported (b) Interactions performed

Source: Research data.

The main interactions of these workers are asynchronous, based on email communications, which many times has a delay on response or sometimes is dispersed in other kinds of communications. Because of that, they do not have many opportunities to put into action the processes of knowledge creation and knowledge

sharing with their community. Therefore, the main advantage of the mobChangeLab to these workers was to consolidate the communication in one place promoting the occurrence of learning actions. In the data collected it was observed some examples of learning actions. Some of them are the representation of small-scale cycles of expansive learning, and others represent an initiative of the first steps of the large-scale cycle of expansive learning. Figure 44 presents an example of the first steps of the large-scale cycle of expansive learning.

Figure 44 – Some examples of learning actions of the EDU_A case

Example 1: Students were anxious about the grades and send a lot of emails to lecturers/tutors	
mobChangeLab step	**Example**
Problems and challenges identification (Questioning)	Participant 1: The students have doubts about the deadline of grades publication. […] Is the deadline not clear to them? Any suggestions for improvement?
Target definition (Analysing the situation)	Participant 2: This information, as well as what is now valid that is the partial grade and not the final grade... I think we could put in the Moodle section. As it is the first semester of many, this always arises...
Solution elaboration (Modelling and Examining the model)	Participant 1: Yeah! Perhaps in the general section we could have a part with information about the deadlines. We could ask for some art from the Support team... What do you think? Participant 2: It would be great, and there could be placed in all communities of the first semester. It helps us on other disciplines too...
Solution implementation (Implementing the model)	This idea is carried out by the team (work in progress)

Source: The author.

An interesting representation of small-scale cycle of expansive learning was carried out by them and is continuing until now. The workers started to report all the difficulties expressed by the students in the mobChangeLab app and use it to guide the web conferences to solve doubts. Because the students do not participate as expected, using their doubts to conduct the web conferences motivate the engagement of students. From this interaction, the script of these web conferences began to be based on the students doubts reported in the mobChangeLab. The lecturers and tutors adapted the use of the tool also to create this doubts history and use it in the preparation for the web conferences.

> My overall evaluation is that we always should use the app because I think it is very productive, for instance, in the short, medium and long term it is very productive, it promotes productivity.

> At least my expectation since you introduced it was attended very well. I think we had great gains last semester, then I think we should continue to use. (Participant 2)
>
> I liked it a lot because it's a place that we could centralise, this communication issue, could be an official tool to centralise the communication, you know? Because it is to go there and register and it is fast, do you understand? Last semester helped a lot, even to identify topics for the web conferences to solve doubts. (Participant 3)

This team continues to use the artifact after the period of trial. As presented above, they liked the experience with the artifact and decided to continue using it.

5.3.1.2 Case EDU_B

The team of the case EDU_B was a team of two lecturers (one lecturer act as a tutor) from the same University of the case EDU_A. The team's activity is to coordinate and help undergraduate students in learning of Costs and Budget for Decision Making in distance education – the shared object. The need for change that engaged the team in the trial is related to the changes that the academic activity are involved. In the beginning, this academic activity was offered particularly for the students of the Human Resource Management Degree Program. So the content and exercises are directed towards this group of students, who have specific abilities and skills. Then, in the semester of the trial, the academic activity was also shared with other degree programs that have students with different profiles, students of the Financial and Commercial Management degree programs. Figure 45 presents the participants identification in this case.

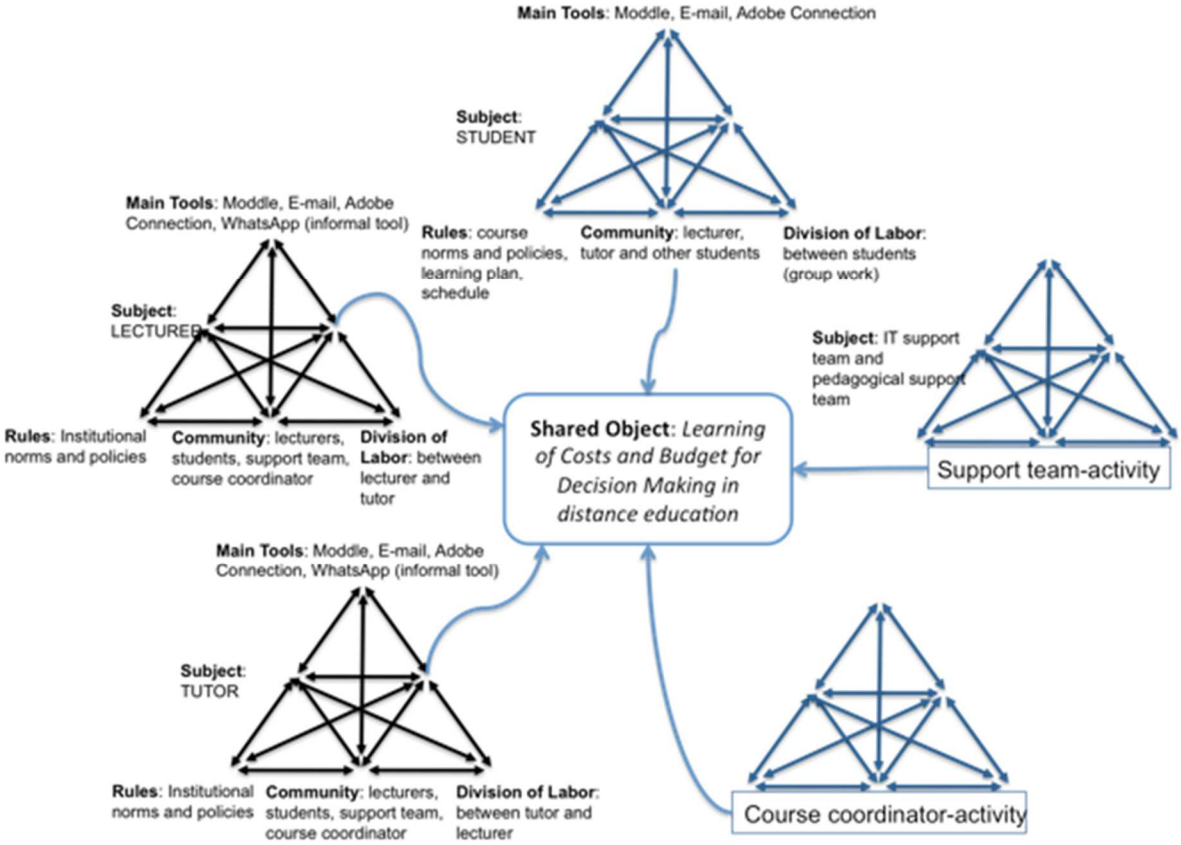
Figure 45 – Participants identification in the EDU_B case

		Participants Identification	
		1	2
Position	Lecturer	X	
	Tutor		X
Gender	Male		X
	Female	X	
Age	31-40	X	X
Type of Mobility	Alternating between two fixed locations	X	X

Source: Research data.

The activity system of the case study B is presented in Figure 46. Because this team is from the same organisation of case EDU_A, their activity systems have the same characteristics. The lecturer and tutor are the MKWs who experienced the artifact. The lecturer is responsible for the definition and elaboration of the content, exercises and assessment instruments. The tutor is responsible for students' attendance and the correction of exercises and evaluation activities. The students and the support team also share the same object.

Figure 46 – The activity system of the EDU_B case



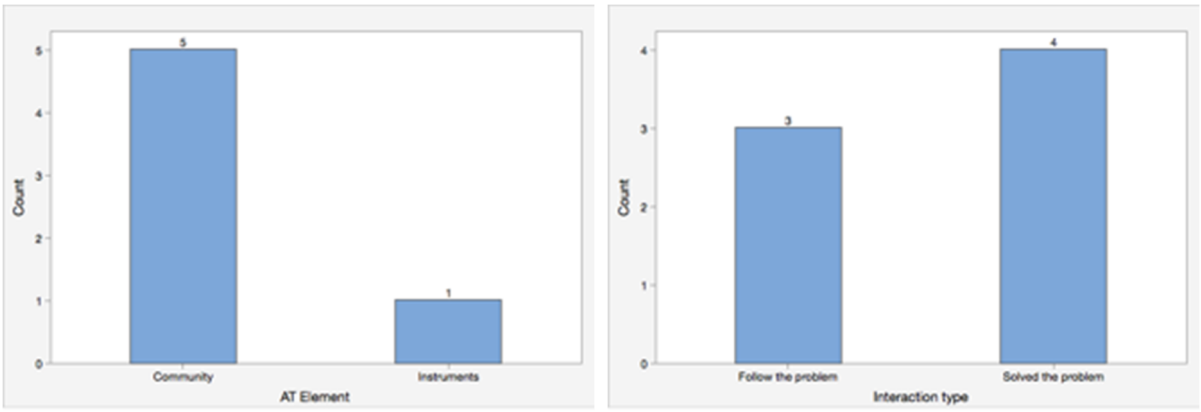
Source: Research data.

As illustrated in Figure 47, the disturbances reported by the Lecturers of this case were primarily related to 1) Community and 2) Instruments. These disturbances reported are strictly linked to the fact that the learning content and exercises were planned for students who have particular skills, the students of HR Management. The main disturbances reported indicate students' difficulties to understand the learning material, to perform the tasks and also, a low participation of the students in the learning activity – involvement in collaborative learning events.

> With the change and when we diversified the students profile in the community, this generated a certain difficulty because we had to review of all the exercises, so we could have tasks that allowed all the students from different backgrounds to identify themselves with the area and how they could apply it in management. How they could apply the concepts in HR management, in Financial Management or Commercial Management of the companies, then this was an initial difficulty that the tutor and I had to work. There is also the question about the students' profile because when you already work with a group of HR, you know the rhythm of the students, you know. When the discipline was shared, so the number of students grow within the community, and the tutor and I needed to reorganise the process and knew the new students' profile. (Participant 1)

Figure 47 also presents the numbers and types of interactions made in the app by this team. In this team, only the "follow" and "solved" interaction were performed. As illustrated the "solved interaction" was the feature more used by this team. When questioned why they do not use the "had" problem, the participants answered that all the disturbances reported were new for each one of them, so they did not use this feature.

Figure 47 – Disturbances and interactions observed in the EDU_B case



(a) Disturbances reported (b) Interactions performed

Source: Research data.

Similarly to the team of case EDU_A, this team also use email frequently to communicate and share information. It is very rare for them to accomplish face-to-face interactions. However, because the lecturer and the tutor have a longer partnership, they worked in this discipline since the beginning (2009), they already have a synergy to work. Another point is that the lecturer also works as coordinator of the face-to-face undergraduate degree programs at the University, so she already knows the shortcuts to dealing with the support team when needed.

The main advantage of the mobChangeLab to these workers was also to consolidate the communication in one place, keeping the history about the students'

difficulties and also providing a tool to rethink the activity. The difficulties reported will be used in the next semester as one of the inputs to the revitalization of the content of the academic activity. According to Participant 1, all the material and exercises will be modified. “I'm not going to continue with this academic activity, but the lecturer who will work with it is already aware that she has this task to work on its improvement” (Participant 1). Consequently, mobChangeLab helped to start a large-scale cycle of expansive learning that will continue in the next semesters. Figure 48 presents an example of the first step of the large-scale cycle of expansive learning.

Figure 48 – Some examples of learning actions in the EDU_B case

Example 1: Students’ difficulty in carrying out the proposed tasks	
mobChangeLab step	**Example**
Problems and challenges identification (Questioning)	Participant 2: Students present difficulties to meet the deadlines of the proposed tasks.
Target definition (Analysing the situation)	Participant 1: The proposed tasks format was not appropriate for the type of task that should be carried out. For example, in tasks that involved calculations, questionnaires were set up, while the most appropriate would be file submission (using Excel)
Solution elaboration (Modelling and Examining the model)	Participant 1: To solve the problem, we involved the course coordination and she intermediates the contact with the support team. With this support, the tasks have been redesigned to facilitate the resolution and the delivery of tasks by students.
Solution implementation (Implementing the model)	This idea is carried out by the team (work in progress)

Source: The author.

In the evaluation interviews the participants mention three interesting points about the artifact. First, according to Participant 2, the tool is intuitive, he did not read the tutorial sent to him and he uses it without any problem. Second, they think that the artifact can be used not only for small teams to improve their disciplines but also in large groups, for instance, a group of undergraduate lectures and course coordinators at the University. They could use the artifact to collaborate and think about the improvements together. And third, the idea to store the information as a history about the disturbances and changes made to solve them that the tool provides. They think this is very interesting because can be used as an evidence or justification to carry out the improvements.

> When we need to request a revitalization of a discipline, I have to answer a questionnaire, and I have to justify why I'm asking. Because this involves, for example, the University budget, so if you have the whole history, this can be used as justification, and we can do the various accompaniments there. So I found it very useful, as well as a tool that helps, solve the problem, discuss the issue, but also as an instrument that helps, thinking in this way from the perspective of coordination, you know, from someone who is taking a more general view. Also, the responsible teachers' development sometimes could look at it and think in new ways to prepare training that could help them to discuss the main difficulties, so I believe that it has the condition to collect a lot of valuable information for improvement of the courses. (Participant 1)

Another interesting idea highlighted by Participant 1 above, is the possibility to use the information gathered and the history to plan training and other learning activities to improve the skills of the subjects and also their community.

5.3.1.3 Case ITCON

The team in this case is formed by four IT and business consultants. The team's activity involves "thinking better processes". They need to understand the processes from their clients considering their business objectives and identify process improvements. The clients' processes improvements are the shared object between this team and their community. The need for change that engaged the group in the trial is related to the issues that they constantly need to deal with in their projects. Since they are involved in different projects and different people who work on these projects, it is very common that impediments for the achievement of the objectives of the projects arise. Therefore, they engaged in the trial to observe what are the main disturbances they have faced and what they could change to perform better. Figure 49 presents the participants identification in this case.

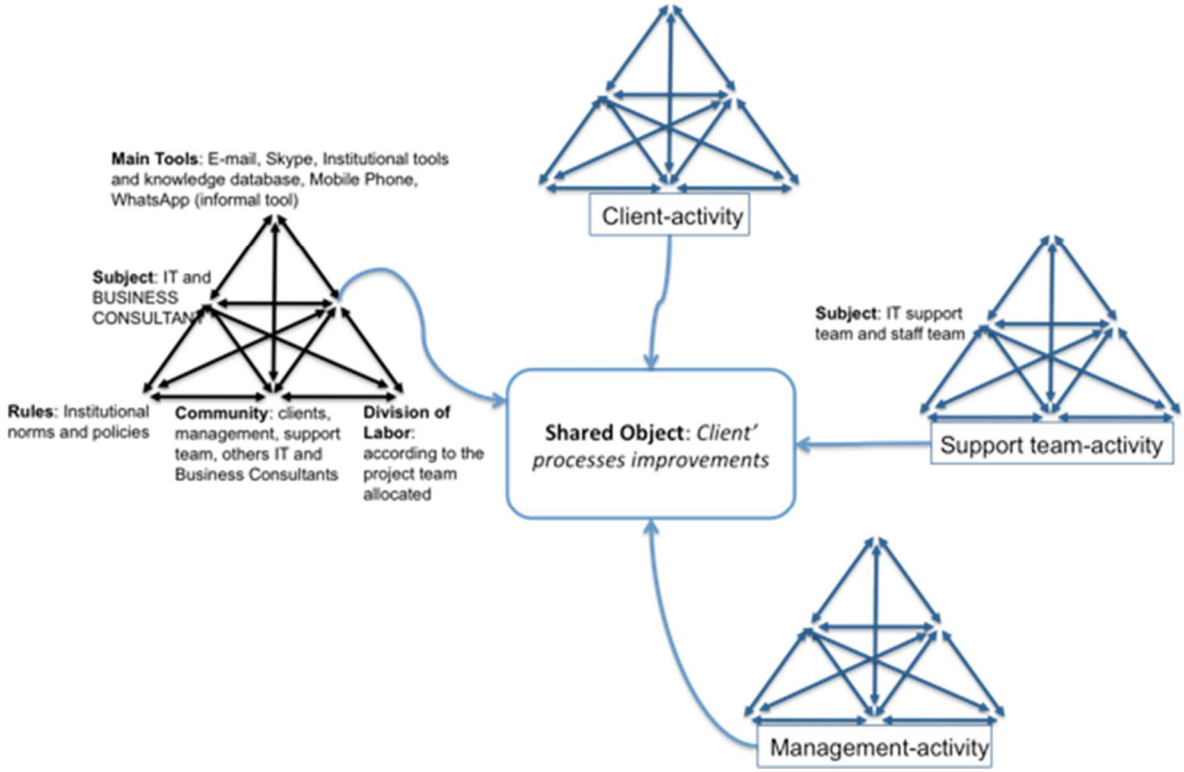
Figure 49 – Participants identification in the ITCON case

		Participants Identification			
		1	2	3	4
Position	IT and Business Consultants	X	X	X	X
Gender	Male	X	X	X	X
Age	20-30		X		
	31-40	X		X	X
Type of Mobility	Working at three or more places and constantly moving	X	X	X	X

Source: Research data.

The activity system of case ITCON is presented in Figure 50. The IT and business consultants are the MKWs who experimented the artifact. The manager is responsible for the definition of the team of consultants – who often work independently – and for the project management. The team of consultants can work on many projects at the same time, and they have autonomy to work on the projects when they think as appropriate or based on the negotiation with clients. They have particular tasks to perform and specific roles to assume in the projects. The Support team, in turn, is responsible for helping the consultants with the tasks that can be completed in the company headquarters. For instance, whether one consultant needs someone to programming some computer routine, they can trigger the support team. The clients also share the same object of the consultants since they are responsible for the processes in which the project focuses.

Figure 50 – The activity system of the ITCON case



Source: The author.

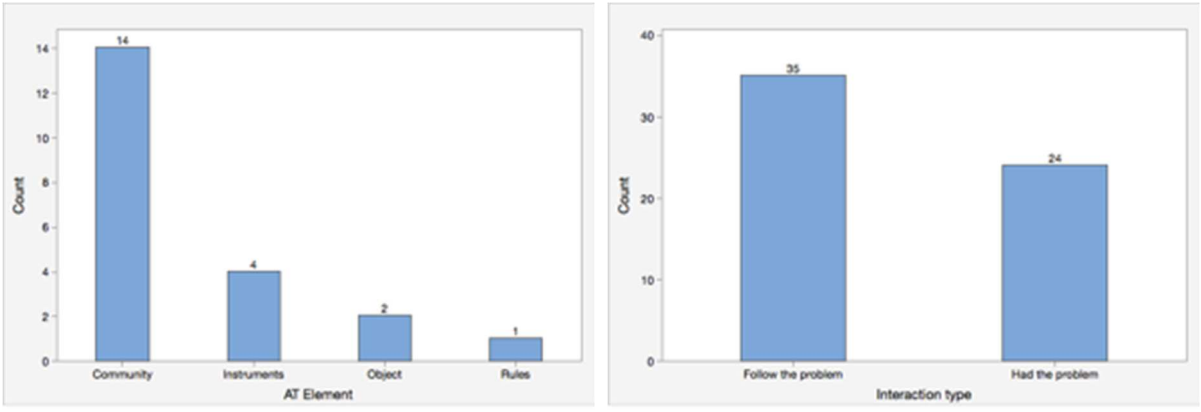
As illustrated in Figure 51, the disturbances reported by the IT and business consultants were primary related to 1) Community, 2) Instruments, 3) Object and 4)

Rules. About the community and object, the main disturbances were generated by the difficulty to interact with the clients' and also with the support team. As mentioned by Participant 1 "I do not have problems in working on a team, however, I see that my best results are in isolated activities." Also, they often mention the difficulty in defining or keeping the project scope. They state that clients are always changing the scope and this can generate conflicts and, many times, rework.

Regarding the instruments and rules, the main disturbances reported are related to the use of ICT tools inside the clients site, they always need to configure something different for each customer, and the rules they need to follow either from the client and from their own company. Because many times the rules of their company, in a certain way, reflects on the clients' rules, then, they also need to deal with this situation and coordinate the healthy relationship between the customers, where they are in the most of the time, the support team and the management. As mentioned by Participant 4 "They many times do not recognise the urgency of the thing, so we need to deal with this since we are face-to-face with the customer".

Figure 51 presents the numbers and types of interactions performed in the app by this team. Only the "follow" and "had" interactions were observed. When questioned why they did not use the "solved" problem, the participants did not know to explain why. However, the participants mentioned that when they "solved" something, they used the comments feature to register the solution.

Figure 51 – Disturbances and interactions observed in the ITCON case



(a) Disturbances reported (b) Interactions performed

Source: Research data.

The main interactions of these workers are based on instant messages via Whatsapp and Skype tools. They also used phone calls, when they need urgency to solve something or email when the situation is not so urgent to address. Due to that and also due to the characteristics of MKW (i.e. high mobility, autonomy, etc.), the opportunities to put into action the processes of knowledge creation and knowledge sharing with their community are restricted. Therefore, the main perceived benefit of mobChangeLab to these workers was also to consolidate the communication in one place and promote the occurrence of learning actions. In the data collected was observed some examples of learning actions. The majority of them are the representation of small-scale cycles of expansive learning. Figure 52 presents an example of this kind of expansive learning.

Figure 52 – Some examples of learning actions in the ITCON case

Example 1: Dealing with the client	
mobChangeLab step	**Example**
Problems and challenges identification (Questioning)	Participant 2: How can I deal with a client that changes the requirements at any moment?
Target definition (Analysing the situation)	Participant 4: Are you validating the solution hypothesis with the client before you start developing it? Participant 2: Yes, we always validate everything before starting…
Solution elaboration (Modelling and Examining the model)	Participant 4: A suggestion then would be to get the client acceptance so that it does not change the requirements all the time. There will be exceptions, of course, but maybe that'll soften up a bit. Participant 2: I also thought about using metrics to measure the amount of related tasks done so we can show the time we are missing out on reworking the modified tasks. Participant 1: You could also use the metrics to present to the client the amount of changes made. This would be a way of highlighting that many changes are made after the development has started.
Solution implementation (Implementing the model)	The idea of using metrics is carried out by the mobile worker that had the problem (work in progress)

Source: The author.

In the evaluation, the participants mention that it was easy to use the artifact. “I think it's ok it is easy to see and put the information there, also the comments, I believe that it's very simple” (Participant 3). “It seems like; it seems to have worked well, our interactions” (Participant 4).

5.3.1.4 Case ITPRO

This case was very different from the others since the MKWs in this case study were not from the same organisation. Following one idea that was built during the researcher participation in an entrepreneurship competition, the artifact developed could help any professionals who have an active community of practice (CoP)[1], formal or informal, to evolve their knowledge. The key condition is to perform similar practices, such as IT Professionals who manage projects in their companies. Therefore, the team of case study D was a team of 10 IT professionals. Each professional works in a different company, but they have similar attributions. They are also part of a strong social network; they already worked together in the past. They are IT Consultants and IT Project Managers who work with different clients and different teams. Although they do not work together and do not have an apparent reason for a change, they agreed to trial the artifact with the objective to share common problems and to collaborate in their solution, and consequently in their learning expansion on the move – their shared object. Figure 53 presents the participants identification in this case.

Figure 53 – Participants identification in the ITPRO case

		Participants Identification									
		1	2	3	4	5	6	7	8	9	10
Position	IT Consultant			X		X					X
	IT Project Manager	X	X		X		X	X	X	X	
Gender	Male	X	X		X	X	X	X	X	X	X
	Female			X							
Age	20-30	X	X	X	X		X	X		X	
	31-40					X			X		X
Type of Mobility	Alternating between two fixed locations	X	X				X	X		X	
	Working at three or more places and constantly moving			X	X	X			X		X

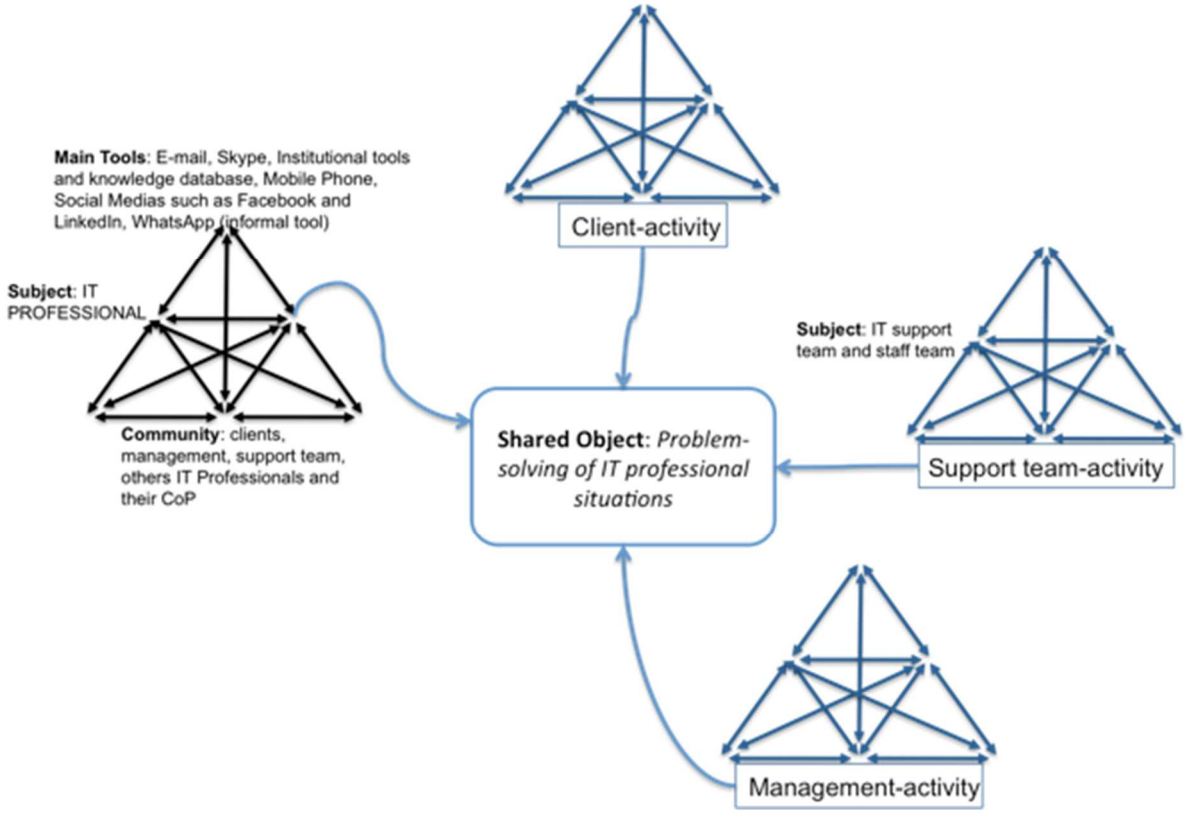
Source: Research data.

The activity system of these professionals is presented in Figure 54. As observed, the activity system is very similar to the activity system of the team studied in case

[1] The community of practice (CoP) can be defined as a group of people who share a concern or a passion for something and regularly interact to learn how to do better (Lave & Wenger, 1991). This concept was presented in section 2.2.1.2 Situated learning theory.

ITCON. However, in this case, the shared object of these professionals and their community is the problem-solving of IT professional situations. The object is directed influenced by the system activities of their community (Client, Management and Support team) since many times the need for knowledge is triggered when the IT Professionals are working with these people.

Figure 54 – The activity system of the ITPRO case



Source: The author.

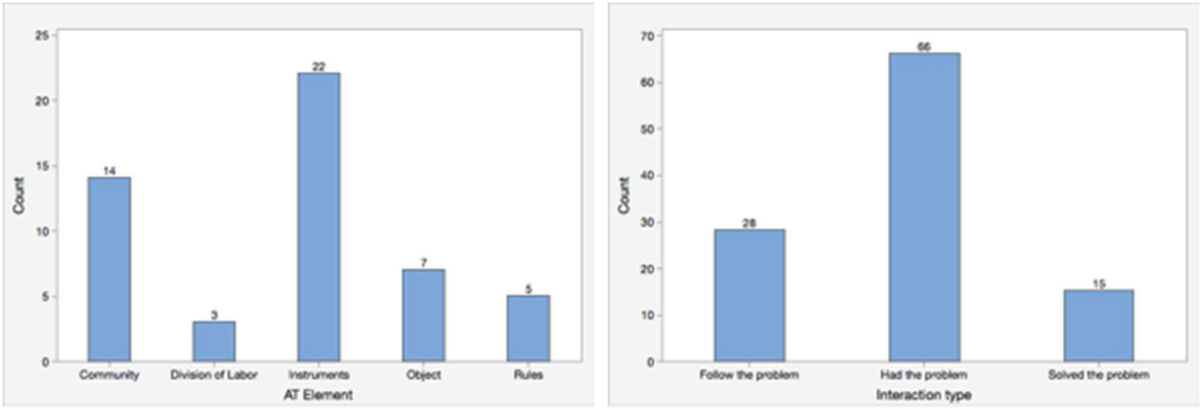
As illustrated in Figure 55, the disturbances reported by this team were primary related to 1) Instruments, 2) Community, 3) Object, 4) Rules and also 5) Division of Labour. According to the professionals, the main criteria used to report the difficulties were those involved in their work process and that could help them to achieve their professional's objectives. "Problems that I was having there at the time and so I reported" (Participant 2). "I reported day-to-day problems" (Participant 3). As also mentioned by Participant 1,

> I first raised questions that involved my work process in my professional organisation and who could help me. For example, when I had an impediment (an obstacle to realise something), then

> I have posted in the group, waiting for an answer, because it was often an experience that I have had there and I wanted to see how was a vision of it in another company, for example.

Figure 55 also presents the numbers and types of interactions in the app done by this team. The three types of interaction were observed, and the “had interaction” was the feature more used by them.

Figure 55 – Disturbances and interactions observed in the ITPRO case



(a) Disturbances reported (b) Interactions performed

Source: Research data.

Since this group considered itself previously as a sort of CoP, sometimes they interact with each other to discuss some issue or a new way of work that they heard about via WhatsApp or Skype tools. They also use phone calls and emails, but the common tools used for knowledge sharing are the first ones. However, these interactions are mainly one-to-one interactions, then, they also have fewer opportunities to put into action the processes of knowledge creation and sharing within the large group. Therefore, the main benefit of mobChangeLab to these workers was also to promote the discussion between all members of the CoP and to allow the occurrence of learning actions among them. In the data collected it was observed some examples of learning actions. The majority of them are the representation of small-scale cycles of expansive learning for the individuals and their context. Figure 56 presents an example of this kind of expansive learning.

Figure 56 – Some examples of learning actions in the ITPRO case

Example 1: Tasks management	
mobChangeLab step	**Example**

Problems and challenges identification (Questioning)	Participant 1: Here in my company, we put all of our tasks in an Excel worksheet, which makes the task definition process very complex and difficult to monitor. Does anyone have any suggestions for a better project management tool?
Target definition (Analysing the situation)	Participant 3: I have worked in two companies that use Redmine to control tasks. I found it easy to use. And in the current company, we use Redmine only for registration, but the time and responsible control is done via 'kanban board' and works well. Participant 7: Have you ever tried to use the MS Project? Participant 8: Jira is better Participant 4: I think MS Project is the best. Participant 7: Excel was not developed for this type of task; I recommend the use of Microsoft Project that was created to manage projects, teams and resources. Participant 9: Trello also could help. It is practical and easy to use.
Solution elaboration (Modelling and Examining the model)	Based on the interactions made, the mobile worker sought to know more about Trello. He searched the Internet and found the website of the tool. After reading about it, he chose to experiment the tool since it is a free tool
Solution implementation (Implementing the model)	This experimentation of the tool is carried out by the mobile worker that had the disturbance reported (work in progress)

Source: The author.

According to the participants, the artifact is interesting and can be used to promote the knowledge sharing between the participants of a group, independent of their work relationship. As mentioned by Participant 8, "It remembers me the Stack Overflow[2]. I think it is a nice tool since you can use it in a closed group". However, the majority of the team agreed that the artifact could be more useful in a team who work together. As stated by Participant 4,

> I think that in a company it would be much more usual, to report and discuss difficulties. For instance, in my process, I had several difficulties, but I did not put there because they were part of my internal process, it is very specific, internal problems of people, I think this in a company it would be better used. More useful, which I consider being quite the focus of the tool.

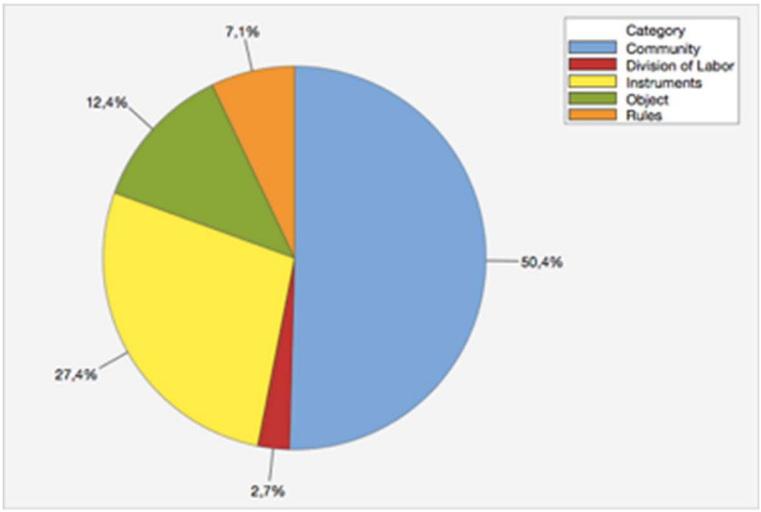
This team also mentioned several interesting ideas to improve the artifact. Some of these ideas are discussed in the next sections. In the next section, the summary of the results of this first trial is discussed.

[2] Stack Overflow is a question and answer site for professional and enthusiast programmers (http://stackoverflow.com/tour)

5.3.1.5 Summary – Case studies

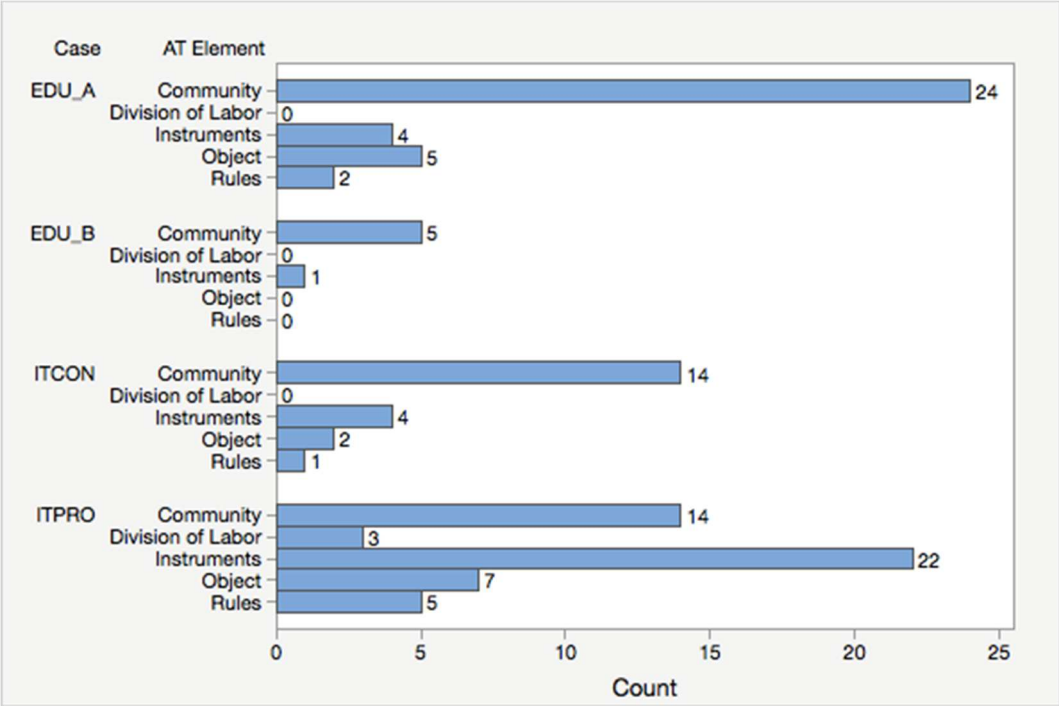
During the first trial period, the participants of the four cases reported a total of 113 disturbances and 201 interactions. As illustrated in Figure 57, more than 50% of the disturbances reported by them were categorized as disturbances with their community. These results indicate that even working alone; these workers interact intensively with their community. Plus, because of their characteristics, such as high mobility and autonomy, this interaction is more susceptible to disturbances and conflict situations. Figure 58 presents the distribution of the disturbances reported, grouped by each case and the AT element used to categorise the disturbances.

Figure 57 – Total of disturbances observed



Source: Research data.

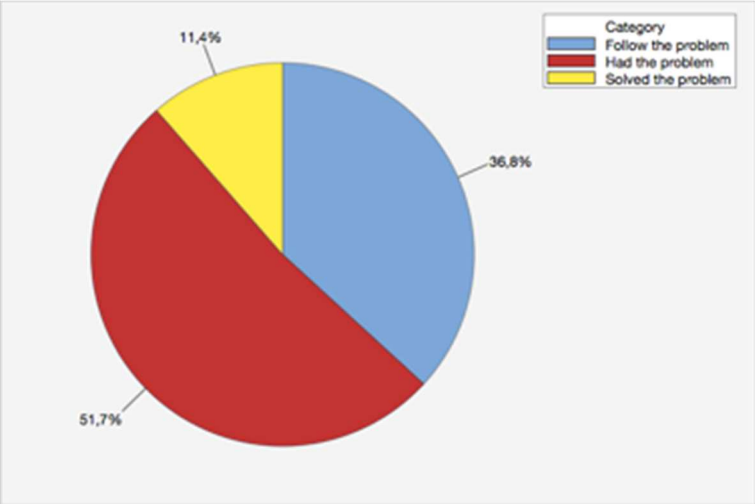
Figure 58 – Total of disturbances reported per case



Source: Research data.

Another interesting result, as presented in Figure 59, is the fact that more than 50% of the interactions were related to the occurrence of the same problem already reported by another worker. This result indicates that it is common to have recurrent problems in the context of MKWs, and the problem-solving of them can be supported by the use of the mobChangeLab. Considering that mobChangeLab was developed to help the MKWs in their own context, they can use it at any workspace they are working. Besides, because the mobChangeLab was designed based on the specific needs of these professionals, identified in the first step of this DSR, the tool can support them to find the people who can help them, and also can stimulate the collaboration in the problem-solving through the resources available in the tool.

Figure 59 – Total of interactions observed



Source: Research data.

One interesting thing that was observed is that, based on the interaction about the problems reported, participants already started to carry out some learning actions and to address possible solutions. These learning actions were carried out mainly for disturbances considered by them as simple, in other words, disturbances that they already knew how to solve or those about they had some ideas (short-term actions to solve it). As mentioned by the Participant 9 in the case of ITPRO “When I had that difficulty already or when I already knew about it, I commented the disturbance and proposed some ideas to solve it”.

In the second phase of the mobChangeLab method, the transformation phase, based on the disturbances reported, participants needed to prioritize and select which disturbances were necessary to address in a long-term action plan. Due to the trial period - only three months - it was not possible to follow the implementation of the solutions modelled by the participants in the long term. Thus, more time to observe this phase need to be planned in future experiments. However, as mentioned by the participants in the evaluation interviews, the method and tool helped them to follow a line and a logical reasoning about what occurs, when, where and with whom. This also allowed them to build a sort of history of the activity.

> The things that I’ve registered here, which are things that have generated even a historical, I also found cool because it was produced a history of the activity. This makes me think that even if another lecturer assumes this academic activity and read this records here, she could also have the condition to follow, a little bit, what happens, you know. Because today all of this history is only with the lecturer/tutor responsible for the academic activity and with the course coordinator, […] but in fact, there is no formal record so complete as this record here. I start to think that it would be useful for this, but of course, it would be useful also for this real-time

> discussion with several people accessing and being able to comment and having access to the issues that we bring here (Participant 1 of the case EDU_B).

Furthermore, as observed, the artifact helped the workers to conduct short-term actions. These short-term actions were carried out even in the first phase of the mobChangeLab, through the interaction in the comments feature, and allowed them to check and to report again disturbances and conflicts generated by the implementation of these actions. This is directly linked to the idea of the small-scale cycle of expansive learning and also to the continuous improvement over time.

It is important to highlight that the idea of continuous improvement was added during the two last iterations of the DSR. This idea was based on the continuous use of the mobChangeLab app by the MKWs and was emphasised for some of the participants in the demonstration step of the DSR. As detailed in the cases results, the team of the EDU_ A case liked the experience of using the tool, and they asked if it was possible to continue using the tool continuously.

During the demonstration step of the DSR, minor changes were made in some screens and features. These changes were made based on the evaluation and feedback provided by the MKWs participants with the purpose to provide a better user experience for them. Besides, to improve the mobChangeLab app, some participants also suggested some offline features mainly related to the disturbance self-reports. As mentioned by the Participant 7 of the ITPRO case “It could work offline... Because when you are without Internet connection in a place, hence you could use it... Because when you are without Internet connection, you can not even report something”. This suggestion was saved for future analysis and evolution of the tool.

Next section presents the details of the second trial carried out with six other IT Professionals.

5.3.2 Second trial

This trial consisted of the test of the Experience Sampling Method (ESM) adapted and developed as a feature in the mobChangeLab app. The original idea of this feature was to use it in the first phase of the mobChangeLab method, the consciousness phase, along with the disturbance self-report. Then, it would be possible to better understand the context of the MKWs observed and get more data to present to them

at the mirror features (timeline and analysis tools of mobChangeLab app) and motivate their knowledge creation and knowledge sharing practices.

However, as already mentioned in the section 4.4 Demonstration of the solution, it was not possible to have this feature available in time for the first trial. Then, this researcher decided to test only this feature with other MKWs. Thus, the second trial was carried out with a team of other 6 IT Professionals who also are MKWs since they work at three or more places. This second trial was carried out with them during four days, resulting in a total of 72 responses in the database. Figure 60 presents the participants identification.

Figure 60 – Participants identification in the second trial

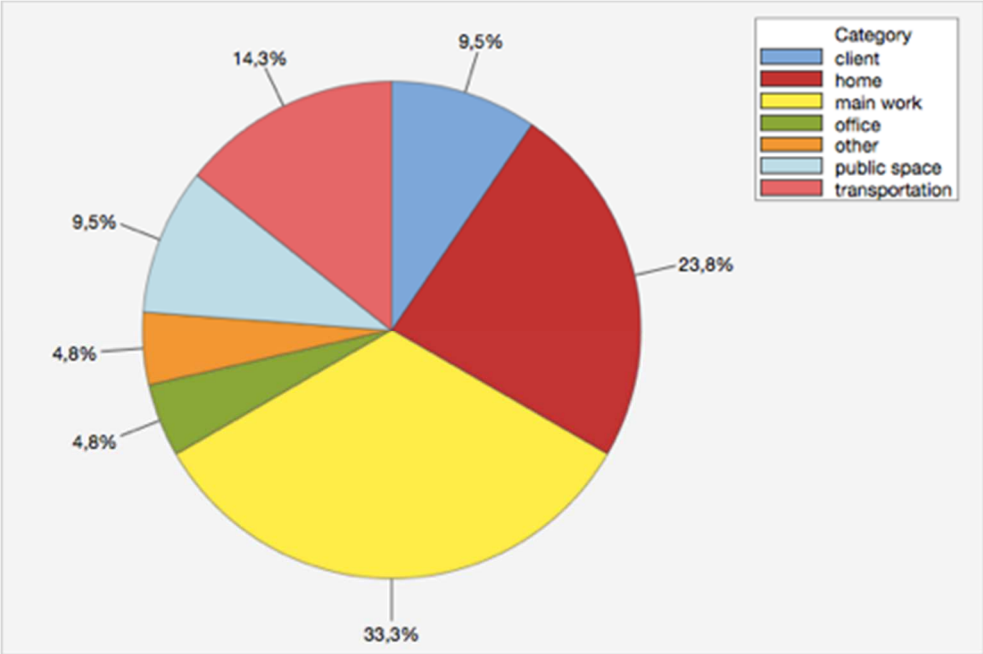
		Participants Identification					
		1	2	3	4	5	6
Position	IT Professional	X	X	X	X	X	X
Gender	Male	X	X		X	X	X
	Female			X			
Age	20-30	X	X	X	X	X	X
Type of Mobility	Alternating between two fixed locations	X	X	X			X
	Working at three or more places and constantly moving				X	X	

Source: Research data.

The responses of this trial are related to three questionnaires that the participants needed to answer randomly. The first questionnaire was about the context of the MKWs' activity, the second was about the ways of searching for knowledge, and the third was about the ways used to share information and knowledge with others.

A results summary of the first questionnaire is presented in Figure 61. The results showed that these MKWs often work in a variety of places; however, the main places often used to work were the site of their company and their home. These results reinforce what was found in the literature and also in the problem understanding step of this DSR. The original idea of collecting this data in the first phase of the mobChangeLab method was to compare with the disturbance self-report and observe where the main disturbances occur. Then, this data could help the workers and also their management to address these situations.

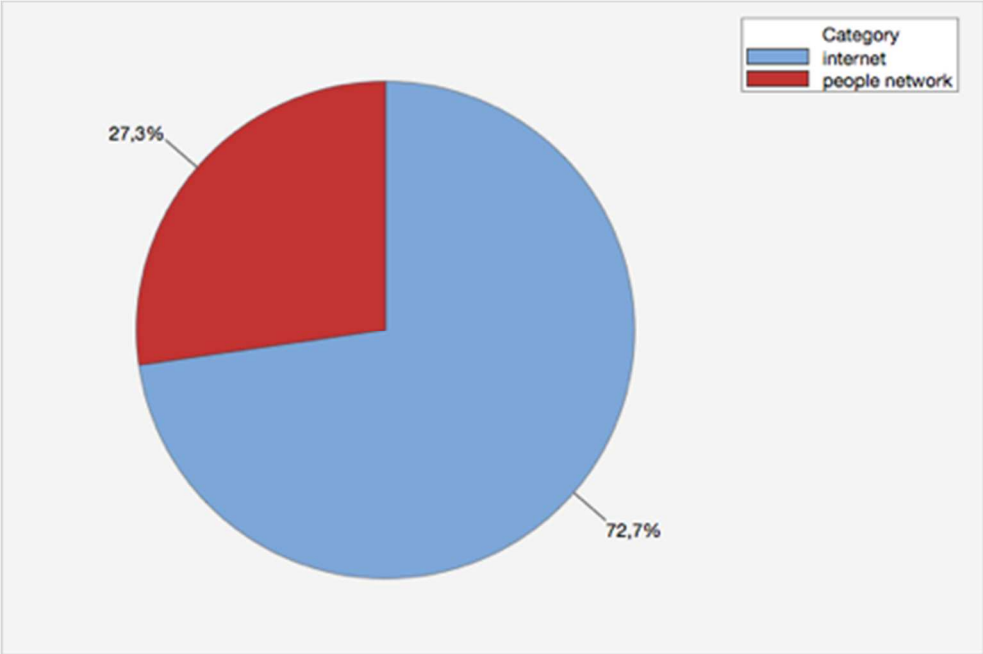
Figure 61 – Places MKWs used to work



Source: Research data

The second questionnaire had as primary objective to observe what ways the MKWs use to search for information or knowledge. The results confirmed the problem understanding interviews. As a first step, it is very common for these workers try by themselves to search for what they need, and they often use the Internet to carry out this search (Figure 62). As mentioned by many participants in the problem understanding interviews, first they need to understand a little bit more about the subject, then they look for people who could help them with more consistent information. They take these steps since they considered that, many times, the information available on the Internet was not so reliable. This is an interesting result and reinforces the need for tools that promotes the collaboration between MKWs.

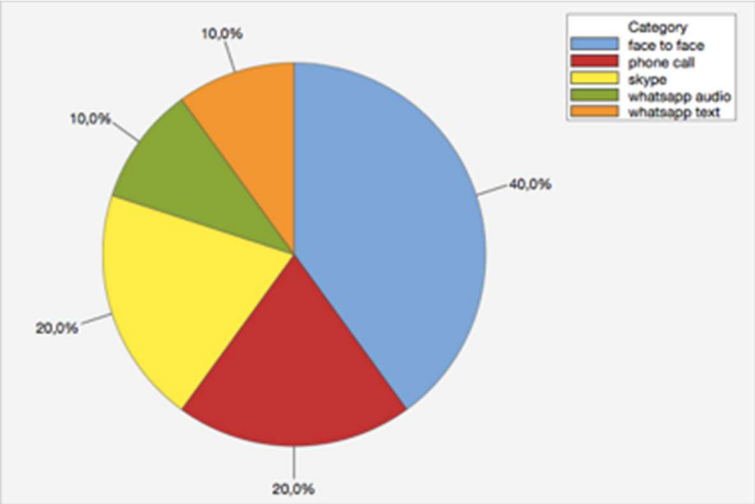
Figure 62 – Where the MKWs searched for information



Source: Research data.

Finally, the last questionnaire had as main objective to understand how frequently these workers share their knowledge and what tools they use for it. The results showed that they are always sharing information with their community and they use a variety of tools to do that. However, as presented in Figure 63, and previously highlighted by the Participant 6 in the problem understanding interview, whenever it is possible, they still prefer the face-to-face contact to share knowledge since they consider this the best way to get information and also collaboration to solve issues. “You can sensitise a person much better if you are in front of her than on the phone or via instant message. It is always better” (Participant 6 of the problem understanding interview).

Figure 63 – Tools used to share information and knowledge with others



Source: Research data.

The results of this trial showed that the feature of the ESM developed helped to better understand the context and practices of knowledge creation and knowledge sharing used by the MKWs in focus. The data generated can also be presented in the mirror feature created in mobChangeLab, to motivate the workers' reflection and help them to better think about how to transform and improve themselves and the results of their work. Next section presents the last procedure carried out in this research to demonstrate and evaluate the artifact developed.

5.3.3 Overview of results from the demonstration to experts and practitioners

As previously mentioned, the demonstration of the artifact to experts and practitioners was also performed through: (1) meetings/presentations to experts in the mobility field and entrepreneurship and to practitioners (15 meetings); (2) emails and informal conversation and (3) survey with practitioners during an entrepreneurship competition (56 participants). All demonstrations had a positive feedback and also many contributions to improve the artifact. As more demonstrations were made, more new ideas emerged. For instance, the use of the artifact by practitioners who wanted to help each other - not necessarily their co-workers - but they need to be engaged in to co-create and improve themselves with others' help. This is directly related to the ZPD concept, one of the key concepts in this research.

Another interesting result of these demonstrations was the idea to allow the use of the artifact by other professionals, not only mobile workers. For instance, a contact

from CONFEA (Federal Council of Engineering and Agronomy - Federal District) was received in which they were interested in the artifact to better perform their activities of processes improvements. The researcher is in contact with them to perform a new trial of the artifact with this public.

> I am very interested in the tool, but not only for the identification of improvements and problem solving in the context of mobile workers. I think the tool should be very useful for other types of problem solving related to processes in general. Would it be possible to know the tool without been in the specific context of mobile workers? (CONFEA Contact - received in a response to a social media communication released).

Lastly, contacts from other entrepreneurs and companies related to BPM (Business Process Management) and Agile Project Management were received with an invitation to conduct a business partnership. Two of them are presented below and the second one is in progress.

> I found your project very cool. We are currently launching LeanPB, which is a tool for managing agile projects. We don't have yet a mobile version to support this tool, I found your idea interesting, and I believe we could work in partnership (Contact from an Entrepreneur of a company that has tools for Agile Project Management).

> Without appearing exaggerated, but with the proper "tone" of my perception, I think the consulting market for small and medium-sized companies can be revolutionised with our union (Contact from a BPM Consultant and Entrepreneur recognised in the BPM area. He is one of the responsible of the ABPMP Brazil[3]).

The demonstration results indicate that the artifact developed in the DSR is useful and could help not only mobile workers but also other professionals. These results meet the main objective of the DSR method that is to make real and practical contributions.

5.3.3.1 Obstacles to test the mobChangeLab

Despite the positive feedback received during the demonstration to experts and practitioners, some obstacles were also encountered that made difficult to carry out more tests and cases. A summary of these obstacles is presented in this section.

The first obstacle was related to the confusion about the research project and the "mobChangeLab product". Many practitioners understood the mobChangeLab as a commercial product and questioned about price, security information and integration

[3] http://www.abpmp-br.org/

with other tools. As mentioned by one practitioner, participant in one of the demonstration meetings, “We already have some tools that help us, but we want to know more about your product”. This situation occured at least three times, with different organisations that have MKWs. Unfortunately, after the demonstration meeting and contacts, by telephone and email, these organisations did not return the last contacts in which they were invited to test the artifact.

Another obstacle faced was related to the use of the word “problem” in the context of the mobChangeLab. It was observed some resistance about the use of this word. Many practitioners, even experts, in the demonstration phase, claimed that they did not have “problems” but “difficulties”. This situation occurred a lot, and, because of that, the word “problem” was changed by “difficulty” inside the mobChangeLab app. After this change in the tool, it was observed less resistance to understand the concept of the project and to participate in the trial.

A third obstacle encountered was related to the work relations between some types of MKWs and the companies they work for. For instance, one organisation that had MKWs (management consultants that travel to attend clients) wanted to use the mobChangeLab to help them in a strategic project that was aimed to improve the work practices of these workers. However, because the project was strategic, the organisation did not want that the MKWs participated or collaborated in the definition of changes. The responsible for the organisation stated that they wanted to use the mobChangeLab to change the work practices of their MKWs, improving them, but they did not want to involve the MKWs because they are outsourced, independent workers. Therefore, the concern of the organisation was to make sensitive and strategic information available to them. After three meetings and contacts by email and Skype conversations, this organisation also did not return the last contacts about testing the artifact.

One more obstacle observed was related to the individual use of the mobChangeLab. Some practitioners wanted to use the artifact alone, but this was against the very goal of the artifact. Considering the premise of this research that learning occurs based on social interaction, to stimulate collaborative problem-solving a community, of at least two participants, are needed.

One last obstacle observed was related to the systems requirements to use the mobChangeLab app. Another team from the same University of the EDU_A and EDU_B cases wanted to use the artefact, but the mobChangeLab app was developed

to work only on iOS and Android platforms, and one member of this team had a smartphone with another operational system (Windows Phone). According to the global statistics about mobile operational systems[4], Windows Phone is used only by 0.96% against to 71.84% of Android usage and 19.88% of iOS usage. Therefore, the author decided not to implement a new version of the mobChangeLab, especially for Windows Phone. However, for the app evolution, it is already planned a web version that could be used in any smartphone or notebooks.

The next section presents the overview of results from the evaluation of the mobChangeLab.

5.3.4 Overview of results from the mobChangeLab evaluation

As already mentioned, the evaluation of the mobChangeLab was processual. During the period of trials the evaluation was made through the observation of app use and also in informal conversations with the participants. These procediments helped to evolve the artifact according to the needs observed. As mentioned before, the artifact was improved 6 times. Most of improvements were made in the mobChangeLab app. Only one improvement was made in the mobChangeLab method, the idea of continuous improvement between the two phases over time. Figure 64 illustrated the mobChangeLab method improved.

About the improvements in the mobChangeLab app, first, minor changes were made in the timeline screen to help the MKWs quickly know which disturbances already had interactions from their community. Then, the notifications were evolved to allow all the participants knew where a new disturbance was reported. Afterwards, there were improvements in the statistics screen, and the English version was also made available. Finally, improvements in the comments interaction were also deployed.

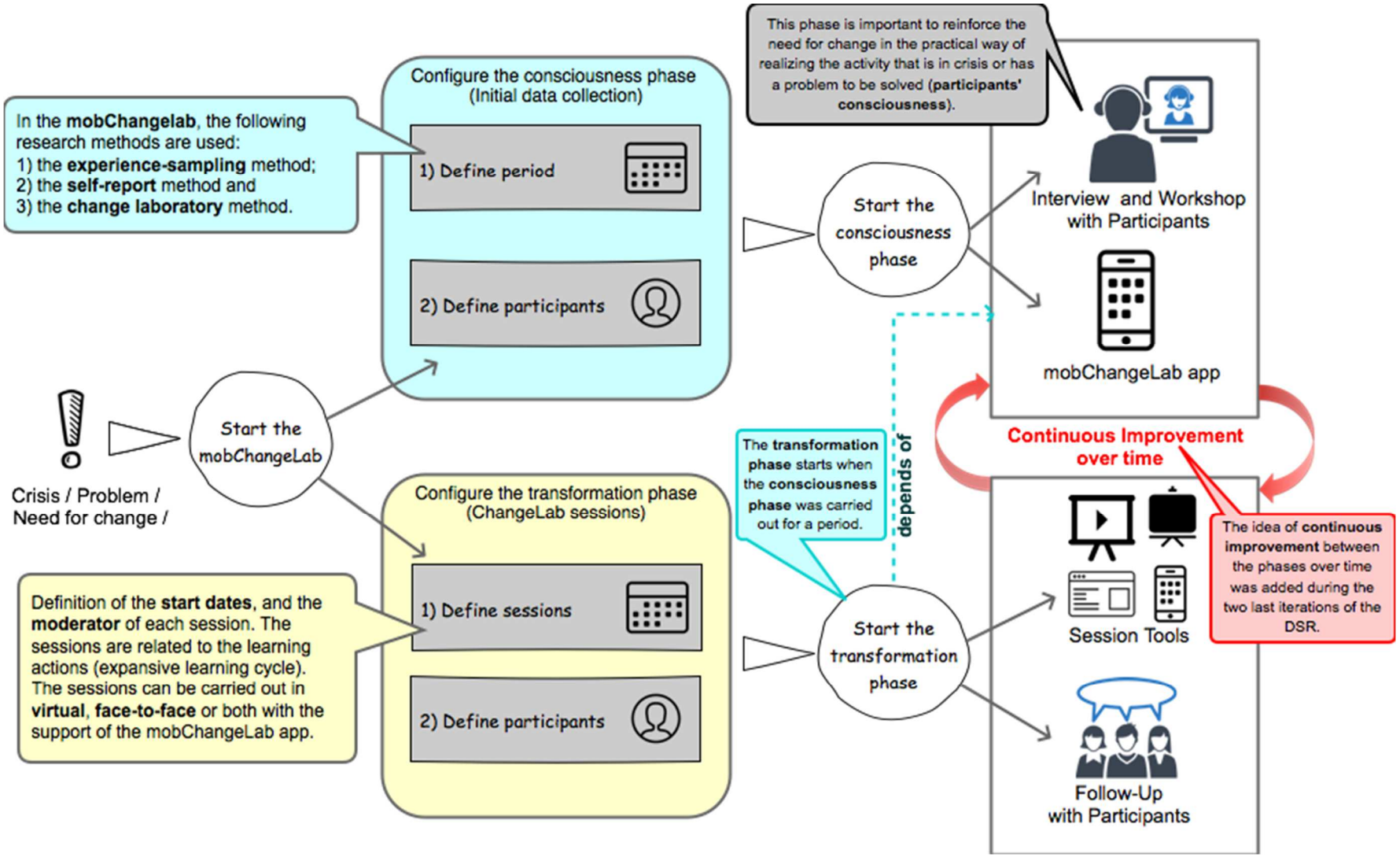
Other improvements were identified in the final evaluation of the artifact. All of them are related to the mobChangeLab app. For instance, the main improvements pointed by the participants were: (a) the possibility to use the app without Internet, reinforced mainly by the participants of the ITCON case, (b) the possibility to create or adapt the subcategories in the disturbance report, (c) the possibility to use it in a notebook or in a desktop computer – a web version, (d) the possibility to allow the

[4] http://gs.statcounter.com/os-market-share/mobile/worldwide

MKWs to create and interact with other communities in parallel – in a separate way, and (e) the possibility to register the disturbance and also to hear the interactions or disturbances registered by others through audio. The MKWs stated that these resources could help them a lot, mainly when they are working on the move.

In the next chapter, a discussion of the results presented in this section is carried out.

Figure 64 – The mobChangeLab method improved



Source: The author.

6 DISCUSSION

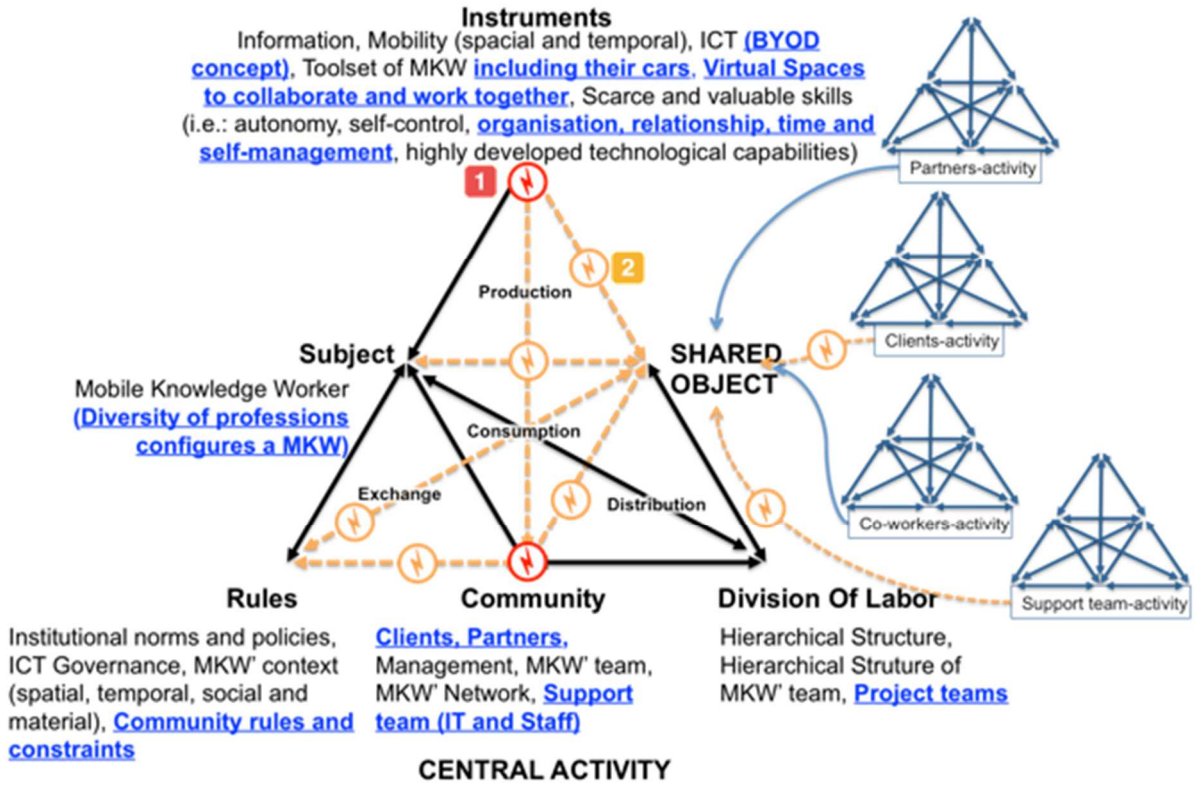
In this chapter the discussion of the research findings is presented. First, the research question and research goals are reviewed, and its main results are discussed. Then, the conceptual model and the research propositions are reviewed and discussed.

6.1 MAIN CHARACTERISTICS AND CHALLENGES OF THE MKW' CONTEXT

The first specific objective of this research was to identify the main characteristics and challenges of the MKW's context. The results of this objective are presented in the literature review (see 2.1 MOBILE WORK AND MOBILE WORKERS), and also in the empirical results gathered in the first step of the DSR (see 5.1 UNDERSTANDING THE PROBLEM) and in the fourth and fifth step of the DSR (see 5.3 DEMONSTRATION AND EVALUATION OF THE ARTIFACT).

Based on the framework of the AT proposed by Engeström (1987), it is possible to summarise and better understand the main characteristics and challenges of the MKW's work context. Figure 25 uses the AT framework to consolidate the MKW' context, according to the literature review. Figure 65, in turn, solidifies the research findings, from the literature review and also from the empirical results. The highlighted items in Figure 65 represent the main empirical results that are discussed as follows.

Figure 65 – Activity System of the MKW's context



Source: The author.

As presented, the AT framework (Figure 65) allows to summarise and better understand the main characteristics and challenges of the MKW's context. These characteristics are discussed below, following each element of the framework.

Subject. The literature review indicated that many professions are considered MKWs (Cohen, 2010; McDaniel et al., 2016). In this research, the following professions were observed: IT Relationship Manager, IT Project/Services/Systems Manager, Business Consultant, Account Executive, CMO – Chief Marketing Officer, Lecturer, Lawyer. Despite the specific characteristics of each one of these professions, the AT framework helped to identify the particularities of being a mobile worker, independent of the profession. As presented in the literature review, these professionals work alone most of their work time (Di Domenico, Daniel, & Nunan, 2014; Sayah, 2013) and they are more than 20% of their working hours on the move, away from their main fixed workplace (Bosch-Sijtsema et al., 2010). This situation was also observed in the empirical results, the mobile workers observed usually work on the move and beyond the contracted hours.

Besides, since the main attributions of these workers are related to work with people (clients, partners or teamwork) (Vartiainen, 2008), they participate in diverse

situations where they can perform different roles in the projects they are involved, and they usually work on more than one project at the same period. Besides, these professionals need to be able to deal quickly with the day-to-day impediments (Jarrahi & Thomson, 2016) such as cancelled meetings, cancelled flights, different time zones, etc. This situation was observed in the empirical results; for instance, many mobile workers participated in meetings or collaborative problem-solving situations from the space where they were on the move.

All the mobile workers observed in this study perform knowledge-intensive work. They were always involved in activities to create new ideas, new technology or creative content. According to the literature, these professionals are more independent, self-organized and devoted to their performance (Yuan & Zheng, 2009). Because of that, they have more concern about their skills and competencies and often are the main responsible for their own improvement (Harmer & Pauleen, 2012). Considering that MKWs have a high mobility, they work in many places (Koroma, Hyrkkänen, & Vartiainen, 2014) and they have difficulties to meet face-to-face (Vartiainen, 2008), then, they mainly use virtual spaces to work and communicate with others. These virtual spaces were accessed by the variety of instruments they carry on to perform their work activity (Dal Fiore et al., 2014). In this research, the instruments used by the mobile workers, especially mobile ICT, helped them to be online through the virtual spaces and to keep in contact with their co-workers.

Instruments. As observed in the literature review the MKWs need to be equipped with a diversity of instruments to perform their work activity (Jarrahi & Thomson, 2016; Koroma et al., 2014). They mainly need to have information available, mobility (spatial and temporal), ICT tools, and also scarce and valuable skills to conduct their work practices (such as autonomy, self-control, organisation, relationship skills, time and self-management). The empirical results also revealed that these workers are very involved in the BYOD trend “bring your own device”. According to the participants, they prefer to use their personal ICT equipment since they have more freedom to choose which equipment is better for them and which applications they need or want to install. Two instruments were highlighted in the empirical results: (a) the consideration of their car (and the key features of it, such as embedded GPS) as a required instrument to work and (b) the constant use of many virtual spaces, such as social media spaces, to collaborate and work together.

Community. The literature review presented that these workers always need to deal with different people (new clients, teams, co-workers, etc.) (Kietzmann et al., 2013; Koroma et al., 2014). This was also observed in the empirical results, for all participants. Besides, this involvement was not only with the members of its company, but also the relationship with their clients, partners and also their network. The support and good relationship with the staff team or the ICT team is very important for their work.

Rules. The literature reviewed does not discuss the rules that the MKWs need to follow. Karanasios & Allen (2014) present some information about rules because they used the AT framework in their analyses. Some information about it also appears in (Kietzmann et al., 2013), but these two studies were focused in the MFW (Mobile Field Workers). Rules of MKWs were observed in the empirical study. The main rules that these workers need to observe are related to (a) institutional norms and policies and (b) ICT governance. However, it is important to highlight that these two types of rules are directly interrelated to the workplace of the MKWs. Then, they need to be aware of the norms, policies and ICT governance from their company, from their clients and also from the places in which they work on the move. For instance, some MKW needs to access its corporate social media to get some information or documents and the client's ICT governance does not allow this access. Another important situation is that, many times, their work activity can be influenced by their community' rules and constraints. Because they need to interact with their community, they need to follow the rules or constraints establish by them. An example of this situation is when a MKW needs support from the staff team in a specific moment, such as during lunch hour, and the staff team asks him to return later, after their lunch.

Division of Labor. As presented in the literature review, these professionals work alone most of their work time (Di Domenico, Daniel, & Nunan, 2014; Sayah, 2013). This situation was also observed in the empirical results. However, since their main attributions are mainly related to work with people (clients, partners or teamwork), they can participate in diverse situations where they can perform a different role. For instance, the IT Consultants can perform different roles in the projects they are involved and they usually work on more than one project at the same period. Then, they can participate in many structures of division of labor at the same time.

Shared Object. Each subject of the Activity System (in this case the MKW) has his own object. Due to the characteristic of the MKW, this object is shared with his or

her community. This situation is presented in the literature review about the AT (Engeström & Blackler, 2005; Miettinen, 2005; Stetsenko, 2005) and was also observed in the empirical results. In this research, the MKW' object is mainly shared with their clients and the team (IT team or staff team from their company) that support them.

The empirical results also revealed some disturbances and contradictions in the Activity System of the MKW' context. These disturbances and contradictions are strictly related to the challenges faced by the MKWs. More details about this are discussed in the next section.

6.1.2 Challenges of the MKW' context

Through the data analysis using the AT framework, it was possible to better understand what disturbances and contradictions the MKWs need to deal with. As already presented in the literature review, there are four levels of contradictions (see Figure 19): 1) **primary contradictions**: it occurs within the components of the activity system, 2) **secondary contradictions**: it takes place between the components of the activity system, 3) **tertiary contradictions**: it happens between the current activity system and its new form, the new activity system that is being transformed and (4) **quaternary contradictions**: it occurs between the activities systems, the new activity system generated can lead to mismatches in the relation with the other existing systems, that already interacted with the old format of the transformed system (Engeström, 1987).

In the empirical results mainly the primary and second contradictions were observed. Since the tertiary and quaternary contradictions happen in a large-scale cycle of Expansive Learning, it is necessary a longitudinal study to observe these types of contradictions. The contradictions observed in this study are discussed below.

Instruments. In this element it was observed a case of the primary contradiction. According to Engeström (1987), a primary contradiction is a double nature of the element. For instance, the MKW' activity includes a variety of equipment and technologies. Then, the contradiction here is: "which instrument is better to deal with my object? Because there are so many!"

Community. In this element it was also observed a case of primary contradiction, because, due to the diversity of people in the MKW' community, many times it is difficult

for them to decide who can help them better. Then, the contradiction here is: “who can better help me to deal with my object?”

The secondary contradictions were also observed in the empirical results. The secondary contradictions occur between the components of the system (Engeström, 1987). These contradictions observed in the empirical results are discussed below.

Subject ←→ Shared Object. As observed in the literature review, the MKWs work anytime, anywhere and beyond the contracted hours (Koroma et al., 2014). They have many attributions and information they need to deal with and do not have a strict routine (Jarrahi & Thomson, 2016), then they often work with a diversity of things. These situations were also observed in the empirical results and challenge the MKWs to deal with their object. For instance, many times they had difficult to deal with their object since they do not recognise it as theirs (why do I need to do that?), such as bureaucratic activities from their own company.

Instruments ←→ Shared Object and **Instruments ←→ Community**. One interesting situation was observed as a secondary contradiction between the Instruments and the Shared Object and the Instruments and the Community. Many MKWs started to adopt tools on their own, but their clients or team who shared the same object did not use or did not have experience with the new tool, challenging the collective objective of the activity system. An example of this situation was observed with the adoption of WhatsApp for information sharing and the tool Trello[1] to organise the tasks in a virtual space.

Rules ←→ Shared Object and **Rules ←→ Community**. The empirical results also evidenced some rules that made difficult for the MKWs to deal with their object or their community. For instance, the difficulties observed between the company’s rules or communities’ rules and the context of the MKWs. An example about these contradictions is related to the rules that MKWs need to follow in their own organization that conflict with the clients’ need. As presented in the empirical results, this situation makes MKWs to adopt a mix of procedures to achieve their activity goals. Then, when this happens, they start to provoke conflicts between the Rules of their companies, followed by their co-workers and support team, such as staff and ICT teams. Besides, since the mobility weakens the relationships of the MKWs with the staff or other people,

[1] https://trello.com/

these professionals face some constraints or boundaries imposed by their community, such as the lunch hour presented in the previous section.

Community ←→ Shared Object. The last secondary contradiction observed in the empirical results was related to the MKW' community and the shared object. This contradiction occurs when the community has difficulties to deal with the shared object. For instance, many IT Consultants related the disagreement on the shared object – what were the client's expectation or needs.

Based on the framework of AT and its key concepts it was possible to identify the challenges faced by MKWs. These challenges are mainly related to the disturbances or conflicts they need to deal in their everyday work. The aggravation of these disturbances or conflicts results in contradictions, that can be understood based on the AT framework. Therefore, to solve these contradictions, MKWs start to carry out learning actions to provoke the transformation and development of their activity systems. When the learning actions start, the processes of knowledge and sharing are performed. The next section discusses these practices used by the MKWs to create and share knowledge.

6.2 KNOWLEDGE CREATION AND SHARING IN THE MOBILE WORKERS' CONTEXT

The second specific objective of this research was to identify what factors are involved in the processes of knowledge creation and sharing in the context of mobile workers. As already mentioned, there is a lack of studies related to knowledge creation and knowledge sharing in the mobile workers' context. Only two studies were found (Kietzmann et al., 2013; Lundin & Magnusson, 2003). Based on the theoretical background of the AT and its key concepts such as ZDP and Expansive Learning, key concepts of this research (see Figure 24 – Key research concepts), it was possible to identify and understand these practices. These results also helped to achieve the third specific objective of this research: to analyse the way by which mobile workers create and share knowledge especially during problem-solving situations.

It was possible to observe the occurrence of ZPD in the situations where an inexperienced professional (MKW) followed an experienced one (MKW) to observe and learn in doing. These situations were observed many times with the IT Relationship Managers. Another frequent occurrence of ZPD observed is related to the participation

of these workers in problem-solving situations through ICT tools, when someone asks an experienced person for help in some specific situation. Since the MKWs need to deal with the contradictions mentioned in the previous section (manifested through disturbances about the need for information or the need to work on many projects at the same time), they first try to solve their problematic situations alone. For instance, when they need some information, they first try to find it on the Internet, and after that, they contact their community to verify if the information gathered is valid.

Finally, either in the first step of the DSR (understanding problem), and in the demonstration phase, it was possible to observe occurrences of Expansive Learning actions. In the first step of the DSR, in the participant observation, it was also possible to observe a large-scale cycle of Expansive Learning (see Figure 23 – Large and small cycles of expansive learning), where the group of MKWs started the cycle and created a new tool to help them to deal with their shared object (see Figure 33 – The Expansive Learning among the MKWs observed). In the demonstration phase, in turn, it was possible to observe small cycles of Expansive Learning in the four cases observed and, in some circumstances, the first step of the large-scale cycle. These results evidenced that the MKWs can create and share knowledge in their context and they mainly perform this through collaborative problem-solving situations mediated by the use of mobile ICT.

The next section discusses, with more details, the role of ICT in these collaborative problem-solving situations.

6.3 COLLABORATIVE PROBLEM-SOLVING MEDIATED BY MOBILE ICT

The fourth specific objective of this research was to analyse how mobile ICT are used to support collaborative problem-solving in the MKW's context. It was observed that the urgency to solve problems, to achieve their activity's goals, anytime and anywhere, made them to intensively use mobile devices to access virtual communities created in social media tools such as Whatsapp and Facebook, as an attempt to strengthen their work relations, create and share knowledge. The email is an important tool used by them to formalise the interaction with clients and staff; however, the overload of emails and its information via this media is huge. So, the use of email became "formal communication" and, for urgent communication and problem-solving situations, instant messaging such as Whatsapp is used with clients and staff.

Considering the great usage of these tools, such as Facebook and Whatsapp, the fifth research specific objective was to propose an approach to stimulate knowledge creation and sharing through collaborative problem-solving in the mobile knowledge workers' context, and the mobChangeLab artifact was created (see 5.2 ARTIFACT DEVELOPMENT) following a social media logic. The mobChangeLab comprehended tools to support the Expansive learning actions, and these learning actions were observed in the four case studies in which the mobChangeLab was used, it can be assumed that the artifact can help MKWs in their practices of knowledge creation and sharing, especially in problem-solving situations.

The demonstration and evaluation of the artifact had positive feedbacks. The results evidenced cases of expansive learning actions in all the four cases observed in the first trial of the mobChangeLab. Besides, the implementation of the mirror in the timeline feature in the mobChangeLab app had the expected effect, to evidence the existence of disturbances and to stimulate the collaborative work and small cycles of Expansive Learning towards them. Besides that, considering that the app is easy to use and does not take too much time and effort in its utilisation, it can be adopted as a new instrument to assist the professionals in becoming more aware of their everyday practices. This occurred with the team in the EDU_A case that requested to continue the use of the tool.

In the final evaluation of the artifact, some important improvements were pointed out by the MKWs (see 5.3.4 Overview of results from the mobChangeLab evaluation). These improvements are relevant to the artifact developed and can advance the support to collaborative problem-solving in the MKWs' context. For instance, because the MKWs work with a diversity of people, the idea of allowing multiple communities in the mobChangeLab app could help them to solve problematic situations with their various communities.

Next section resumes the conceptual model and research propositions defined by this study.

6.4 TEST OF RESEARCH PROPOSITIONS

The aim of this section is to discuss the research propositions defined and the final version of the conceptual model of investigation. These elements were initially

presented in section 3.5 the conceptual model of research. The three research propositions are discussed as follows.

Proposition 1. The need for knowledge and information in the Mobile Knowledge Workers' context steers the adoption of new instruments based on collaborative practices with their community.

As discussed in the previous sections, because the MKWs often work alone, have knowledge and information as their primary resource to perform their work activity, and are responsible for their own knowledge improvement, then, it is usual for them to adopt new instruments that help them to acquire the knowledge or information needed and also to participate in collaborative practices with their community. The example of the adoption of the Whatsapp or Facebook groups by the MWK and even the adoption of the mobChangeLab app by the EDU_A supports this proposition. Besides, because they often work in different contexts with different people, they need to deal with a high amount of information, rules and the restricted time to perform their activities or made decisions. Then, it is common that they look for resources, such as knowledge or information, first in their instruments and after, or when necessary, in their community.

Proposition 2. The adoption of collaborative practices for problem-solving in the Mobile Knowledge Workers' context is made through learning actions and keeps them engaged in knowledge creation and sharing.

The empirical results further demonstrated the commitment of the MKWs with their community in practices of knowledge sharing, mainly in problem-solving situations. As presented, it was very common to observe the occurrence of ZPD between these workers. Also, in the empirical results, it was possible to observe occurrences of learning actions. In the participant observation, for instance, a case of a large-scale cycle of Expansive Learning was observed. In the four cases of the test of the mobChangeLab, in turn, small cycles and first steps of a large-scale cycle were observed. Although the mobChangeLab was developed to allow the occurrence of large-scale of Expansive Learning, more time is needed to observe its happening. Considered that, this second proposition was partially supported by this research.

Proposition 3. The collaborative problem-solving in the Mobile Knowledge Workers' context is mainly mediated by mobile ICT.

The third and last proposition, in turn, brings the idea of collaborative problem-solving mediated by mobile ICT. It was observed a large adoption of mobile devices and social media such as Whatsapp, Facebook and e-mail – this one used to formalise communication. Another important evidence supporting this proposition is the positive feedback of testers about the mobChangeLab app, as already presented.

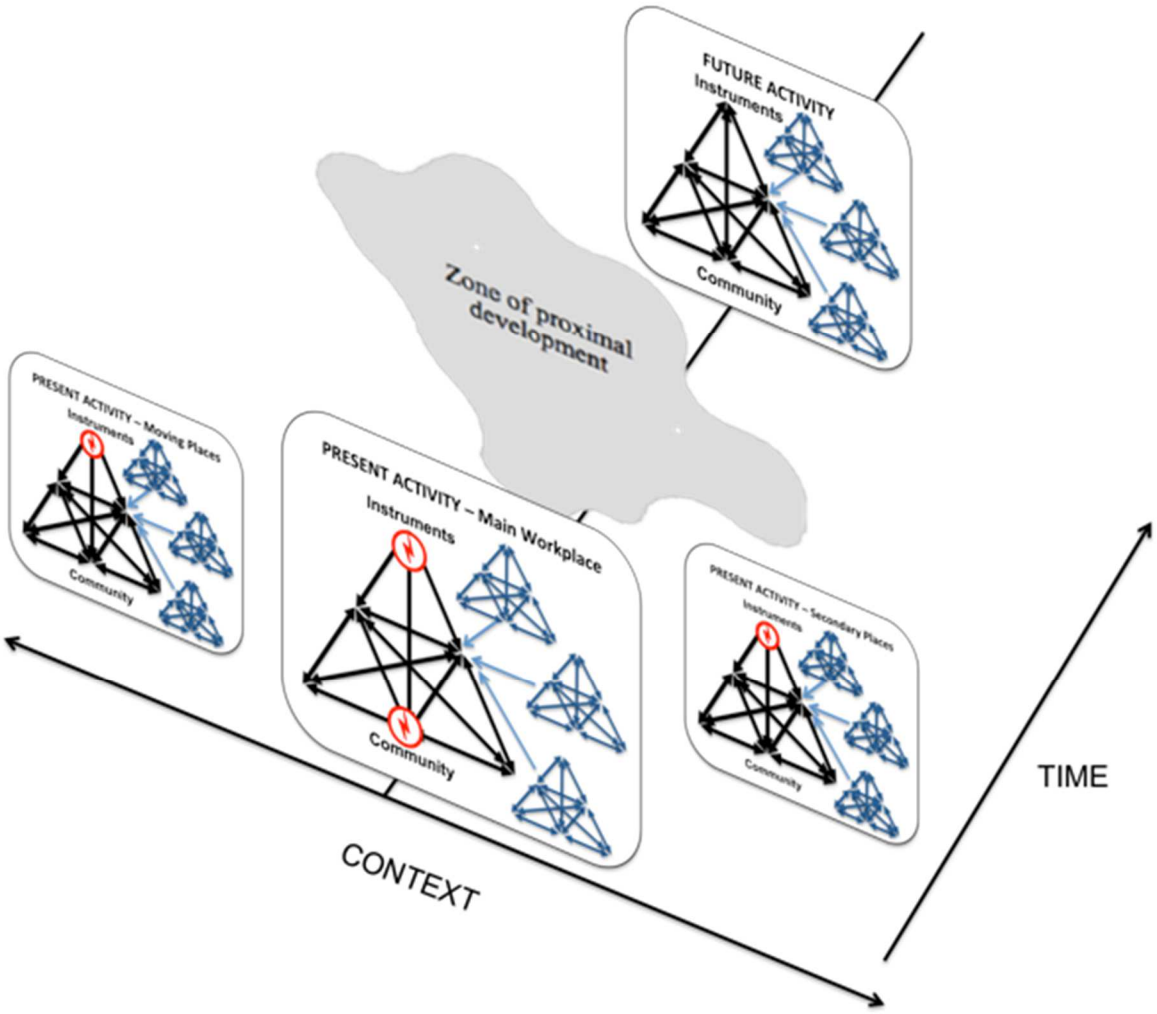
Considering the main research results and the verification of research propositions, it was possible to expand the first version of the conceptual model of research, in order to better represent the dimensions of time and space in the processes of knowledge creation and sharing of MKWs. Then, based on the five workplaces defined by Koroma, Hyrkkänen, & Vartiainen (2014): (1) moving places such as cars and airports, (2) main workplace such as the main office, (3) secondary places such as client's, (4) third places such as hotels and (5) home; the conceptual model was revised to consider them. Figure 66, presents the conceptual model revised.

The present activity system of the MKW can happen in the five places defined by Koroma, Hyrkkänen, & Vartiainen (2014). In Figure 66, three of these places are illustrated. The present activity in the model corresponds to the actual activity performed by the MKWs, in their own context – one of the five places, which has contradictions related mainly to his instruments and community –, as the research results showed. This element of the conceptual model is related to the first research proposition (P1).

To solve these contradictions, the MKW needs to participate in collaborative problem-solving with his community (P2) via the mobile ICT (P3). These collaborative problem-solving situations occur through the ZPD, where the more experienced professional helps the less one to solve the problematic situation. The learning steps they take are related to the Expansive Learning cycles. The small cycles of expansive learning are more frequent since a large-scale cycle can take years to be completed. Besides, due to the characteristics of the MKW and his/her context, the mobile ICT help them in collaborative problem-solving since it provides agility to access people and information. Then, in the individual dimension, the mobile knowledge workers create new concepts and knowledge and, in the organisational dimension, new ways

of work (occurrence of ZPD and Expansive learning actions). Therefore, in time, a new form of activity is created, the future activity system of these workers with some new or changed elements.

Figure 66 – Conceptual model revised – final version



Source: The author

7 CONCLUSIONS

This chapter presents the research conclusions. The main goal of this investigation was to analyse how knowledge creation and knowledge sharing are carried out in collaborative problem-solving situations in the mobile workers' context. It was observed that these workers use their ICT tools, especially mobile ICT, to conduct the majority of their collaborative problem-solving situations and subsequently, to create and share knowledge on the move. They do that mainly because of their characteristics of high mobility and flexible work. However, since the main reason of their high mobility is to meet people (clients, team, etc.), whenever possible, they try to perform problem-solving situations in face-to-face events since they consider it as a better way to sensitise people.

To reach the main research goal, the following specific objectives were defined: a) to identify the main characteristics and challenges of the mobile work context; b) to identify what factors are involved in the processes of knowledge creation and sharing in the context of mobile workers; c) to analyse the way by which mobile workers create and share knowledge, especially during problem-solving situations; d) to analyse how mobile technologies are used to support collaborative problem-solving in the mobile work context and e) to propose an approach to stimulate knowledge creation and sharing through collaborative problem-solving in the mobile knowledge workers' context. The results of these specific objectives were addressed and discussed in the results and discussion chapters.

To achieve these results, this study applied Activity Theory (AT) and its key concepts as a theoretical lens. This theoretical approach allowed better understanding both the individual (the MKW) as well as his/her relations in his/her social context. Considering the premise of this investigation, that learning is based on social interaction, AT helped to reach the research goals of this study. Besides, the adoption of the Design Science Research method (DSR) provided tools for a deeper understanding of the research problem and also to propose an approach to stimulate knowledge creation and sharing through collaborative problem-solving in the mobile knowledge workers' context.

Therefore, the key argument tested in this thesis, which is that collaborative problem-solving mediated by mobile ICT can support and stimulate knowledge

creation and knowledge sharing in the context of mobile workers was supported by the research results presented.

This research makes a theoretical contribution, by exploring this key argument with the use of AT as a theoretical lens to understand: (1) the elements of the activity system and the contradictions helped to analyse the main characteristics of the mobile knowledge workers, how their work practices are performed and what are the main challenges faced by them; (2) the ZPD and the Expansive Learning concepts helped to better understand how knowledge creation and sharing are performed by these workers in collaborative problem-solving situations.

Since this theory was not used so far to analyse practices of knowledge creation and sharing in the context of mobile workers, this study contributes to the expansion of this theory in this subject. The results of the empirical data also provided lessons from the practice that can contribute to the theory. Due to the diversity of workplaces that the MKWs can use to perform their work activity, as illustrated in the final version of the conceptual model proposed by this study (see Figure 66 – Conceptual model revised – final version), the same activity can occur differently in different contexts and, depending on the MKWs' context, they can face different contradictions and chose different ways of engagement in the practices of knowledge creation and sharing. These collaborative practices are mainly performed through the use of mobile ICT as a support to enter a ZPD and take learning actions.

This research also makes a methodological contribution to the IS field. The adoption of DSR and the description of its application in detail contribute to reinforce the use of this method in IS researches. Considering that, the DSR helped to understand the research problem in deep, and also to create a solution (artifact) that aims to contribute to the processes of knowledge creation and sharing as well as to the processes of collaborative problem-solving in the mobile work context. In addition, the use of the research methods: the experience sampling method (ESM), the self-report method (SRM), and the change laboratory method (CLM) to design and develop the DSR artifact, also helped to understand how these methods can be used in future investigations. Moreover, researchers, in forthcoming studies, can use the artifact developed to improve the knowledge about the subject of mobile knowledge work. As demonstrated in this research, there is a lack of studies on this subject.

Likewise, this research additionally makes practical contributions. The artifact developed, composed of the method and the mobile app, can contribute to the

following publics: (1) MKWs, (2) the management of MKW, (3) the HR area, IT teams and back office teams of the companies that support MKWs, (4) other professionals who also make use of mobile ICT to work sometimes and also (5) software developers. Considering that the artifact was developed to the needs of MKWs in the processes of knowledge creation and sharing through collaborative problem-solving, then, they are the main public that the artifact contributes. Considering that the artifact aims to stimulate improvements in the mobile workers' context, it is suggested that it can help professionals to reflect on their work practices and the challenges they face. Also, the artifact can stimulate them to look for new ways and to engage themselves in the construction of these new ways to work better.

Furthermore, the artifact also can contribute to the management, HR area, IT teams and back office teams of the companies that have mobile workers because the artifact can be used to observe who are the main contributors in helping their colleagues and what are the solutions adopted. The evolution of these solutions also can be traced (monitoring) in real time, and historical analysis of the changes in the practices can be made (to see the success and failures). The artifact can also contribute to other professionals who also use mobile ICT and aim to improve themselves through the use of a collaborative problem-solving tool. Finally, for software developers, both the method and the details of the mobile app can contribute to think and develop new ICT solutions to address the practices of knowledge creation and sharing in the context of MKW.

The findings of this study also highlight the importance of further research in this topic. It was observed a lack of studies related to mobile knowledge workers and also related to knowledge creation and knowledge sharing in the context of these workers. Moreover, since there is a forecast (McDaniel et al., 2016) that estimates the increase of mobile knowledge workers in the next years, the use of Activity Theory and Expansive Learning to analyse this context can be seen as an opportunity. The rise of mobile workers, in turn, is related to the constant evolution and acceptance of the new mobile/ubiquitous ICTs such as biometric readers, wearables, voice control, near-field communications (NFC), augmented reality, etc. Therefore, new technologies (instruments) and new ways (methods) to stimulate collaborative problem-solving can be adopted in the mobile workers' context. For instance, the use of augmented reality in the collaborative problem-solving situations.

As this study concentrates on mobile knowledge workers (MKWs) such as IT Professionals, Business and IT Consultants, and Lecturers, the conceptual model elaborated and the DSR artifact developed can be used in longitudinal studies, aimed to validate the conceptual model, contributing to the AT expansion and the evolution of the artifact. Also, further researchers can use the same method (DSR) and procedures of this research, focusing in the MFWs (mobile field workers). Finally, both for the MKWs and MFWs, more studies can address the large-scale cycle of Expansive Learning, considering that only one case was observed in this study.

The presented research has some limitations. First, the author's intensive participation in the research process can affect some results (researcher's bias). Also, the conceptual model was tested on a small number of participants. Additionally, due to the period of demonstration of the DSR artifact, it was possible to observe only small cycles of Expansive Learning in the cases carried out. Generalisations should be avoided, and interpretations and comparisons to other domains should be drawn with great caution as well. Further research might concentrate on testing the conceptual model and the artifact developed in other contexts.

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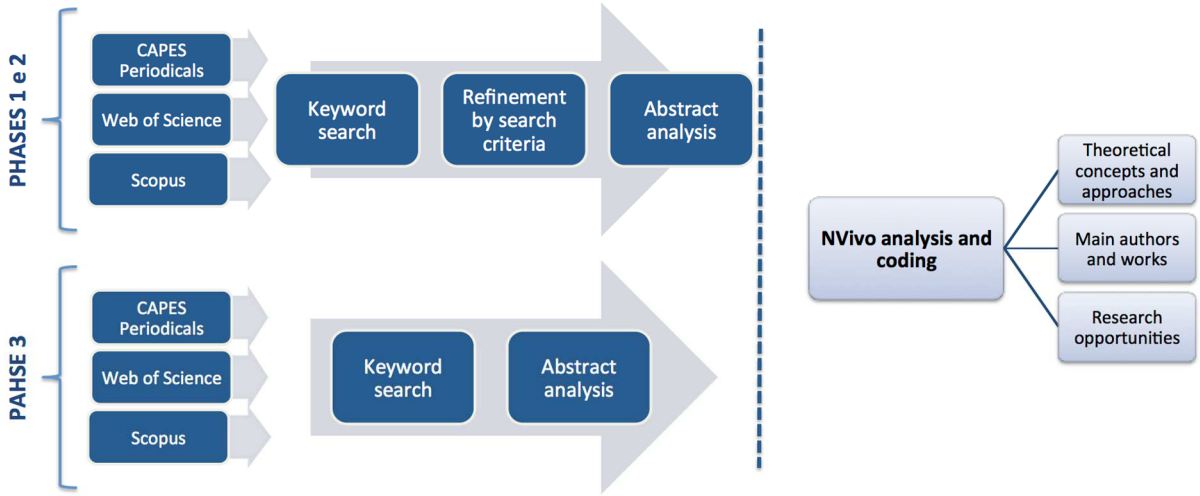
APPENDIX A – SYSTEMATIC LITERATURE REVIEW

For the systematic review of the literature two procedures were used: 1) a search for works in the scientific databases and 2) a content analysis through coding in the NVivo tool. The first procedure consisted of the utilisation of the databases: 1) Capes periodicals, 2) Web of Science and 3) Scopus; for the location of works related to the themes of the present study. The search in the databases was divided into three phases, as shown in Figure 67.

Figure 67 – Research approach for reviewing the literature



Source: The author.

The first phase of the database search was aimed to look for studies related to the topic of knowledge creation and sharing. Thus, the search was carried out through the terms ("knowledge creation" OR "knowledge sharing" OR "knowledge collaboration" OR "knowledge transfer") AND ("organisation" OR "organization"). The terms were used for search in the title, abstract and keywords of the articles of the databases, without restriction by a period of time. The result of the search was very extensive, a total of 6,971 papers in Capes Periodicals, 1,585 papers in the Web of Science database and 3595 papers in the Scopus database.

The following filter criteria were applied to carry out a first refinement of the search result: 1) Research area: Business; 2) Type of document: Scientific article; 3) Language: Portuguese and English. The application of these criteria resulted in 406 papers in Capes Periodicals, 333 papers in the Web of Science database and 846 papers in the Scopus database, and a new refinement was necessary. For this reason, the following criteria were used in the second refinement: 1) Research area: Business; 2) Type of document: Scientific article; 3) Source: a) All sources of articles in Portuguese and b) International journals related to the present research topics: *Academy of Management Journal*; *Business Information Review*; *Journal of Information Systems and Technology Management*; *Journal of Knowledge Management*; *Journal of Management Studies*; *Knowledge Management Research & Practice*; *MIS Quarterly*; *Organization Science*; *Organization Studies*; *Strategic Management Journal*; *The Electronic Journal of Knowledge Management*; *The International Journal of Human Resource Management*.

The result of this last search returned 44 papers in the Periodicals of Capes, 82 works in the database of Web of Science and 151 works in the database Scopus. A new refinement was made based on the analysis of the abstracts of the articles. The analysis aimed to select works related to the creation and the sharing of knowledge in the organisational context, published in scientific sources. Therefore, studies that focused only on technology were discarded. This analysis resulted in 91 articles that were selected for the present study.

The second phase of the database search aimed to check out for works related to the theme: enterprise mobility. Therefore, the search was carried out using the terms (“enterprise mobility” OR “mobile business” OR “m-business” OR “corporate mobility” OR “business mobility” OR “mobile business”). The terms were used to search throughout the content of the articles, without restriction by a period of time. The result returned 727 papers in the Capes Periodicals, 567 papers in the Web of Science database and 772 papers in the Scopus database. Next, the following filter criteria were applied to refine the search results: 1) Research area: Business; 2) Type of document: Scientific article; 3) Language: Portuguese and English.

After the refinement, the search results returned 58 papers in the Periodicals of Capes, 21 works in the Web of Science database and 52 works in the Scopus database. A second refinement was applied based on the analysis of the abstracts of these articles. This analysis intended to identify only works related to enterprise mobility, in the organisational context, published in scientific sources. The studies that had as main purpose the technological development or with specific domain and locality were discarded. The studies from sources such as ComputerWorld and Information Week also were discarded. At the end of the analysis, 32 papers were selected and used in the review of the literature for the present study.

The third phase of the database search aimed to find works related to enterprise mobility and creation and sharing of organisational knowledge. Thus, the search was carried out through the terms (“knowledge creation” OR “knowledge sharing” OR “knowledge collaboration” OR “knowledge transfer”) AND (“organisation” OR “organization”) AND (“enterprise mobility” OR “mobile business” OR “m-business” OR “corporate mobility” OR “business mobility” OR “mobile business”). The terms were used to search throughout the content of the articles, without restriction by a period of time. As this search criterion did not return any publication, two further attempts were made:

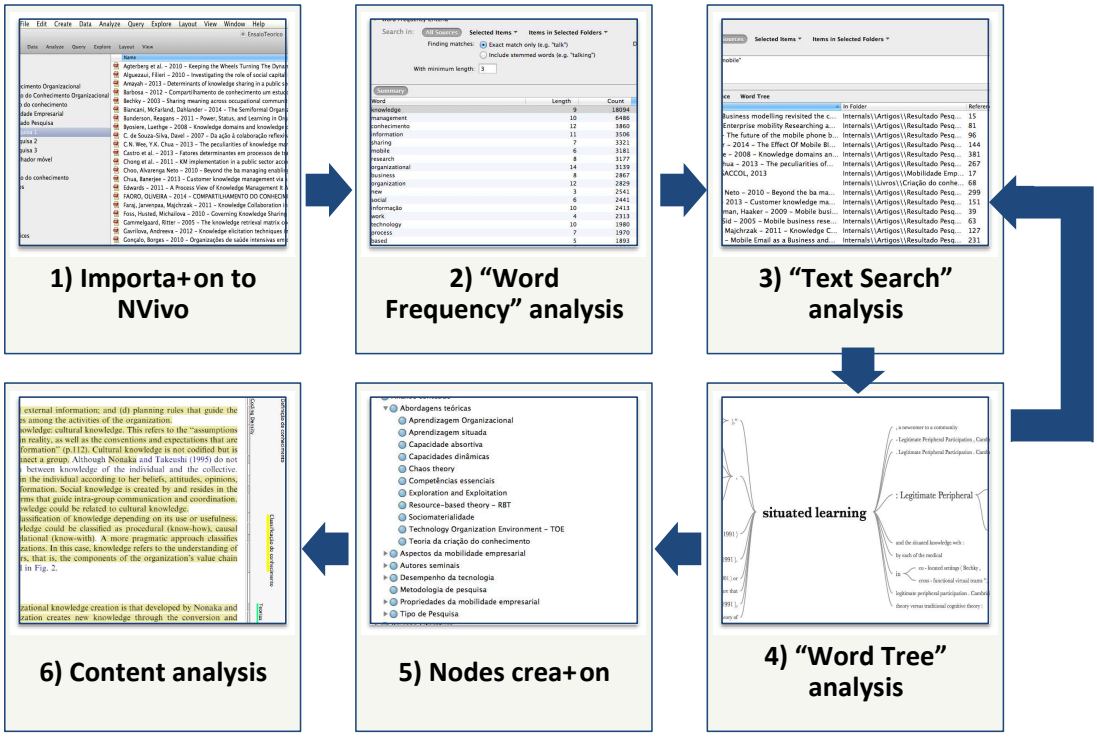
1) By removing the criteria: AND ("organization" OR "organisation") and keeping: (“knowledge creation” OR “knowledge sharing” OR “knowledge collaboration” OR “knowledge transfer”) AND (“enterprise mobility” OR “mobile business” OR “m-business” OR “corporate mobility” OR “business mobility” OR “mobile business”). This search also did not return results, so a new attempt was made;
2) By modifying the filter to use only the keywords: (“knowledge”) AND (“enterprise mobility” OR “mobile business” OR “m-business” OR “corporate mobility” OR “business mobility” OR “mobile business”), in addition to the same search criteria already used in the second phase (based on the Research Area, Document Type and Language).

The result of this search returned 22 papers in the Periodicals of Capes, 2 works in the database of Web of Science and 14 works in the database Scopus. Subsequently, the refinement based on the analysis of the abstracts of the articles was carried out. This analysis aimed to identify only studies related to enterprise mobility

and knowledge creation and sharing in the organisational context, published in scientific sources. The same exclusion criteria used in the second search phase were also applied. The analysis resulted in 14 articles that were used in the literature review. Ten of them had already been identified in the second phase of the search. The database search, therefore, resulted in 127 articles for the literature review. Besides, based on the Snowball technique, the main references cited by these selected papers were reviewed, which led to the total number of 176 references considered.

The NVivo tool was used to assist both the structure and the analysis of the selected studies. Figure 68 illustrates the procedures employed for the analysis and coding of the articles in this tool. First, the papers were imported in the NVivo, and folders were used to organise and categorise them. The second, third and fourth procedures aimed to identify patterns and recurrence of terms in articles. Through these procedures, it was possible to identify the first “nodes” with the following categories: concepts and theoretical approaches, main authors and works, besides the type of research - theoretical/empirical research, qualitative/quantitative research. Whenever necessary, the “Word Tree” and “Text Search” analysis was used to delimit the results and find new patterns. The fifth procedure, in turn, allowed the creation of “nodes” based on the defined categories. Finally, in the sixth and last procedure, content analysis and coding were performed manually.

Figure 68 – Research approach for analysis and coding the papers

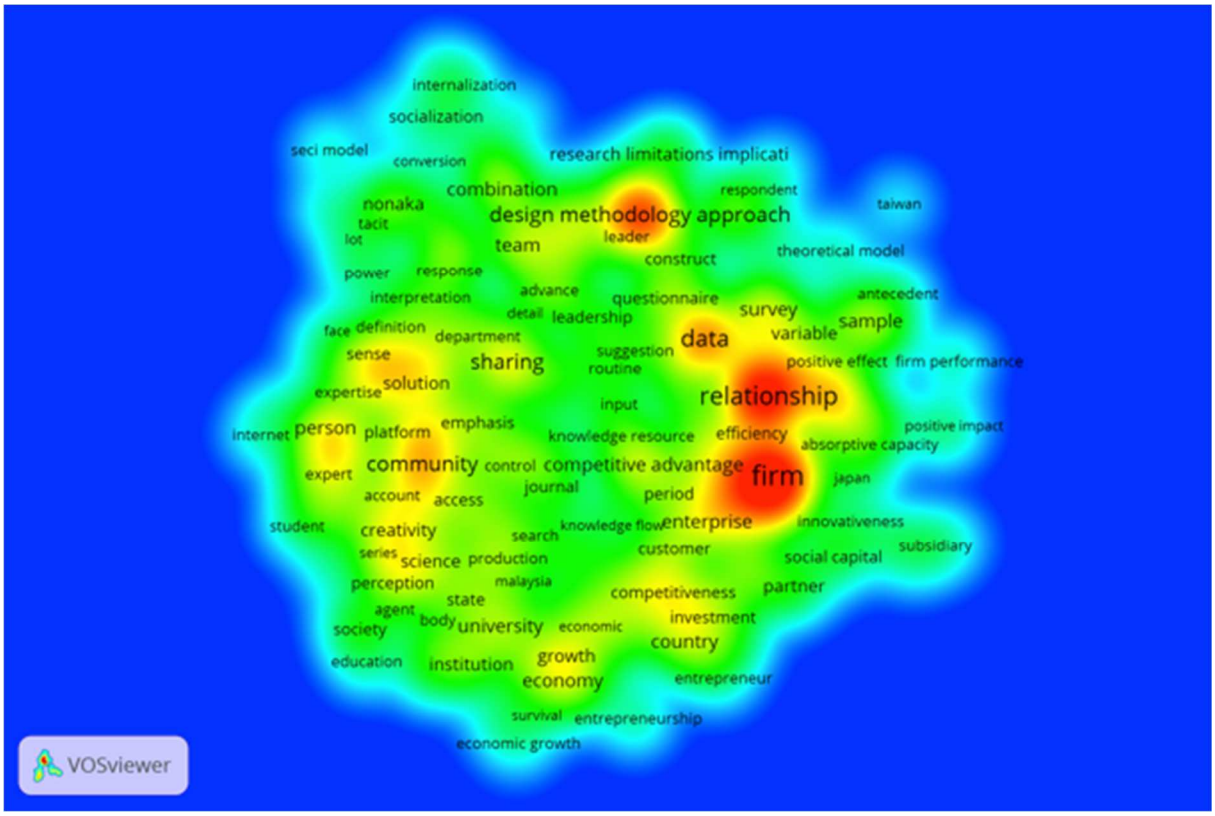


Source: The author.

APPENDIX B – BIBLIOMETRIC STUDY

Based on the findings of the literature review and aiming to complement them, a bibliometric method was carried out to get more evidence about the research gap (see the procedures realised below). According to Zupic & Čater (2014), bibliometric methods can help researchers in mapping research specialties based on a measure of objectivity by aggregating the results of various scholars in the field. This quantitative approach is used to map the structure and development of scientific areas and disciplines (Zupic & Čater, 2014). As detailed below, the main technique of the bibliometric method used to map the research gap was the cluster density visualisation. “In the cluster density visualisation, each point in a map has a colour that depends on the density of items at that point” (Eck & Waltman, 2013, p. 6-7). By default, the colour of the point is somewhere between red and blue, where the larger number of items in the neighbourhood of a point is red and the smaller is blue (Eck & Waltman, 2013). Therefore, the topics appeared in red and yellow colours in the bibliometric results represent the topics more discussed in the literature. In contrast, the topics appeared in blue and green are the topics that do not have many discussions in the literature. Figure 69 illustrates the cluster density visualisation resulted for the topic “knowledge creation”. The tool used to perform the bibliometric study was the VoS Viewer (Eck & Waltman, 2013).

Figure 69 – Cluster density visualization example

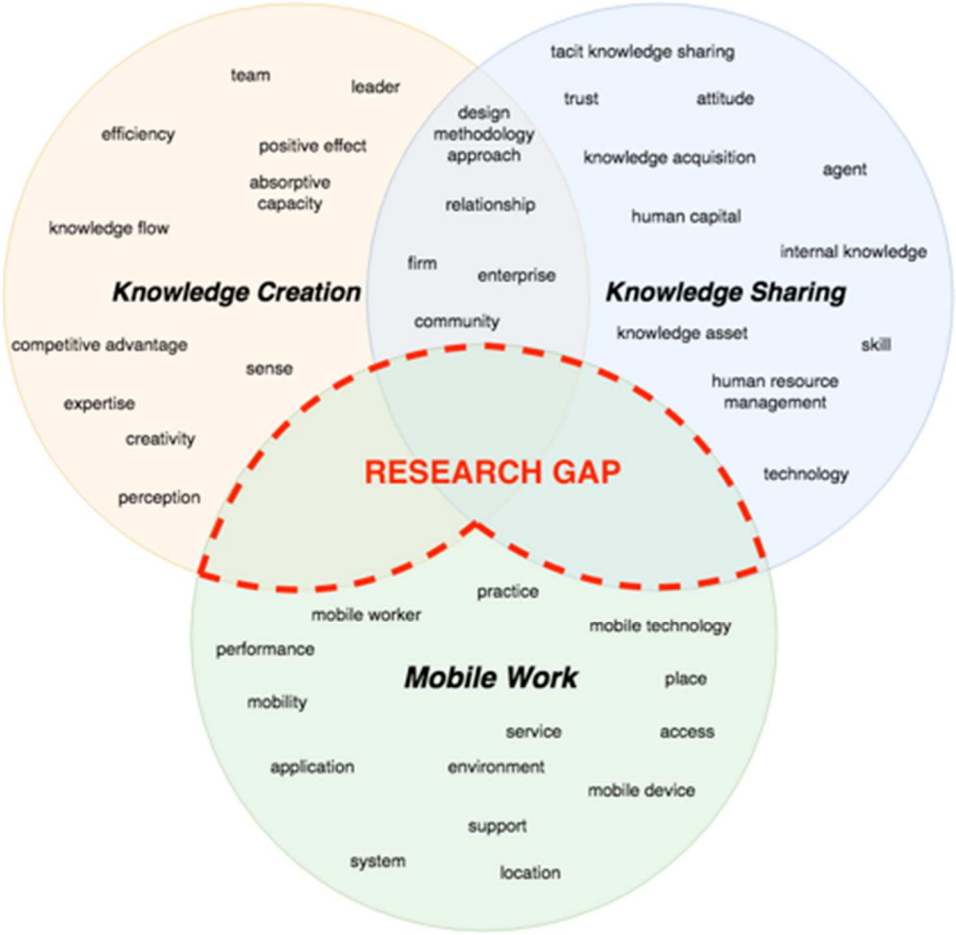


Source: The author.

The results of the bibliometric method helped to identify tendencies, the main subjects, studies and authors of the following topics: Mobile Worker, Knowledge Creation and Sharing. Besides, the results also evidenced the lack of studies in the

intersection of these topics. Figure 70 illustrates the research gap of this study. The terms presented in Figure 70 are the more discussed topics, which appeared in red and yellow colours in the results of the cluster density visualisation of the bibliometric results for each topic. These results indicate that more studies are necessary to address the intersection of these topics.

Figure 70 – Research GAP



Source: The author.

APPENDIX C – INTERVIEW QUESTIONS: UNDERSTANDING THE PROBLEM

This document contains a list of the interview questions. This list is an adaptation of the instrument elaborated in the paper **Mobile Technology in Mobile Work: Contradictions and Congruencies in Activity Systems** (Karanasios & Allen, 2014). The first author, Stan Karanasios, allowed the adaptation and use of the questions in this research.

Mobile knowledge worker questions

About the subject

1. Age
2. Gender
3. Education
4. Profession
5. Background and experience (How long?)
6. What is your organizational position? How long do you work in this position and company?
    a. Background and historicity
7. What is your employment modality?
    a. For instance, some mobile workers are small companies working for big companies

About the activity / object / outcome

8. Can you describe, briefly, what do you do in your job?
    a. Prior activity and activities related (object)
9. Which places do you often use to perform this job?
    a. For instance, in the literature the job can be performed “on the move”: from home, at client’s site, in the car, in a restaurant, etc.
10. What is your main workplace? How much time do you spend outside the main workplace?
11. Could you talk, in summary, how is your daily routine?
12. What are the main problems encountered in your daily routine? How do you solve them?
    a. Social and technical issues

About the instruments

13. Which mobile devices and applications do you often use (personal and professional)? Why do you use them? Which are yours and which are from your organization?
    a. Concrete devices and applications used
14. Which mobile and ubiquitous technologies do you often use to perform your job?
15. Are you able to perform your activity at anywhere because you have these [mobile and ubiquitous technologies]? Why? How? Give some examples.
16. What other tools do you use to perform your job?
    a. For instance, the literature presents this instruments: ICT, Mobile devices, Communication tools, Information tools, Time zone, Language, Collaborative practices, etc.

(Historicity / Changes in the instruments)

17. Has your perception of your job changed since you've been using mobile and ubiquitous technologies?

About the rules

18. What conventions, norms or procedures you need to follow to perform your job?
19. Could you talk me through a job task with and without the mobile and ubiquitous technologies, what rules and norms have changed?
20. Are there any rules or norms to follow in the places you often use to work?
    a. For instance: public workplaces, client's site, etc.

About the community

21. When do you need to interact with others to perform your activity? Why? Give some examples.
22. Do others interact with you during the daily work? Why? Give some examples.
23. Does the use of mobile and ubiquitous technologies changed your way to interact with others? Why? Give some examples.

About the division of labour

24. Has mobile technology changed the way you work with your supervisor / coordination / client? Why? Give some examples.
25. Do you think they can supervise / manage better? Or more intrusively? Why?

About knowledge creation and sharing

26. Where do you usually seek knowledge to solve your problems? Give some examples.
27. What do you do when you face some new situation in the work? Do you look for help in your team / network? Give some examples.
28. When you learn how to lead with this new situation, do you share with someone?
    a. Yes: Can you describe how does this happen? Which tools do you use? How often this happen? Give some examples.
    b. No: What does make difficult to share? Why? Give some examples.
29. When you started in your company, where did you get the information to do your job? Did you have some training? Did someone help you? Give some examples.
    a. What was more effective: training or people help?

Additional comments

30. Do you have some additional comments?

APPENDIX D – PARTICIPANTS IN THE INTERVIEW: UNDERSTANDING THE PROBLEM

		Participants Identification																														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Position	IT Relationship Manager		X	X			X				X																					
	IT Project/Services /Systems Manager					X			X	X						X										X	X					
	Business Consultant	X			X			X				X	X	X														X	X			
	Account executive																X	X	X		X	X										
	CMO – Chief Marketing Officer																			X												
	Lecturer																						X	X	X						X	X
	Lawyer														X															X		
Gender	Male	X	X	X		X	X		X	X		X	X	X	X	X			X	X	X	X		X	X	X	X	X	X	X	X	X
	Female				X			X			X						X	X					X									
Age	20-30	X	X									X	X					X						X				X				
	31-40			X	X	X	X	X	X	X					X	X	X		X	X	X		X		X	X	X		X	X		
	41-50													X																	X	X
	Over 50										X											X										

	Alternating between two fixed locations				X	X		X											X	X			X	X	X		X	X	X	X	X	X
Type of Mobility	Working at three or more places and constantly moving	X	X	X			X		X	X	X	X	X	X	X	X	X	X		X		X				X					
	Face to face (coffee shop, company site, home)						X				X								X												
Type of Interview	Online (Skype, Google Hangouts, WhatsApp, Appear.in, WebEx)	X	X	X	X	X		X	X	X		X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X

APPENDIX E – SAMPLES OF THE EXPERIENCE SAMPLING

Sample 1: (Place, Activity, Community and Feeling: disturbance at work?)

1. Where are you?
    a. Data/time: auto
    b. Location: auto via API (latitude and longitude)
    c. Possible responses: home, transportation, main work or office, public space, client, other (fill – few words)

2. What are you doing right now?
    a. Main activity or related activity

3. Are you working with someone right now?
    a. Y-N

4. (If yes) Who is this person?
    b. Leader
    c. Colleague
    d. Client
    e. Team Member
    f. Other (fill – few words)

5. How are you feeling right now? (Inkinen et al., 2013)
    a. Positive: enthusiasm, interest, determination, being energetic
    b. Negative: irritation, exhaustion, nervousness, anxiety

For this sample the idea is notify the user: 1 time (random) a day between 9-17h during 4 days. The main criteria for the questions is the user could answer < 1 min

Sample 2: (Knowledge creation)

1. Did you look for some new information or knowledge today?
    a. Y-N

2. (If yes) Say something about what you needed (few words)?

3. Did you find what you needed?
    a. Y-N

4. (If yes) Where do you find?
    a. People Network, Internet, Book, Other

5. (If is a person) Who is this person?
    a. (Few words)

6. (If is a person) Which tool did you use?
    a. Face-to-face conversation, Call, Text Message, WhatsApp Audio, WhatsApp Text, Skype, Other (fill)

For this sample the idea is notify the user: at the end of the day, between 17-21h during 4 days. The criteria for the questions is the user could answer < 1 min

Sample 3: (Knowledge sharing)

1. Did you share some information or knowledge with someone today?
    a. Y-N

2. (If yes) Who is this person?
    a. (Few words)

3. (If yes) Say something about what she/he needed (few words)?

4. Which tool did you use?
    a. Face-to-face conversation, Call, Text Message, WhatsApp Audio, WhatsApp Text, Skype, Other (fill)

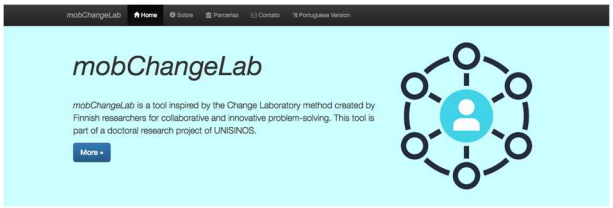
For this sample the idea is notify the user: at the end of the day, between 17-21h during 4 days. The criteria for the questions is the user could answer < 1 min

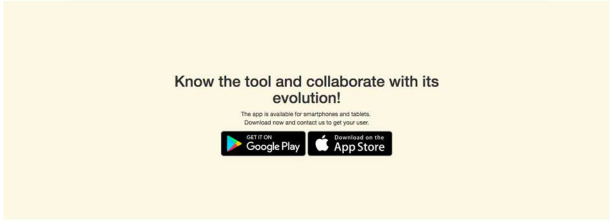
Experience Sampling Planning

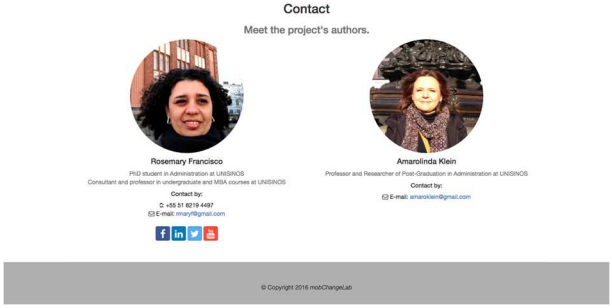
		Day 1	**Day 2**	**Day 3**	**Day 4**
09-17h	Time 1	Sample 1	Sample 1	Sample 1	Sample 1
17h-21h	Time 2	Sample 2	Sample 3	Sample 2	Sample 3
	Time 3	Sample 3	Sample 2	Sample 3	Sample 2

APPENDIX F – PROJECT WEBSITE: DEMONSTRATION

Project website: http://www.mobchangelab.com







APPENDIX G – PROJECT WEBSITE STATISTICS: DEMONSTRATION

This statistics is from Google Analytics.

	Country	Sessions	% Sessions
1.	Brazil	204	33.77%
2.	Russia	152	25.17%
3.	United Kingdom	106	17.55%
4.	(not set)	54	8.94%
5.	United States	39	6.46%
6.	Austria	10	1.66%
7.	Germany	9	1.49%
8.	Iraq	8	1.32%
9.	Italy	8	1.32%
10.	Saudi Arabia	7	1.16%

APPENDIX H – MEETING SCRIPT: DEMONSTRATION

Agenda:

1. *Introduction (10 minutes)*
    a. Researcher profile presentation
    b. Research goals presentation:
        i. To propose an approach to stimulate knowledge creation and sharing through collaborative problem-solving in the mobile knowledge workers' context
    c. Change Laboratory presentation:
        i. Research method created by Finnish researchers

2. *Research presentation (10 minutes)*
    a. Research problem:
        i. Little is known about the consequences in the organisational practices (Karanasios & Allen, 2014; Reynolds, 2015) and also about professional practices or actions outside of traditional centralised offices (Jarrahi & Thomson, 2016)
        ii. Difficulties to create and share knowledge in the mobile workers' context (Kietzmann et al., 2013; Lundin & Magnusson, 2003) considering that learning is a social practice (Engeström, 1987; Lave & Wenger, 1991; Nonaka & Takeuchi, 1995)
        iii. There is a lack of studies related to knowledge creation and knowledge sharing in the context of mobile worker. Only two studies were found (Kietzmann et al., 2013; Lundin & Magnusson, 2003)
        iv. *How knowledge creation and knowledge sharing are carried out in collaborative problem-solving situations in the mobile workers' context*?
    b. mobChangeLab presentation
        i. The method
        ii. The mobile app

3. *Parternship with enterprise mobility experts (5 minutes)*

4. *Parternship with mobile workers companies (5 minutes)*

APPENDIX I – TEST PLAN FOR THE ARTIFACT: DEMONSTRATION

1. Client: Companies (especially those companies that have mobile workers)

2. Companies' pain points:
    a. Recurrent problems (among workers)
    b. Customer dissatisfaction due to delay in problem-solving situations
    c. Lack of retention of the problem's solutions in the organisational context = REWORK and OPPORTUNITY LOSS
    d. Lack of a platform to stimulate collaboration in problem-solving situations

3. Possible gains:
    a. Knowledge retention
    b. Knowledge database
    c. Problem Statistics for Process Improvements

4. What will be tested?
    a. H1: Is there rework in the companies due to recurring problems?
    b. H2: Are the companies willing to invest in a collaborative problem-solving platform?
    c. H3: Would practitioners collaborate on problem-solving situations through a collaborative problem-solving platform?

5. How will be tested?
    a. Google Forms

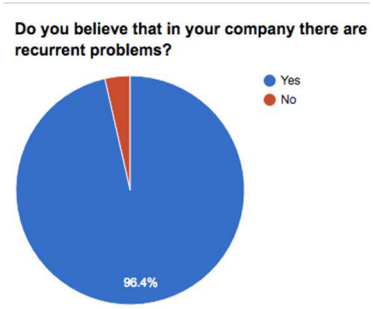
6. How will be disclosed?
    a. Social media: Facebook, Twiter, Likedin, WhatsApp

7. What metrics will be used??
    a. Demand rate: % of YES in 1 to 3
    b. Interest rate: Number of people that indicated the Name, Email and Comments

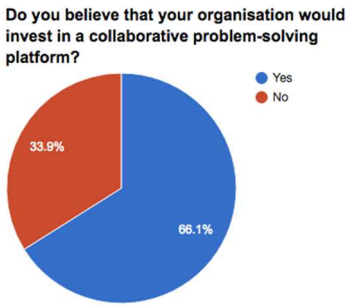
8. What are the guarantees that the hypotheses have been validated?
    a. Minimum 51% YES in questions 1 to 3 (considering a minimum of 50 respondents)

Fifty-six participants answered the test plan, and thirty-four informed the name and e-mail for further contact. The results of the test plan are presented in Figure 71.

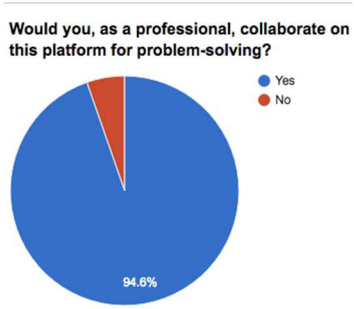
Figure 71 – Results of the test plan



(a) H1



(b) H2



(c) H3

Source: Test plan data.

APPENDIX J – CROSS-CHECK WITH EXPERTS: EVALUATION

Gmail

Rosemary Francisco <rmaryf@gmail.com>

ChangeLab Platform - Some drafts
2 messages

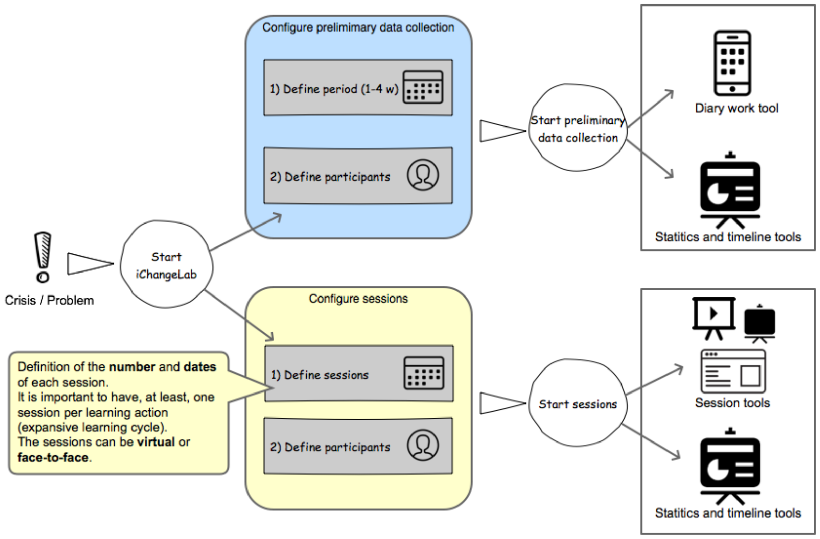
Rosemary Francisco <rmaryf@gmail.com> 8 December 2015 at 12:47
To: [redacted]@helsinki.fi>

Hi [redacted]

I am still planning the platform, but I attached the draft of the flow and some prototypes for you check :)

If you have availability some day, let's talk about this.

Best, Rose



Diary Work Tool:

[redacted]@helsinki.fi> 8 December 2015 at 12:59
To: Rosemary Francisco <rmaryf@gmail.com>

Looks Great!!! I want to hurry all the other tasks quickly out of my way to start discussing about this with you!!!

APPENDIX K – INTERVIEW QUESTIONS: EVALUATION

The interviews were conducted with the participants who made use of the mobChangeLab tool. The interview considered the phases implemented in the tool: Diagnosis, Analysis and Transformation and the Expansive Learning cycle.

Diagnosis phase

1. Can you briefly describe what significant difficulties have occurred in your daily routine? (Instruments, Object of the Activity, Community, Rules, Division of Labor, Other Related Activities)

2. Did you look for help to solve these difficulties? If yes, where did you look for help?
    a. Example of search sources: Management, Team, Network, Books, Internet, Others

3. Have you interacted with your community to ask for support in solving the difficulties?
    a. If not, why not?
    b. If yes, what tools did you use to get help?
        i. Examples of tools: Face-to-face conversation, Phone call, Text Message, WhatsApp Audio, WhatsApp Text, Skype, mobChangeLab, Others

    c. During the interaction with your community did you learn a new way to conduct/carry out your main work activity? Could you explain/give examples?

4. Can you give some examples of how you've solved the difficulties you've faced?
    1. What tools did you use when solving the difficulties?
        i. Examples of tools: Face-to-face conversation, Phone call, Text Message, WhatsApp Audio, WhatsApp Text, Skype, mobChangeLab, Others

5. Has your community interacted with you for help in solving difficulties?
    a. If not, what is the likely reason?
    b. If yes, can you give an example of what were the main difficulties in your community in which they asked for your help? (Instruments, Object of the Activity, Community, Rules, Division of Labor, Other Related Activities)

    c. What tools did you use to interact?
        i. Examples of tools: Face-to-face conversation, Phone call, Text Message, WhatsApp Audio, WhatsApp Text, Skype, mobChangeLab, Others

Analysis and Transformation phases

6. Have you interacted with the community in developing new ways of working?
    a. If not, why not?
    b. If yes, can you give an example of how this process was?

   c. What tools did you use?
      i. Examples of tools: Face-to-face conversation, Phone call, Text Message, WhatsApp Audio, WhatsApp Text, Skype, mobChangeLab, Others
   d. Have you become responsible for some action to implement new ways of working? If yes, how was this experience considering the mobility context?

7. During the design and implementation of new forms of work, have you and your community faced new challenges?
   a. If yes, can you explain briefly what were the main difficulties? (Instruments, Object of the Activity, Community, Rules, Division of Labor, Other Related Activities)
   b. How did you solve the difficulties?
   c. What tools did you use?
      i. Examples of tools: Face-to-face conversation, Phone call, Text Message, WhatsApp Audio, WhatsApp Text, Skype, mobChangeLab, Others

Opinion about the method and mobile app

8. Considering the mobChangeLab method and application, do you believe that having the disturbances and interactions about them organised in a single "location" enabled a better analysis for future improvements?
9. Have you used other media and other forms of interaction beyond the application? Which are? Why?
10. Can you briefly comment on your opinion on the process used to diagnose difficulties, analyse and transform work practices? Do you think it was efficient? If not, what could be different? What could be improved?
11. Could you please comment on the mobile app - what extent was it (1) easy to use and (2) useful compared to other tools?
12. What suggestions would you have for enhancing the mobChangelab?

Open question

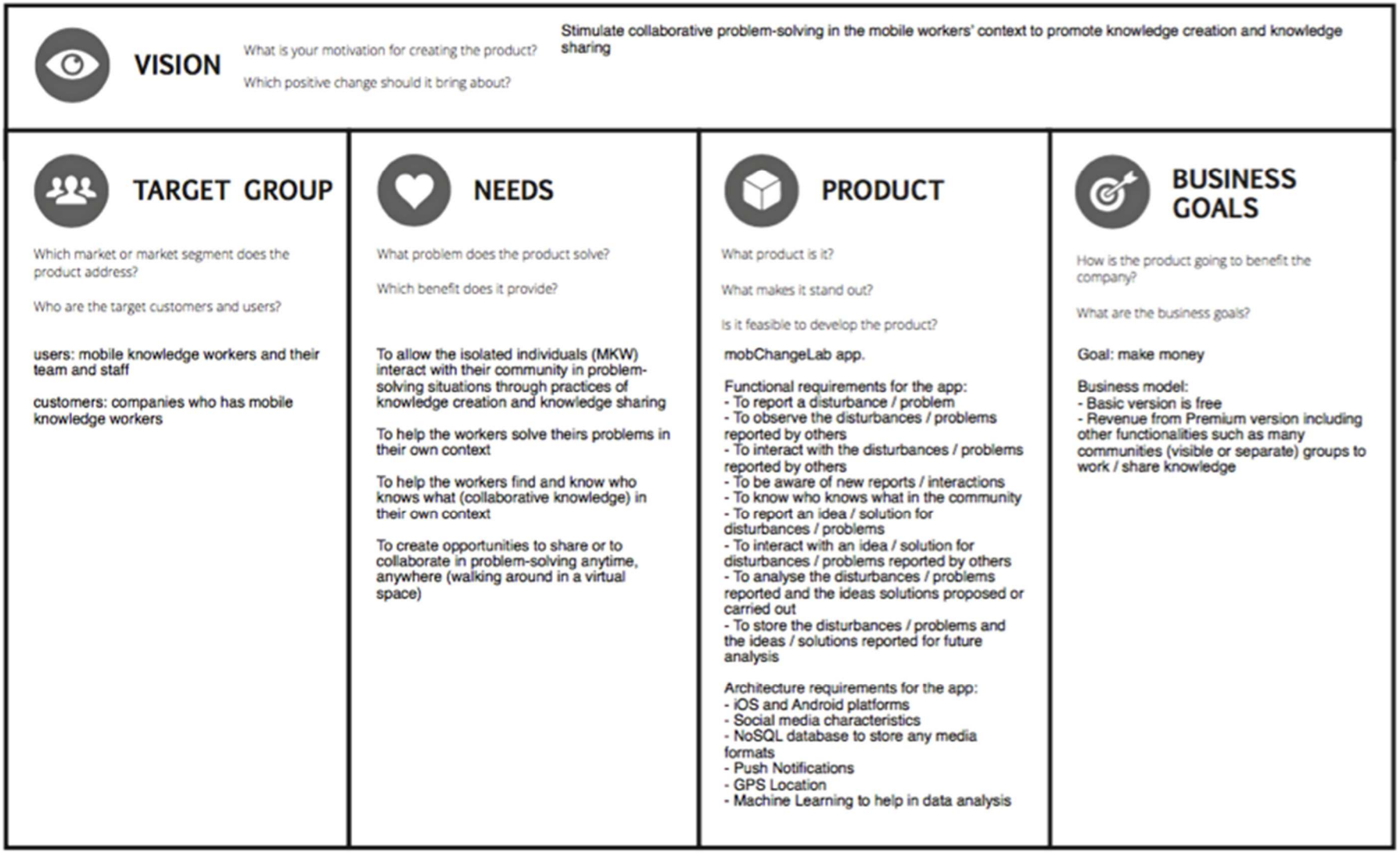
13. Any other comments?

APPENDIX L – EXPANSIVE LEARNING ANALYSIS: EVALUATION

To analyse the data collected by the mobChangeLab app, it was used the framework of Activity Theory and the cycle of Expansive Learning. The analysis of the Expansive Learning cycle was performed based on the following worksheet.

Expansive Learning cycle		mobChangeLab	
Phase	**Step**	**Resource**	**Phase**
1. The first action is questioning, criticizing or rejecting some aspects of the accepted practice and existing wisdom. For the sake of simplicity, this action is named questioning	Formulate problem	Disturbance Report	Diagnosis
		Had interaction	
		Sample 1 - Experience sampling	
		Sample 2 - Experience sampling	
		Sample 3 - Experience sampling	
	Discuss problem	Disturbance comments	
2. The second action is analysing the situation. Analysis involves mental, discursive or practical transformation of the situation in order to find out causes or explanatory mechanisms. Analysis evokes "why?" questions and explanatory principles. One type of analysis is historical-genetic; it seeks to explain the situation by tracing its origins and evolution. Another type of analysis is actual-empirical; it seeks to explain the situation by constructing a picture of its inner systemic relations	Analyze Problem	My Summary Log	Diagnosis and Analysis
		Community summary log	
		Disturbance detail log	
		Statistics log	
		Follow interaction	
	Discuss problem	Disturbance comments	
	Share knowledge	Disturbance comments	
		Solved interaction	
3. The third action is modelling the newly found explanatory relationship in some publicly observable and transmittable medium. This means constructing an explicit, simplified model of the new idea that explains and offers a solution to the problematic situation	Analyze Problem	Session 1 - Check relevant difficulties	Analysis and Tranformation
	Discuss problem	Disturbance comments	
		Session 1 comments	
	Share knowledge	Disturbance comments	
		Session 1 comments	
4. The fourth action is examining the model, running, operating and experimenting on it in order to fully grasp its dynamics, potentials and limitations	Analyze Problem	Session 2 - Prioritize Difficulties	
		Session 3 - Develop solutions	
	Discuss problem	Disturbance comments	
		Solutions comments	
		Session 2 comments	
		Session 3 comments	
	Create / Share knowledge	Session 3 - Develop solutions	
		Solutions comments	
		Session 3 comments	
5. The fifth action is implementing the model by means of practical applications, enrichments, and conceptual extensions	Create concepts	Session 4 - Implementing solutions	
		Solutions comments	
		Session 4 comments	
6. The sixth is reflecting on and evaluating the process and consolidating its outcomes into a new stable form of practice	Justify concepts	Session 5 - Retrospective and Follow-up	
		Solutions comments	
		Session 5 comments	
7.Consolidate		Out of scope because it is long term	

APPENDIX M – PRODUCT VISION



APPENDIX N – FINAL REPORT OF STUDIES IN CRADLE

REPORT
OF THE STUDIES
OF THE VISITING
DOCTORAL STUDENT

December 17, 2015

ROSEMARY FRANCISCO
PhD Candidate at Management UNISINOS - RS - Brazil

CHALLENGES TO CREATE AND SHARE KNOWLEDGE IN THE CONTEXT OF MOBILE WORKERS: An analysis based on Activity Theory

Rosemary Francisco, a PhD Student at Management in UNISINOS - RS - Brazil, has studied on a status of a Visiting doctoral student in The Faculty of Behavioural Sciences, University of Helsinki Finland at the Center for Research on Activity, Development and Learning CRADLE under the supervision of Professor Yrjö Engeström between 03.08.2015 and 22.12.2015.

CRADLE conducts research on foundational issues of cultural-historical activity theory, especially related to work, technology and organizations going through transformations. Rosemary's research plan, entitled as "CHALLENGES TO CREATE AND SHARE KNOWLEDGE IN THE CONTEXT OF MOBILE WORKERS: An analysis based on Activity Theory", has been the basis of her research work during her stay in CRADLE. Rosemary has been involved in a number of activities in our research group. The strongest emphasis she has put on developing her own research work further and on working on the theoretical aspects of her PhD thesis.

Rosemary Francisco has taken part in a number of internal seminars, courses, discussions and lectures of both The Center for Research on Activity, Development and Learning, CRADLE and the Faculty of Behavioural Sciences, University of Helsinki, Finland.

The work language of the center is English. Rosemary has presented also her own research work at CRADLE.

Sincerely,

Yrjö Engeström, Professor
Director, Center for Research on Activity, Development and Learning CRADLE
Institute of Behavioural Sciences, University of Helsinki

HELSINGIN YLIOPISTO
HELSINGFORS UNIVERSITET
UNIVERSITY OF HELSINKI

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Institute of Behavioural Sciences, P.O. Box 9 (Siltavuorenpenger 3A), 00014 University of Helsinki Telephone +358 9 191 44165, fax +358 9 191 44579, www.helsinki.fi /cradle/

ANNEX A – CHAPTER PROPOSAL APPROVED

Gmail **Rosemary Francisco <rmaryf@gmail.com>**

Chapter Proposal Approved

IGI Global Book Submission System <booksubmissionsystemadmin@igi-global.com> 16 February 2017 at 06:20
Reply-To: dk@learning.aau.dk
To: rmaryf@gmail.com

Dear Prof. Francisco,

Thank you for submitting your chapter proposal, "Expanding knowledge on the move: A case of expansive learning among mobile workers," for the upcoming book, "Online Collaboration and Communication in Contemporary Organizations." After reviewing your recent proposal, I am exited about the content, and I believe the topic of your proposed chapter could make a significant contribution to this project. I therefore encourage you to begin preparing your full chapter and submit a copy before Wednesday, May 31, 2017 at the following URL:

http://www.igi-global.com/submission/submit-chapter/?projectid=24a09e17-9542-4d3d-903a-b578daa9424d

Please note that you will be asked to create an account prior to uploading your chapter to the system. This is to ensure the security of your work and to assist you in organizing your materials for submission, receiving and providing peer reviews, and making any necessary revisions to your chapter. For information on creating and accessing your Web account, please see our tutorial at www.igi-global.com/publish/contributor-resources/book-submission-system/video-guide/#creating-a-user-account.

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Image guide:
http://www.igi-global.com/publish/resources/image-guide.pdf

Your adherence to the guidelines provided in these documents is very important. Should you have any questions regarding your proposed chapter, please do not hesitate to contact me, Ditte Kolbæk, at dk@learning.aau.dk.

I look forward to receiving your chapter!

Ditte Kolbæk

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