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Summary

The digitalized work environment poses challenges to the workforce, such as the meaningful use of ever-new technological advances, dealing with increasingly complex tasks, or effective collaboration in dispersed work groups. The individual worker needs to adapt to rapidly increasing demands due to far-reaching changes in the workplace, to complete their everyday work tasks. However, there is an increasing discrepancy between the existing and required digital competencies in the workforce. Due to the urgent need to expand the scientific knowledge on this important topic, the main focus of this dissertation is on the development and measurement of the construct of digital competencies at work.

In the scientific literature, a comprehensive framework that integrates the perspectives of prior research and practitioners in a work context has not been developed yet. Additionally, a common definition of digital competencies at work was still lacking although many wordings have been used for the concept. Modern work practices, such as the ubiquity of remote work for office workers emphasize the importance of digital communication and collaboration competencies at work. Yet, to date, there was no measurement tool for individual digital communication and collaboration competencies at work that is needed to conduct more scientific research on the construct. Another research gap derived from the results of the prior studies in this dissertation measuring digital competencies: The high mean values in all collected data sets led to the assumption that office workers might over-estimate their digital competencies. However, the research question of how the self-assessment of workers' digital communication and collaboration competencies can be influenced by varying instructions has not yet been explored in an experimental study. Moreover, to further explore the nomological net of the construct, the relationship between digital communication and collaboration competencies and the motivation to train those were investigated.

In my dissertation, I realized the collection of quantitative and qualitative data in nine samples and conducted a literature review to address the outlined research gaps. By integrating perspectives from research and practice and combining diverse methods, a coherent and detailed framework of digital competencies at work was created and a definition of the concept was provided in Paper 1. As depicted in Paper 2, building on the theoretical framework and prior research, digital communication and collaboration competencies were identified as dimensions with particular relevance to the challenges of today's work environments. By using mixed methods, a measurement tool for digital communication and collaboration competencies was developed. The role of those competencies as potential resources in a gain spiral with social support, ultimately boosting work engagement in the unique setting of a pandemic that fundamentally altered the way of work worldwide based on the *Job Demands-Resource model* (Demerouti et al., 2001) and the *conservation of resources theory* (Hobfoll, 2011) was explored. Although results did not support the assumption of a gain spiral, we found that digital competencies, social support, and work engagement were stable and high during the crisis. The findings add knowledge

about the motivational processes of workers in times of crisis. Subsequently, in Paper 3 the initial measurement tool was refined into a reliable and valid short-scale of digital communication and collaboration competencies at work. In several studies, the short-scale was validated and the nomological net of the constructs was explored. The last part of my dissertation is dedicated to the systematic examination of the effect that varying instructions have on workers' self-assessment of digital communication and collaboration competencies and the motivation to train those. The results imply that the self-assessment of competencies and the motivation to train those cannot be influenced easily by varying instructions. Nevertheless, workers with high levels of digital communication and collaboration competencies also showed high motivation to train those.

The findings of this dissertation provide a solid base for further theory building and extension in research on digital competencies at work. The insights gained from the studies of this dissertation comprise theoretical and practical implications for training development and human resource management. Overall, the results of this dissertation imply that digital competencies at work could be an important benefit in meeting the challenges of today's digital work environments. The concept of digital competencies at work deserves more attention in future research.

Keywords: digital competencies; digital communication; digital collaboration; work context; motivation; resources; self-assessment; scale validation; measurement instrument; digital work environment; COVID-19 pandemic

Zusammenfassung

Die digitalisierte Arbeitsumgebung stellt Arbeitskräfte vor Herausforderungen wie der sinnvollen Nutzung immer neuer technologischer Weiterentwicklungen, der Bewältigung zunehmend komplexer Aufgaben oder der effektiven Zusammenarbeit in global verteilten Arbeitsgruppen. Arbeitende müssen sich aufgrund der weitreichenden Veränderungen ihrer Arbeitsplätze an diese rasant steigenden Anforderungen anpassen, um ihre täglichen Arbeitsaufgaben zu erledigen. Es besteht jedoch eine zunehmende Diskrepanz zwischen den vorhandenen und den erforderlichen digitalen Kompetenzen der Arbeitenden. Aufgrund der dringenden Notwendigkeit, den wissenschaftlichen Kenntnisstand zu diesem wichtigen Thema zu erweitern, liegt ein Schwerpunkt auf der Entwicklung und Messung des Konstrukts der digitalen Kompetenzen bei der Arbeit.

In der bisherigen wissenschaftlichen Literatur wurde kein umfassendes Rahmenmodell für den Arbeitskontext entwickelt, welches die Perspektiven der bisherigen Forschung und die der Praktiker integriert. Außerdem fehlte bisher eine allgemeingültige Definition digitaler Kompetenzen bei der Arbeit, obwohl viele unterschiedliche Bezeichnungen für das Konzept verwendet wurden. Moderne Arbeitsweisen, wie zum Beispiel die allgegenwärtige mobile Arbeit für Büroarbeitende, unterstreichen die Bedeutung digitaler Kommunikations- und Zusammenarbeitskompetenzen bei der Arbeit. Bisher gab es jedoch kein Messinstrument für individuelle digitale Kommunikations- und Zusammenarbeitskompetenzen am Arbeitsplatz, das für die weitere wissenschaftliche Erforschung dieses Konstruktes erforderlich wäre. Eine weitere Forschungslücke ergab sich aus den Ergebnissen voriger Studien im Rahmen dieser Dissertation, in welchen digitale Kompetenzen gemessen wurden: Die hohen Mittelwerte in allen erhobenen Datensätzen legten die Vermutung nahe, dass Büroarbeitende ihre digitalen Kompetenzen möglicherweise überschätzen. Die Forschungsfrage, inwiefern die Selbsteinschätzung der digitalen Kommunikations- und Zusammenarbeitskompetenzen von Arbeitenden durch unterschiedliche Instruktionen beeinflusst werden kann, wurde jedoch noch nicht in experimentellen Studien untersucht. Um das nomologische Netz des Konstrukts weiter zu erforschen, wurde außerdem der Zusammenhang zwischen digitalen Kommunikations- und Zusammenarbeitskompetenzen und der Motivation, diese zu trainieren, untersucht.

In meiner Dissertation habe ich in neun Stichproben quantitative und qualitative Daten erhoben und eine Literaturanalyse durchgeführt, um die dargelegten Forschungslücken zu schließen. Durch die Integration von Perspektiven aus Forschung und Praxis und die Kombination diverser Methoden wurde in Paper 1 ein kohärentes und detailliertes Rahmenmodell für digitale Kompetenzen bei der Arbeit und eine Definition des Konzepts vorgestellt. Wie in Paper 2 dargestellt, wurden aufbauend auf dem theoretischen Rahmenmodell und früheren Forschungsergebnissen digitale Kommunikations- und Zusammenarbeitskompetenzen als Dimensionen mit besonderer Relevanz für die Herausforderungen der heutigen Arbeitswelt identifiziert. Mithilfe verschiedener Methoden wurde ein Messinstrument für

digitale Kommunikations- und Zusammenarbeitskompetenzen entwickelt. Die Rolle dieser Kompetenzen als potenzielle Ressourcen mit sozialer Unterstützung in einer positiven Ressourcenspirale, die letztlich das Arbeitsengagement erhöhen, wurde untersucht auf der Grundlage des *Job Demands-Resources Modells* (Demerouti et al., 2001) und der *Conservation of Resources Theorie* (Hobfoll, 2011) in der einzigartigen Situation einer Pandemie, welche die Art der Arbeit weltweit grundlegend verändert hat. Obwohl die Ergebnisse die Annahme einer Ressourcenspirale nicht stützten, haben wir festgestellt, dass sowohl digitale Kompetenzen als auch soziale Unterstützung und Arbeitsengagement während der Krise stabil hoch blieben. Die Ergebnisse liefern neue Erkenntnisse über die Motivationsprozesse bei Arbeitenden in Krisenzeiten. Anschließend haben wir in Paper 3 das ursprüngliche Messinstrument zu einer reliablen und validen Kurzskala für digitale Kommunikations- und Zusammenarbeitskompetenzen am Arbeitsplatz weiterentwickelt. In mehreren Studien wurde die Kurzskala validiert und das nomologische Netz der Konstrukte erforscht. Der letzte Teil meiner Dissertation widmet sich der systematischen Untersuchung des Effekts, den unterschiedliche Instruktionen auf die Selbsteinschätzung der digitalen Kommunikations- und Zusammenarbeits-kompetenzen Arbeitender haben sowie auf die Motivation, diese zu trainieren. Die Ergebnisse implizieren, dass die Selbsteinschätzung der Kompetenzen und die Motivation, diese zu trainieren, nicht ohne Weiteres durch unterschiedliche Instruktionen beeinflusst werden können. Nichtsdestotrotz zeigten Arbeitende mit einem hohen Niveau an digitalen Kommunikations- und Zusammenarbeits-kompetenzen auch eine hohe Motivation, diese zu trainieren.

Die Ergebnisse dieser Dissertation bilden eine solide Grundlage für die weitere Theoriebildung und -erweiterung in der Forschung zu digitalen Kompetenzen bei der Arbeit. Die Erkenntnisse, welche aus den Ergebnissen der Studien in dieser Dissertation gewonnenen werde können, beinhalten theoretische und praktische Implikationen für die Entwicklung von Trainings und Human Ressource Management. Insgesamt deuten die Ergebnisse dieser Dissertation darauf hin, dass digitale Kompetenzen bei der Arbeit einen wichtigen Beitrag zur Bewältigung der Herausforderungen der heutigen digitalen Arbeitswelt leisten können. Das Konzept der digitalen Kompetenzen bei der Arbeit verdient in der zukünftigen Forschung mehr Aufmerksamkeit.

Schlüsselwörter: Digitale Kompetenzen; digitale Kommunikation; digitale Zusammenarbeit; Arbeits-kontext; Motivation; Ressourcen; Selbsteinschätzung; Skalenvalidierung; Mess-instrument; Digitale Arbeitsumgebung; COVID-19 Pandemie

List of Papers Included in This Publication-Based Dissertation

The following research articles are part of this publication-based dissertation:

Paper 1:

Oberländer, M., Beinicke, A., & Bipp, T. (2020). Digital competencies: A review of the literature and applications in the workplace. *Computers & Education, 146*, 103752. https://doi.org/10.1016/j.compedu.2019.103752

Paper 2:

Oberländer, M., & Bipp, T. (2022). Do digital competencies and social support boost work engagement during the COVID-19 pandemic? *Computers in Human Behaviour, 130*, 107172. https://doi.org/10.1016/j.chb.2021.107172

Paper 3: This article was submitted and is currently under peer-review

Oberländer, M., & Bipp, T. (2022). Assessing digital competencies at work and improving training motivation. Manuscript submitted for publication in the *International Journal of Selection and Assessment* [Submission Status: Under Review].

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Chapter 1 – General Introduction

This dissertation aims at shedding light on one phenomenon that has gained more and more attention in the world of work and the lives of people, but has not been subject to extensive research efforts, yet: digital competencies at work. In the face of fast-changing work environments due to societal megatrends such as digitalization and globalization enabling colleagues to work in dispersed groups around the globe and a global pandemic accelerating the urge to collaborate online, a digitally competent workforce is a highly relevant resource (Kniffin et al., 2021; Murawski & Bick, 2017). Individual competencies in communicating and collaborating online became even more important for office workers since the COVID-19 pandemic has accelerated the shift away from office-based work towards working from home (Meske & Junglas, 2020; Wang et al., 2021). In 2022, after two years of the pandemic situation, big renowned companies worldwide, such as Twitter, SAP, and Airbnb, announced making some of the remote work policies a permanent work arrangement, allowing employees to work from anywhere they like full-time or offering hybrid work arrangements to their employees (L. Yang et al., 2022). Thus, workers' digital competencies will be an important asset in the future world of work. However, empirical findings from scholarly research to guide organizations, politics, and individuals were still largely lacking.

Following this brief introduction, I begin with an outline of the challenges that the digital work environment poses to the workforce. After the definition of competencies in general, I introduce the main concepts of this dissertation and provide definitions for digital competencies at work and digital communication and collaboration competencies at work. Following an outline of the research gaps leading to the main topics of this dissertation, including the derivation of research questions and aims that constitute the contributions of the research presented, I end the introduction with summaries of the three papers included in this dissertation. After presenting the papers in the Chapters 2, 3, and 4, I present an integrated summary of the main findings. This is followed by a detailed illustration of practical and theoretical implications that can be derived from the findings and an in-depth discussion of limitations and further research opportunities across all studies included in this dissertation. To sum it up, I end with an overall conclusion.

1. Challenges caused by the Digital Work Environment

Societal megatrends shape the nature of work and rapidly increase the demands on the workforce. Examples of such trends are globalization, demographic changes in the workforce, digitalization, and more recently severe interruptions at work due to a global pandemic (Junghanns & Morschhäuser, 2013; Wang et al., 2021). Due to globalization, team members work dispersed all over the globe and in different time zones, posing challenges to collaboration methods, working times, and forms of communication, for example. Digitalization leads to new technological advances that offer new opportunities to deal with these challenges on the one hand, but at the same time increase the demands on the workforce on the other hand (Meske & Junglas, 2020). Researchers found negative consequences, such as increasingly cognitive and complex work tasks, that require more sophisticated coordination (Junghanns & Morschhäuser, 2013). Workers suffer from the intensification of work, reduced feelings of social inclusion and trust, and the pressure of constant availability, for example, leading to a decreasing quality of the working life (e.g., Korunka & Kubicek, 2017; Vuori et al., 2019). On the bright side, digitalization brought solutions and advances, too (Colbert et al., 2016). For instance, the improvement of digital communication technologies enables experts to communicate and collaborate worldwide on a daily basis without any travel expenses (DeShon & Gillespie, 2005). Large online networks facilitate knowledge sharing and foster the information flow within and between organizations (Golden & Raghuram, 2010; Krumm et al., 2016; Trenerry et al., 2021). The introduction of new technologies can change work processes profoundly or introduce new work settings. In fact, the opportunity to work from home became possible only since the rapid and ongoing digital transformation caused tremendous changes in the way of work (Schulze & Krumm, 2016; Wang et al., 2021). Even though there was a trend towards working from home, the stay-at-home policies to condemn the COVID-19 pandemic accelerated this shift and fundamentally changed the work environment for many workers from one day to the next (L. Yang et al., 2022). These rapid changes posed new challenges to the workforce. For example, work-life boundaries blurred because of caregiving responsibilities during work times, or communication became ineffective due to lacking communication channels (Dirani et al., 2020; Wang et al., 2021). Nevertheless, today remote work settings are a new normal for many knowledge workers.

With the rise of such new possibilities at work, the first research on virtual teams, telecommuting, and computer-mediated work occurred (Golden et al., 2008; Hertel et al., 2006; e.g., Kirkman & Mathieu, 2005; for an overview, see Raghuram et al., 2019). Yet, the research on this topic comes from a variety of fields, that include management, psychology, information systems, and communication, the definitions, concepts, and methods of which are often conflicting (Makarius & Larson, 2017; Raghuram et al., 2019). Research with a focus on work design aspects investigated how work characteristics influence remote work outcomes, for example as mediators, moderators, or antecedents (Gajendran &

Harrison, 2007; Wang et al., 2021). Remote work was defined as a work setting where workers work somewhere else than in the office and do not communicate face-to-face with colleagues and supervisors, but use digital communication and collaboration channels (Wang et al., 2021). However, other terms used for the same work practice include working from home, telework, telecommuting, virtual work, and distributed work (Allen et al., 2015). Other research streams focused on team aspects in a virtual work setting, such as communication or collaboration (e.g., Schulze & Krumm, 2016). Most definitions for virtual teamwork include aspects of geographic dispersion, the use of digital technology to communicate or collaborate, and shared goals (Krumm & Hertel, 2013; Raghuram et al., 2019; Schulze & Krumm, 2016). The advantages of virtual collaboration and remote work in practice include worldwide recruiting opportunities for organizations. Workers profit from flexible work arrangements, and reduced commute times. To profit from the advantages, challenges such as the lack of contextual cues due to asynchronous communication, handling the fast-changing technology or a reduced knowledge transfer must be overcome (e.g., Driskell et al., 2003; Mesmer-Magnus et al., 2011). Thus, digital competencies of the workers are essential to overcome these challenges.

This digital work environment requires a digitally competent workforce, who can communicate and collaborate efficiently, share their knowledge and use their creativity to solve upcoming problems. To handle the fast-changing work environments, workers have to commit to lifelong learning. Tasks at these modern workplaces require more and broader competencies that go beyond the skills acquired during job training (Blumberg & Kauffeld, 2021). However, it is not just the need for expanding competencies. Recognizing, measuring, and tracking those competencies is equally important, especially with a growing, heterogeneously competent workforce (Kauffeld & Frerichs, 2018).

2. Required Individual Competencies in the Digital World of Work

The changes at the workplaces fuelled by these societal megatrends shift a focus on the competencies in the workforce (Arnold et al., 2016; Colbert et al., 2016). The continuous development of the competencies in the workforce in almost all branches became a necessity – and even more so for basic competencies such as digital competencies that are required at most modern workplaces. Despite the increasing demand for knowledge on needed competencies, research on this important topic was still scarce. As outlined above, a great amount of research focused on work design aspects of remote work and characteristics of virtual teams, but less attention was paid to the individual worker and their competencies. To complement these prior research efforts, in this dissertation, I focused on competencies from the perspective of an individual worker as opposed to analyzing team or organizational-level competencies (Meske & Junglas, 2020).

Researchers define competencies as a set of different characteristics, including for example knowledge, abilities, skills, personality characteristics, experiences, motivation, and behaviours (Conte & Landy, 2018). It is important to note that competencies go beyond any single one of these characteristics; competencies are not just knowledge, just one skill, or just a single ability. Competencies are defined as specific sets of such characteristics that are instrumental to the successful accomplishment of concrete tasks in complex situations and the delivery of the desired outcomes including the ability to make appropriate and effective use of those (e.g., Krumm et al., 2012; Kurz & Bartram, 2002). Specificity in this definition means that the competencies have relevancy only to that specific series of actions meeting the specific requirements in that very situation. The KSAO approach, on which I based the understanding of competencies in this dissertation, focuses on knowledge (K), skills (S), abilities (A), and other characteristics (O), such as personality or interests, as the main constituting characteristics of competencies (Aamodt, 2009; Campion et al., 2011; Krumm et al., 2012). In research contexts, individual competencies are often organized and depicted in competency models. Krumm and colleagues (2016) define a competency model as the collection and description of workers' competencies that are considered relevant for performing current and future job tasks successfully. The lowest level of a competency model describes observable behaviours, for example, someone is having a conversation. On the next level, the psychological characteristics that are needed to show the behaviours such as abilities or knowledge are depicted. To have a conversation, this includes knowledge about social norms and the ability to talk, for example. On the next higher level these characteristics are summarized into competencies such as the competency to communicate effectively. On the highest level, these competencies are grouped into clusters. The cluster interpersonal competencies, for example, could include the competencies to communicate effectively, create a good atmosphere for conversation, and show empathy. In terms of the KSAO concept, the competency model includes specific sets of knowledge, skills, abilities, and other characteristics clustered into specific competencies that are relevant to the corporate strategy or one's career planning (Aamodt, 2009). For example, the competency to design great juice bottles requires a combination of artistic skills to create a design, creative and enduring personality characteristics, and procedural knowledge about manufacturing processes for juice bottles. The competencies included in the competency model are essential for future success, based on future job requirements. For juice-selling companies, hiring and retaining employees with the competency to design great juice bottles is fundamentally important for the future success of the company and therefore needs to be considered in the companies' competency model. This already stresses the importance of competencies for organizations and individuals. It is therefore self-evident that competency models are used as a basis for decisions on career paths, individual developmental opportunities, personnel selection and development, succession planning, or designing incentive systems in practice (Campion et al., 2011). While competency models are widely used in organizations, few empirically derived models exist. As an exemption, Hertel and colleagues (2006) developed a conceptual competency model as a basis for a measurement tool for the selection and placement of

workers in virtual teams. Based on their theoretical model, the authors provide evidence that so-called telecooperation-related competencies such as learning motivation, interpersonal trust, or intercultural competencies, are related to high performance in teams.

Even though competencies are closely associated with performance, these two constructs may not be confused with each other: competencies are the prerequisite for performance. However, factors such as lacking motivation or difficult conditions can hinder performance (Krumm et al., 2012). A competent person can use their competencies appropriately in the situation. Moreover, competencies are a multi-dimensional construct, that can be developed continuously through random or targeted learning, experience, or training (Krumm et al., 2012; North et al., 2018). In contrast to qualifications that are usually attested with certificates after completing a predefined curriculum in a structured learning setting, competencies can be acquired in any learning setting, for example, while solving new problems at work (Kauffeld & Frerichs, 2018). Core competencies have been described as personal resources that are critical to success, unique features, and competitive advantages for organizations (Kauffeld & Frerichs, 2018). Competent workers are scarce resources as it takes time to build those specific competencies and they are almost impossible to transfer or substitute. To keep pace with the fast-changing modern work environment, workers have to develop their competencies continuously, which is reflected in better performance.

Notably, there was no consistent scientific definition of digital competencies at work, yet. Hence, based on prior research on competencies, in this dissertation, digital competencies at work are defined as follows:

> *"Digital competencies at work are a set of basic knowledge, skills, abilities, and other characteristics that enable people at work to efficiently and successfully accomplish their job tasks regarding digital media at work."*

Implying, that digital competencies are needed at most workplaces to perform even basic everyday tasks, that go beyond official job training just as social competencies, for example; these can be classified as basic competencies (Blumberg & Kauffeld, 2021). Mostly, digital competencies are not included in official job training curricula, although crucial at most office jobs and constituting prerequisites for many job positions. Furthermore, digital competencies are a multi-faceted concept, including different dimensions, such as programming, handling hardware, innovative capability and creativity, problem-solving, and netiquette.

Although all dimensions of digital competencies at work are relevant to master the requirements of the digitalized work environment, now and in the future, this dissertation focused on two particularly relevant competencies: digital communication and collaboration competencies at work (Ala-Mutka, 2011; Murawski & Bick, 2017). As already mentioned, text-based and asynchronous communication

through technology, such as e-mails, instant messages, and posts in forums, increased in private as well as work contexts. Unfortunately, research found that this is accompanied by new communication problems that arise in text-based digital interactions, as workers cannot use the visual and auditory cues they are familiar with from face-to-face communication (Schulze et al., 2017). Therefore, Trenerry and colleagues (2021) stress the importance of enhanced virtuality to facilitate task-oriented and relational communication and team collaboration. This is important as successful communication and collaboration in a work team are associated with positive work outcomes like organizational performance, knowledge sharing, and relationship-building with team members (Trenerry et al., 2021). Based on the broader definition of digital competencies at work, in this dissertation, digital communication competencies are defined as follows:

> *"Digital communication competencies are defined as the competency to use appropriate digital communication channels to communicate with colleagues, supervisors, and business partners."*

A worker who is competent in digital communication knows how to formulate digital messages, when to send them, and which digital channel to use. Likewise, in this dissertation digital collaboration competencies at work are defined as follows:

> *"Digital collaboration competencies are defined as the competency to use digital media and programmes for business collaboration, for example with colleagues, supervisors, business partners, and customers."*

A worker with high levels of digital collaboration competencies knows how to use digital technology to retrieve important information and is at least as efficient in online collaboration as offline. The definitions presented in this section are the definitions developed and used throughout this dissertation.

3. Research Gaps and Contribution of This Dissertation

As outlined above, there is an urgent need for research on digital competencies at work, and with this dissertation, I intended to meet this need and make a substantial contribution to the development of the construct. Figure 1 summarizes the main research questions and aims addressed within this dissertation.

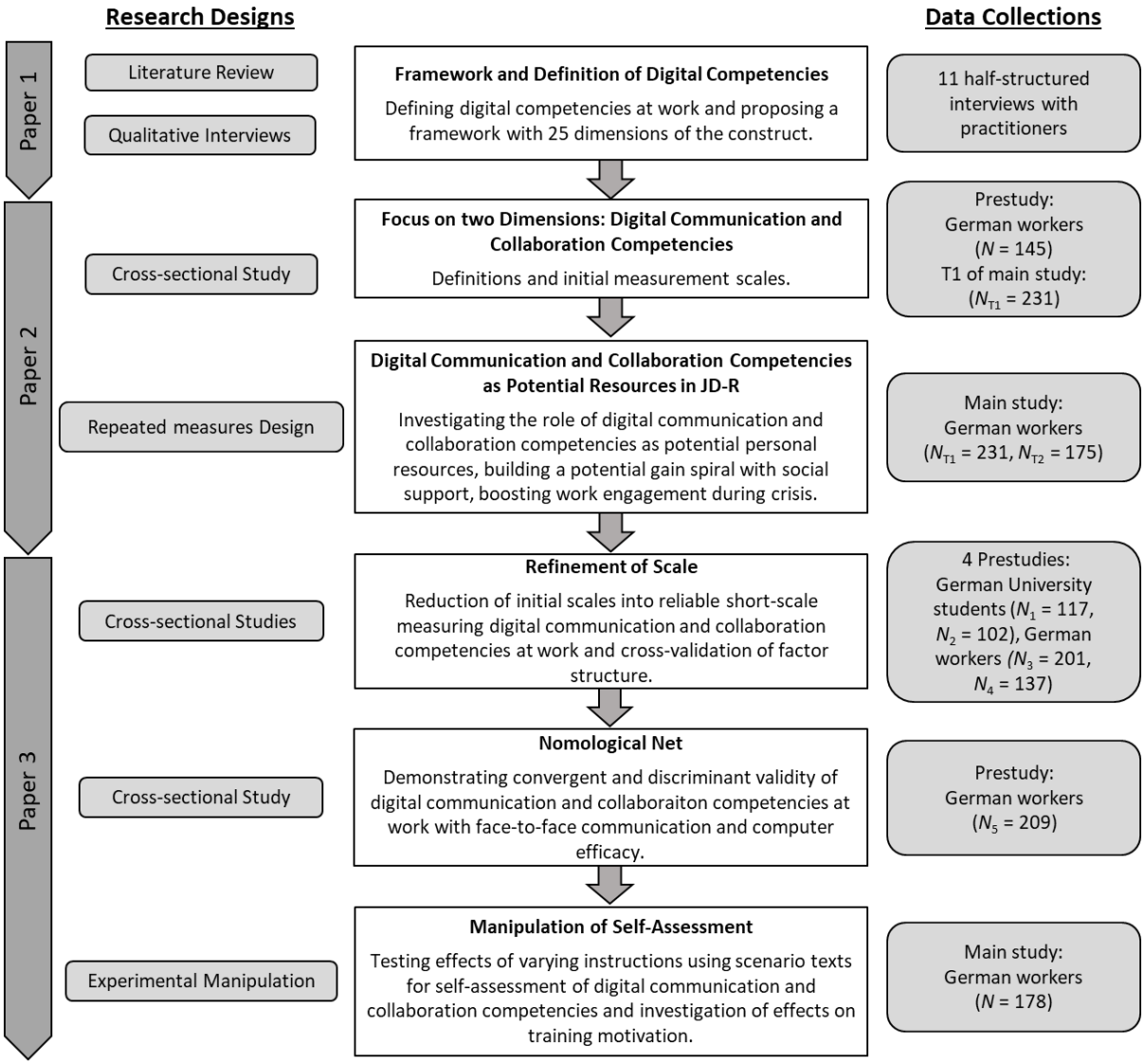

Figure 1. Overview of research aims including research designs used and data collections conducted in the papers included in this dissertation.

The first aim of this dissertation is to find an appropriate framework and a clear definition of digital competencies at work as a solid foundation for further research on the topic. However, an extensive review of the existing literature about conceptualizations of digital competencies (Paper 1) revealed that there are as many wordings as there are different perspectives on this construct (Ferrari, 2012; Murawski & Bick, 2017). Moreover, a clear definition of digital competencies for the work context remained elusive. Although there has been research on digital competencies, also proposing frameworks, the wide variety of those conceptualizations of digital competencies in diverse fields does not contribute to understanding the core of the construct (Janssen et al., 2013). A comprehensive model for digital competencies at work was lacking. Furthermore, even though politicians, practitioners, and researchers alike emphasized the need for a digitally competent workforce, prior research about digital

competencies focusing on adults at work as a target group was rare (Ancarani & Di Mauro, 2018; Arnold et al., 2016). Regarding digital competencies, it is mainly schoolchildren that have been investigated as a target group, and more often than not, the focus of the research is on early learning. While this prior research is as necessary as valuable, it neglects a vast part of the population: Adults, who need digital competencies to accomplish everyday tasks at work. Based on these findings, the aim of Paper 1 was the development of a definition and framework for digital competencies at work.

Even though all of the 25 dimensions of digital competencies that we mentioned in our framework in Paper 1 are needed to navigate the complex challenges of the digitalized world of work, two of them are particularly relevant: digital communication and collaboration competencies. Digital communication, as well as digital collaboration competencies, are prevalent merits at work, both in theory and practice. Since most work tasks are too complex to be handled by one person, digital communication and collaboration with team members are important aspects of most jobs (Gilson et al., 2014). In today's workplaces, a day in the office without e-mails or chat messages would be hard to imagine, to name just one example (Raghuram et al., 2019). Communicating and collaborating online makes work more efficient and faster than it has been ever before (Wang, 2010). Moreover, in theory, digital communication and collaboration have been mentioned as essential competencies of the current century often (e.g., Schulze et al., 2017) and were included as integral parts in most theoretical models of digital competencies (e.g., Hertel et al., 2006). This is not surprising, given that high levels of digital communication and collaboration can be associated with desirable work outcomes, such as performance (Hertel et al., 2006; Schulze & Krumm, 2016) or innovation (Trenerry et al., 2021).

Meanwhile, the outbreak of the COVID-19 pandemic in the spring of 2020 changed the way of work suddenly and fundamentally for most workers in Germany and worldwide. During this ongoing crisis, the need for digital competencies – communication and collaboration competencies in particular – became even more urgent (Wang et al., 2021). Suddenly, large parts of the workforce had to convert from meeting colleagues in the office every day to working from home exclusively when governments introduced social distancing policies to prevent the virus from spreading. Using digital information and communication technologies to transfer meetings in the digital world was the only way to maintain communication and collaboration in work teams. Fortunately, there has been prior research focusing on topics such as virtual work, telecommuting, or virtual teams, for example, contributing to the broader understanding of the impact of working from home on diverse outcomes that are relevant in the work context (Raghuram et al., 2019). For instance, Golden et al. (2008) found that professional isolation due to teleworking negatively impacts job performance, but can be improved by more in-person meetings with colleagues and supervisors as well as access to technology that enhances communication. However, most of these studies were based on workers who volunteered to work from home or compared workers working remotely with those in the office (Bloom et al., 2015; L. Yang et al., 2022). Moreover, meanwhile, technological advances changed the working conditions offering new options for digital

communication and collaboration. It seemed worthwhile to complement this important perspective with a focus on the individual competencies that workers need to handle current and future challenges in a digitalized world of work. There was a great need to know more about digital communication and collaboration competencies at work in research and practice and not only since the beginning of the crisis altering the ways of work. However, a solid measurement instrument assessing those competencies has not been developed yet. Consequently, our first aim in Paper 2 was to close this gap by developing two scales measuring digital communication and collaboration competencies at work.

Within the framework of the *Job Demands-Resources model* (Demerouti et al., 2001), a broad range of different job (e.g. social support) or personal resources (e.g. emotional competencies) and their effects on motivational processes in terms of work engagement have been researched (e.g., Bakker & Demerouti, 2007; Hakanen et al., 2021). For example, Lorente Prieto and colleagues (2008) found that the personal resources emotional competences were related to increased work engagement in Spanish teachers. While other competencies have been shown to trigger motivation at work, it was unknown if digital communication and collaboration competencies could also act as personal resources, fostering intrinsic motivation at work. Therefore, in Paper 2, the research goal was to investigate the role of workers' digital communication and collaboration competencies as potential personal resources, boosting work engagement in times of crisis. Furthermore, the *conservation of resources theory* (Hobfoll, 2011) suggests a gain spiral of resources that positively influence each other over time, ultimately increasing work engagement (e.g., Llorens et al., 2007). Prior research by Xanthopolou et al. (2009) found, for example, the personal resource optimism fully mediating the relationship between autonomy and work engagement on a daily level in employees of a fast-food company. The findings support the theory of dynamic gain spirals of resources. Building on this *conservation of resources theory*, in Paper 2, we aimed to examine the interplay of digital communication and collaboration competencies with another, up to now well-known job resource in the motivational process, social support, in terms of a gain spiral (Hobfoll, 2011). Additionally, as the COVID-19 pandemic indeed acts as an unprecedented crisis, it heavily influenced the way of work worldwide. Thus, we aimed to collect data during this ongoing global crisis to investigate if the well-known gain spirals of resources and effects of those on motivational processes could also be found in times of crisis.

Systematic research on digital competencies as well as reliable and valid measurement instruments assessing digital competencies in theory and practice were still rare (e.g., Raghuram et al., 2019). Hence, one major goal of this dissertation was to provide researchers and practitioners alike with a practicable, but also valid and reliable scale measuring digital communication and collaboration competencies at work. Additionally, detailed knowledge of the construct's nomological net was still limited. Therefore, another aim was to provide much-needed insights into the convergent and discriminant validity of digital communication and collaboration competencies at work. Moreover, prior research, including our own studies, indicates potential overestimation effects of digital communication

and collaboration competencies at work (see Paper 2). Arguably, medium to high levels of those competencies are assessed with lower precision with the existing scales. Consequently, one aim of this dissertation was to test the effects of varying instructions on the self-assessment of digital communication and collaboration competencies in an experimental setting. In times of fast-changing work environments due to challenges like ever-new technologies, the motivation to self-develop constantly is key for most workers to close their competency gaps (Mason & Brougham, 2020). For example, Yang and colleagues (2004) argue that the learning capability of employees will be the only competitive advantage in companies in the future that is also sustainable. Thus, another research question addressed in this dissertation is whether varying instructions for the self-assessment of digital communication and collaboration competencies can be changed to encourage training motivation at work.

4. Summaries of the Empirical Studies Included in This Dissertation

In the following, I present the empirical studies that we conducted to answer the open research questions and pursue the research objectives outlined above. These studies are included in three papers, depicted in Chapters 2, 3, and 4 of this dissertation. Figure 1 gives an overview of the research aims and questions, research designs, and collected data samples of each paper included in this dissertation.

Paper 1: Digital Competencies: A Review of the Literature and Applications in the Workplace

Even though there is growing awareness of the relevance of a digitally competent workforce in theory and practice and the term digital competencies is used widely, thus far a comprehensive research model and a consistent definition of the construct that is generally accepted were still lacking (Murawski & Bick, 2017). As a first step to help tackle this issue, the aims of Paper 1 were twofold: First, the development of a definition, and second, providing a framework for digital competencies that is suitable for the work context. To gather information on existing frameworks and definitions about the construct of digital competencies to date, we conducted an extensive review of the literature on the one hand. On the other hand, we interviewed eleven practitioners to gain insights into their experiences and knowledge about digital competencies at work. Using a combination of qualitative and quantitative methods, we obtained content-related descriptive units from both, prior scientific findings from the literature review and insight knowledge of professionals from the interviews. These units were sorted by similarity into 25 resulting clusters as core dimensions in a framework for digital competencies at work.

Paper 2: Do Digital Competencies and Social Support Boost Work Engagement during the COVID-19 Pandemic?

Due to technological innovations and societal progress, the need to use digital information and communication technology to accomplish work tasks efficiently increased and became indispensable during the ongoing COVID-19 pandemic. However, the knowledge about digital communication and collaboration competencies that are required at least on a basic level to accomplish daily work tasks was still limited (e.g., Gallardo-Echenique et al., 2015). As a measurement instrument was still lacking, first, we developed two scales to assess digital communication and collaboration competencies at work in two independent samples of German workers ($N_1 = 145$, $N_{T1} = 231$) building on the previously suggested coherent and detailed framework from Paper 1. Our second research goal for Paper 2 was to investigate the role of workers' digital communication and collaboration competencies as potential personal resources in times of crisis. Based on the *Job Demands-Resources Model* (Demerouti et al., 2001), we expected that digital communication and collaboration competencies function as personal resources, and social support as a job resource, enhancing work engagement during the COVID-19 pandemic. Moreover, based on the *conservation of resources theory*, we hypothesized a gain spiral of positive personal and job resources in terms of digital competencies and social support, boosting work engagement (e.g., Hobfoll, 2011; Hu et al., 2017). Therefore, we tested our research model in a cross-lagged study design, collecting data from German workers starting during the pandemic lockdown in April 2020 with a minimum time lag of ten weeks ($N_{T1} = 231$, $N_{T2} = 175$).

Paper 3: Assessing Digital Competencies at Work and Improving Training Motivation

All research and practical interventions on individual competencies are based on the reliable measurement of the construct. Although we developed an initial measurement instrument for the two dimensions digital communication and collaboration competencies in Paper 2, potential ceiling effects indicated by high measured competency levels could not be ruled out. To tackle the issue at hand, we set four research goals for Paper 3. First, we aimed to refine the existing measurement tool from Paper 2 into a reliable and valid short-scale for digital communication and collaboration competencies at work, that is based on both, the framework of digital competencies that we developed in Paper 1 and the definitions of digital communication and collaboration competencies that resulted from our research in Paper 2. Second, we aimed to gain insights into the nomological net of the construct. Third, we pursued the goal of investigating the effects of varying instructions on the self-assessment of digital communication and collaboration competencies at work. Fourth, we aimed to provide answers to the research question of whether different instructions for the rating of one's own digital communication and collaboration competencies affected the training motivation of workers.

Following our first research goal for Paper 3, we conducted four steps using four samples in a series of prestudies. We started by generating new items as more difficult versions of the original items.

Using two samples of University students (N_1 = 117, N_2 = 102), we selected a combination of original and difficult items based on a mix of measures from *Item Response* and *Classical Test Theory*. In a third sample (N_3 = 201), we reduced the adapted scale to a more feasible six-item short-version and cross-validated the internal structure of the short-scale in a fourth sample of German workers (N_4 = 137). Subsequently, following the second research aim, in Study 1, we investigated the convergent and discriminant validity of the construct with face-to-face communication and computer efficacy in a large sample of white-collar workers (N_5 = 209) to provide insights into the nomological net. Following our third and fourth research goals for Paper 3, we conducted an experiment with another sample of workers (N_6 = 178) in Study 2. To realize the manipulation of the self-assessment of digital communication and collaboration competencies and investigate the relation with training motivation, we used scenario texts to induce social comparison or thinking of future work requirements.

Chapter 2 – Paper 1

Digital Competencies: A Review of the Literature and Applications in the Workplace

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Abstract

In today's organisations and politics, there is a growing awareness of the gap between existing and needed digital competencies of the workforce to master the challenges of the digitalised future at work. Nevertheless, no comprehensive framework or definition of digital competencies at work has been proposed so far. Our aim is to offer a holistic view and broaden the scope of the concept of digital competencies, thereby focussing on applications at work. We combine diverse methods to integrate different perspectives on digital competencies. By conducting an extensive literature review about definitions and frameworks of digital competencies that might be applicable at work, we provide an overview of the current state of the art in research on digital competencies. Additionally, eleven half-structured interviews based on the critical incidents technique (CIT) were conducted to gain insights into the perspectives of professionals with expertise in digitalisation processes and digital competencies. Subsequently, researchers with different educational backgrounds clustered the results from both approaches and agreed on 25 dimensions that constitute digital competencies for white-collar workers with office jobs, encompassing a large variety of knowledge, skills, and abilities. The results of this research indicate that even though there is overlapping content, each perspective adds unique content to the concept of digital competencies at work. By creating a coherent and detailed framework and a definition, our research enhances the applicability of professional learning and development of digital competencies at work.

Keywords: digital competencies; review; workplace; lifelong learning

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Digital Competencies: A Review of the Literature and Applications in the Workplace

1. Introduction

Beyond the huge impact of the ongoing digitalisation in our society on our everyday life, new technologies also have a tremendous impact on the way we work (e.g., Murawski & Bick, 2017; Zaphiris & Ioannou, 2016). Devices and software programmes used in professional contexts are constantly renewed to be more efficient and to facilitate work. These changes call for increasing usage of digital information and communication technology (ICT) at work. Indeed the majority of employees today use digital ICT at work, as confirmed by 83% of the participants in a large representative German workforce sample (Arnold, Butschek, & Steffes, 2016). Most workplaces require at least basic digital competencies (Gallardo-Echenique, de Oliveira, Marques-Molias, & Esteve-Mon, 2015). Already in 2006, the European Parliament and the Council identified digital competence as one out of eight key competences for lifelong learning (Ferrari, 2012; van Laar, van Deursen, van Dijk, & de Haan, 2017). In detail, they defined competence as a combination of knowledge, skills and attitudes, and digital competence as "the confident and critical use of Information Society Technology for work, leisure and communication" (Søby, 2013, p. 135).

Therefore, employees have to engage in lifelong learning, and acquire new competencies to adapt to the constantly increasing demands of the fast-changing work environment (e.g., Ahmad, Karim, Din, & Albakri, 2013; Carnevale & Smith, 2013; Cascio & Montealegre, 2016). Indeed, there seems to be a gap between existing and needed digital competencies (DC) of the workforce (e.g., Ancarani & Di Mauro, 2018; Janssen et al., 2013). In the study of Arnold and colleagues (2016), over two-thirds of the interviewed workers indicated that they constantly needed to develop further their competencies at work because of technical innovations. Even though politics and employers are aware of this issue, scientific research focussing on the DC of workers is still scarce (Murawski & Bick, 2017).

1.1 Purposes of this Article

The goal of this research is to foster the understanding and add essential knowledge about conceptualizations and theories of DC at work. Therefore, we provide an overview of existing definitions and frameworks with a focus on evaluating their potential applications at work in a literature review. Afterwards, we aim to address the science-practice gap in this field by developing essential

dimensions of DC for white-collar workers that are not only based on the literature but also on insights of working practitioners.

2. Review of the Literature on Digital Competencies

2.1 Method

2.1.1 Identification of Relevant Studies and Search Process

At first, we screened the literature for definitions and frameworks of DC to get an overview of the existing literature. In detail, we conducted a database search of PsycINFO, SocINDEX, Psyindex, and ERIC using keywords like digital competence, digital literacy, and ICT literacy. Only publications including the keywords in the publication title or abstract were selected. Then, we looked at the reference lists of the selected publications and added relevant publications. Additionally, given our focus on the workplace, we screened the top tier journals in applied psychology according to the SSCI Index (1. quartile) for articles that could add to the clarification of the concept of DC at work. However, this search strategy led only to a limited number of publications in peer-reviewed journals (n = 5). Therefore, we decided to use the portal Google Scholar to search for additional literature, and considered non-reviewed references, too (e.g. policy reports). In total, we found 142 relevant publications that were published before September 2018.

2.1.2 Inclusion Criteria for Article Selection

We screened the 142 identified publications and applied the following inclusion criteria. As we aimed for an overview of existing definitions and frameworks, articles had to offer either a definition, a model, a concept or a framework of DC. Since only a handful of the remaining publications met the criteria to be about adult and working people, we included publications about adolescents and non-working people, too.

2.1.3 Coding of Articles

To get a systematic overview and analyse the remaining publications in detail ($N = 28$), we applied five categories of rating criteria (terminology used, framework proposed, publication, empirical evidence, sample). First, one of the authors of this article rated all of the publications on all of the criteria, thereby developing a detailed rating scheme including a description of the criteria and labels. Afterwards, another author rated the publications independently, following the rating scheme. The initial agreement was very high (e. g., 89.29 % for terminology used). Next, discrepancies and ambiguities in

the rating scores were discussed until consensus was reached and the rating scheme adjusted accordingly.

Terminology used. This criterion lists the terminology that has been used in the publication, as different terms are used to describe the concept of DC, for example, digital literacy, e-skills, and similar terminology.

Framework proposed. We define framework as any kind of model or description that aims to enhance the conceptual understanding of DC by suggesting a structure of the concept. This includes a detailed description of DC and breaking down the concept in coherent categories. A framework could include various elements on different hierarchical levels. The coding scheme differentiates between publications that propose a self-constructed framework (+) and those that did not propose any framework at all (-). Then, we differentiated further between publications that describe basic frameworks on which the ideas for their self-constructed framework about DC were based on (+) and those that proposed new, more complex frameworks with different dimensions and levels that were described in detail (++).

Publication (type, ISI-status).

Type. The publication type depends on many factors, such as the topic, the methods, and the intended audience of the research. We identified different publication types and decided on five labels: *literature review*, *policy report*, *study*, *conference paper*, and *encyclopaedia*. We labelled all the publications *literature review* that offered a discussion on relevant literature without data collection. Publications that we labelled *study* include a data collection process and describe empirical evidence. Publications labelled *policy reports* were published by political organisations. All publications that were published at conferences were labelled *conference papers*. We used the label *encyclopaedia* for entries in a reference work or compendium that provides knowledge summaries from the research field. Furthermore, we added the name of the project that the publication was based on in brackets behind the label if this information was available.

ISI-status. The International Scientific Indexing (ISI) provides indexing of international scientific journals and conference proceedings and can be seen as one common quality criterion for the application of scientific standards. We ranked the publications in journals that are indexed with "+" and other publications with "-".

Empirical evidence (quantitative, qualitative).

Qualitative. Qualitative research methods are used to analyse non-numerical data that have been collected from participants during an empirical data collection process (e.g. interview answers) and are embedded in the research process, which refers to the description, meaning and clarification of concepts or definitions (Field, Miles, & Field, 2012). We differentiated between publications that present any kind of empirical qualitative research on definition, framework, or conceptual clarification of DC (+) and those that did not present any kind of non-numerical data (-).

Quantitative. Quantitative research is the systematic empirical analysis of observable phenomena in form of numerical data by using statistical methods (Field et al., 2012), for example, data collected in structured interviews using psychophysiological methods or questionnaires. We differentiated between publications that presented any kind of numerical data and empirical quantitative research methods on the definition or conceptual clarification of DC (+) and those that did not (-).

Publications that lacked a description of the methods in so far as the rating for quantitative and qualitative was impossible to assign, were labelled as *not available* (*n.a.*). The publications that are neither labelled as qualitative nor as quantitative ("-" on both criteria) are theoretical publications.

Sample (adults, workers).

Adults. As we focus on DC at work, we were mainly interested in research about the DC of adults. This rating criterion differentiates between publications that report about a sample that includes adults (+) or children only (-).

Workers. In our definition of workers, we include employees and self-employed workers at any kind of workplace. In Table 1, we differentiated between publications that include workers in a sample (+) and those that do not (-).

Publications that did not report about data collection with a sample at all are labelled "†". If the publication lacked a comprehensible description of the sample, it was labelled "*n.a.*".

2.2 Results

Table 1 provides a comprehensible overview of the results of the rating process of the 28 identified publications.

Terminology used. *Digital competence* was the most frequently used term (*n* = 20), followed by *digital literacy* (*n* = 5). However, the different terminologies in Table 1 are just examples for the wide variety of terms that are being used to describe the concept of DC in the literature. For instance, Martin (2005) defined *digital literacy* as "the awareness, attitude and ability of individuals to appropriately use digital tools and facilities to identify, access, manage, integrate, evaluate, analyse and synthesize digital resources, construct new knowledge, create media expressions, and communicate with others, in the context of specific life situations, to enable constructive social action; and to reflect upon this process" (p. 155). Calvani, Cartelli, Fini, and Ranieri (2008) proposed a very similar definition but used the term *digital competence*. Yet not only the terminology varies but also the definitions used to explain DC. Ferrari (2012) defines DC in a very broad sense in many different aspects of life today's digital society as "the confident, critical and creative use of ICT to achieve goals related to work, employability, learning, leisure, inclusion and/or participation in society" (p. 3). With this definition, she aims to refer to many different aspects of life in today's digital society. In contrast, Søby (2013) defines DC as a set

of skills, including basic skills such as reading and maths, and advanced ICT skills, like evaluating information and sources. This approach indicates a very general use of the term skills and DC to be a complex concept. According to Ala-Mutka (2011), DC includes knowledge, skills and attitudes, referring to Gilster (1997) who first introduced the concept. In this concept, DC does not only include basic skills such as searching for information online, but also more complex abilities, like the analysis, interpretation, and application of the information in relevant life contexts. Torres-Coronas and Vidal-Blasco (2011) define DC as the "ability to understand and express by making analytical, productive and creative use of the information technologies and social software to transform information into knowledge" (p. 62). According to this definition, students need DC for informed decision-making and collaborative learning with the help of digital tools, for example. Furthermore, not only the terminology of the construct but also the terminology of the different hierarchical levels within the different frameworks is very diverse. What we call *dimensions* as constituting parts of DC on a medium-sized abstraction level, are called "main areas" (Ala-Mutka, 2011, p. 5) or "types" (Torres-Coronas & Vidal-Blasco, 2011, p. 63), for example.

Framework proposed. Only in four of the publications a new framework of DC was introduced, while in 14 publications adapted version of existing frameworks were used. Eight of the publications were based on the DigComp framework (a project aimed to develop and understand the concept of DC for European citizens). Many differences in the proposed frameworks were visible, such as the number of dimensions (three to twenty-one), hierarchical levels, and level of detail in descriptions. For example, van Laar and colleagues (van Laar, van Deursen, van Dijk, & de Haan, 2017) proposed a framework that comprises seven core skills and five conceptual skills, while Torres-Coronas and Vidal-Blasco (2011) propose a framework with three different types of competencies and various levels of mastery within each competency.

Publication (type, ISI-status).

Type. Most of the included publications were rated as *article* (*n* = 9), *literature review* (*n* = 8), or *policy report* (*n* = 7). Even though we decided to narrow down the number of labels for publication type to cluster the results, there is a diversity in styles within these labels. For example, articles included very different types of research and different levels of quality. While some authors of literature reviews are merely describing and comparing existing frameworks, others propose new frameworks. Furthermore, the backgrounds of the researchers publishing about definitions and frameworks of DC (ranging from library science to educational technology) are as diverse as their purposes. The variety of publication types in DC research represents the many different methods, research disciplines, aims, and intended audiences in this area. Eighteen of the analysed publications underwent a peer-review process, while it remained unclear for ten publications if there was a peer-reviewing process before publishing. Three of the peer-reviewed publications were published as conference contributions.

ISI-status. Ten of the peer-reviewed publications were published in indexed journals or proceedings with an ISI-status. Three of these publications were indexed, but without a Journal Impact Factor (JIF, Clarivate Analytics, 11.02.2018). Just seven of the analysed publications met the most stringent requirements and were published in peer-reviewed journals with a JIF.

Empirical evidence (qualitative, quantitative). In just over half of the publications (n = 16), the authors reported clear qualitative and/or quantitative empirical evidence. The authors of eleven publications did not report about the collection of empirical evidence at all. Ten of these publications were of theoretical nature. For the policy report of Carretero, Vuorikari, and Punie (2017), it remained unclear if the authors collected empirical data. Janssen et al. (2013), and Ng (2012) used a mixed methods approach, reporting about the analysis of both qualitative and quantitative data.

Qualitative. In seven publications, the authors reported collecting and analysing qualitative data. The authors described the collection of qualitative data in a wide variety of approaches, for example in form of expert discussions or stakeholder consultation. Many of the publications lacked a detailed description of the research process including methods, instruments, and analyses (for a checklist, see e.g., Desrosiers et al., 2007).

Quantitative. In eleven publications, the authors reported about collecting and analysing quantitative data, mostly using self-report questionnaires. Guzmán-Simón, Garcia-Jiménez and López-Cobo (2016), for example, asked university students to complete online self-report questionnaires with a six-point Likert scale about DC and academic literacy.

Sample (adults, workers). In the further evaluation of this criterion, we included solely publications that provided some sort of empirical evidence and details about the sample, which we labelled with "+" in at least one subcategory of *empirical evidence*.

Adults. From these sixteen publications with data from a sample, less than half of the publications (n = 7) reported results on adults. Even if adults were included in the sample, in most of these publications younger participants were assessed, too (n = 4). For instance, Soldatova and Rasskazova (2014) interviewed adolescents and their parents, whereas Eshet-Alkalai (2004) asked ten university students and ten adults over the age of 30. Only in three publications, the authors reported results on adult samples (inferred from the fact that participants were described as researchers and experts). However, we differentiated between the intended target group and the sample of the research. We define the sample as those participants that contributed qualitative or quantitative data. For instance, even though the samples in the research of Janssen et al. (2013) and of Mengual-Andrés, Roig-Vila, and Mira (2016) consisted of adults only, adults were not the main intended target group.

Table 1

Overview of the publications and rating criteria included in the systematic literature review and results of the rating process.

Author(s)	Terminology used	Framework proposed	Publication		Empirical Evidence		Sample	
			Type	ISI-Status[a]	Qualitative	Quantitative	Adults	Workers
Ala-Mutka (2011)	Digital Competence	+	Policy Report (DigComp*)	-	+	-	n.a.	n.a.
Bawden (2001)	Digital Literacies	-	Literature Review	+	-	-	†	†
Brečko & Ferrari (2016)	Digital Competence	+	Policy Report (DigCompCons)	-	+	-	n.a.	n.a.
Calvani et al. (2008)	Digital Competence	+	Article	-	-	+	-	-
Carretero et al. (2017)	Digital Competence	+	Policy Report (DigComp)	-	n.a.	n.a.	n.a.	n.a.
Cartelli (2010)	Digital Competence	++	Conference Paper	-	-	+	-	-
Eshet-Alkalai (2004)	Digital Literacy	++	Literature Review	+	-	-	+	n.a.
Ferrari (2012)	Digital Competence	+	Policy Report (DigComp)	-	+	-	n.a.	n.a.
Ferrari (2013)	Digital Competence	+	Policy Report (DigComp)	-	+	-	n.a.	n.a.
Ferrari, Punie, & Redecker (2012)	Digital Competence	+	Conference Paper	-	-	-	†	†
Ferrari, Brečko, & Punie (2014)	Digital Competence	+	Policy Report (DigComp)	-	+	-	n.a.	n.a.
Gallardo-Echenique et al. (2015)	Digital Competence	-	Literature Review	-	-	-	†	†
Guzmán-Simón et al. (2017)	Digital Competence	-	Article	+	-	+	+	-
Hatlevik (2009)	Digital Competence	-	Article	-	-	+	+	-
levik et al. (2015)	Digital Competence	-	Article	+	-	+	-	-
Hobbs (2010)	Digital and Media Literacy	-	Policy Report (White Paper)	-	-	-	†	†
Ilomäki et al. (2011)	Digital Competence	-	Literature Review	-	-	-	†	†
Janssen et al. (2013)	Digital Competence	++	Article	+	+	+	+	+
Maderick et al. (2016)	Digital Literacy	-	Article	+	-	+	+	+

Table 1 (continued)

Martin & Grudziecki (2006)	Digital Literacy	+	Literature Review (DigEULit)	-	-	-	†	†
Mengual-Andrés et al. (2016)	Digital Literacy	+	Article	-	-	+	+	+
Meyers et al. (2013)	Digital Literacy	-	Literature Review	+	-	-	†	†
Ng (2012)	Digital Competence	+	Article	+	+	+	+	-
Siiman et al. (2016)	Digital Competence	+	Conference Paper (DigComp)	-	-	+	-	-
Soldatova & Rasskazova (2014)	Digital Competence	++	Article	-	-	+	+	+
Torres-Coronas & Vidal-Blasco (2011)	Digital Skills	+	Literature Review	+	-	-	†	†
van Laar et al. (2017)	Digital Competence	+	Literature Review	+	-	-	†	†
Vieru (2015)	Digital Competence	+	Encyclopaedia	-	-	-	†	†

Note.

+ = yes, - = no, ++ = new framework was proposed, † = no sample, n.a. = not available

[a] International Scientific Indexing

* This project aimed to develop and understand the concept of DC for European citizens

Workers. When looking at the seven publications that collected data from adults, even fewer publications report about the workforce as a target group ($n = 4$). For instance, the sample from Soldatova and Rasskazova includes pupils along with 1209 parents, probably partly composed of workers. Nevertheless, the workforce was not an intended target group of their study. At least eleven of the publications focus on DC in an educational context. While Janssen et al. (2013) asked a panel of experts with various backgrounds on DC of people of all ages, Mengual-Andrés and colleagues (2016) asked 27 university researchers on DC of students in higher education. These examples illustrate that even though the sample is (partly) composed of workers, the intended target group includes or consists entirely of non-working people.

2.3 Discussion

In a first step, we aimed to provide a comprehensive overview of existing definitions and frameworks. Reviewing the literature on DC and their potential applications for the workplace, the following conclusions can be drawn. It is apparent that many different labels for the concept of DC are prevalent, leading Ferrari, Punie, and Redecker (2012) to call this field a "jargon jungle" (p. 11). Oftentimes, different terminology is used interchangeably, as synonyms, describing the same concept, but definitions and intended meanings are rather imprecise and depend on the context of use. The frameworks and concepts proposed in the literature to describe DC differ considerably in content and scope. Most of the frameworks vary tremendously in the number of dimensions and basic assumptions of DC, for example. The high sheer number of different frameworks in Table 1 shows that in the literature there is not only disagreement on the terminology for the same construct, but also on the structure of the concept behind the same term. Moreover, some articles propose overarching definitions of DC and therefore lack the precision and level of detail that is needed to provide an applicable definition of DC at work.

3. Development of a Definition and Relevant Dimensions of Digital Competencies at Work

In this section, we aim to address the science-practice gap with regard to DC by combining qualitative and quantitative research methods and integrating the view of different stakeholders. First, we lay ground for a common understanding of DC at work among researchers, practitioners, and politicians by proposing a comprehensible definition of DC at work. Second, we develop a framework that includes a conclusive description of relevant dimensions of DC at work, which does not only refer to a theoretically well-conceived basis but also allows applications in practice. For this, we combine the

results of the previous literature review with the insight knowledge of practitioners who experience digitalisation processes at work first-hand.

3.1 Proposed Definition of Digital Competencies at Work

So far, there is no agreed-upon definition of DC neither any definition to express a common understanding of DC at work. Based on our literature review, and in particular on existing definitions of the more general concept of competencies at work (Guzmán-Simón, 2017; Kauffeld & Paulsen, 2018) and the respective central characteristics in terms of knowledge, skills, abilities and other characteristics (KSAOs, e.g. Aamodt, 2009; Krumm, Mertin, & Dries, 2012), we propose a working definition of DC at work as follows:

> *Digital competencies at work are a set of basic knowledge, skills, abilities, and other characteristics that enable people at work to efficiently and successfully accomplish their job tasks regarding digital media at work.*

We chose to adopt the term *digital competencies* from the many diverse terms used in the literature for several reasons. We chose the term *digital*, because it is a relatively broad term that includes any kind of ICT and digital media, referring to devices and applications that are used at work, now and in the future.

By choosing the term *competencies* over any other terminology (e.g., literacy), we want to stress that we are building on competencies as a well-established construct in IO research. Building on definitions of competencies, the plural was chosen to highlight that competencies are generally not unidimensional but composed of different dimensions. According to the KSAO concept, which is often used interchangeably with the concept of competencies at work (Aamodt, 2009; Krumm et al., 2012), workers need knowledge (K), skills (S), abilities (A), and other characteristics (O) to effectively and successfully perform at their job (Campion et al., 2011; Spector, 2008). *Knowledge* is described as the information a worker needs to perform a job task. While *skills* are defined as the "proficiency to perform a particular task" (Aamodt, 2009, p. 53) that is learnable, *abilities* are defined as a "basic capacity for performing a wide range of different tasks, acquiring knowledge, or developing a skill" (Aamodt, 2009, p. 53) that can only be trained to a certain degree (Campion et al., 2011; Krumm et al., 2012). Finally, *other characteristics* refer to personality characteristics, motivation, personal interests, prior experiences or degrees and certificates that are required for good performance at work, for example (e.g., Krumm et al., 2012; Spencer & Spencer, 1993). Especially in the work context, a work task usually requires different types of competencies to be mastered successfully (Kauffeld & Paulsen, 2018; Spencer & Spencer, 1993). Each worker has an individual set of competencies and each job position requires a combination of different competencies based on the KSAO concept or its variations. Several different

competencies of workers, teams, or organisations have been shown to predict important observable results and are requirements for good performance at work (Spencer & Spencer, 1993).

Among the various expressions used, we adopted the term *digital media* as it is thought to include different digital devices and applications that are used on a regular basis to master typical office tasks at work, for example, mail programmes. Finally, we focussed on DC *at work* in the definition proposed as this is a life domain, where people cannot decide for themselves if they want to use DC, as they may in their leisure time. Not least because of that, people can benefit the most from their DC at work, where it is important to save resources, act efficiently and fast. We assumed that a majority of the workers at typical office workplaces spent most of the working time using a digital device, nowadays (Arnold et al., 2016; Gallardo-Echenique et al., 2015). Moreover, while teams and organisations can also be digitally competent, we focussed on DC from the perspective of an individual worker in the workforce. Other perspectives, like the organisational or societal ones, are discussed insofar as they contribute to the concept of DC of the workforce.

3.2 Dimensions of Digital Competencies at Work: Integrating the Literature and Practitioners' View

Even though several concepts of DC have been proposed so far (see Table 1; e.g., Carretero et al., 2017; Eshet-Alkalai, 2004), none of them builds on all of the facets of the KSAO approach. Furthermore, research about DC at work is still scarce (Ala-Mutka, 2011; Murawski & Bick, 2017). Therefore, we base our understanding of DC at work on knowledge, skills, abilities, and other characteristics. To specify relevant dimensions for the workplace, we narrowed down the target group of DC to white-collar workers with office jobs who spend most of their time at work with digital devices but do not have digital media as the main content of their work tasks (e.g., like IT specialists).

3.2.1 Method

The extensive review of the literature about DC in Chapter 2 was complemented by interviews with practitioners about the definition of DC at work. From both perspectives, descriptions and elements of DC were collected and clustered, with the aim to develop a comprehensive taxonomy and dimensions of relevant factors of DC at work.

Participants and procedure. We extracted content-related descriptive units about the definition and concept of DC from the literature, based on the previously reported literature review, using methods of the inductive content analysis (Elo & Kyngäs, 2008; Mayring, 2014). The units were chosen to be as small as possible while still adding value in terms of meaningful content. Therefore, the length of the units varied between one word (e.g., communication) and full sentences (e.g., the ability to make informed judgements about what is found online, which he equates to 'the art of critical thinking').

Then, each of the authors clustered the extracted content-related units of DC from the literature by similarity. The separately obtained results were compared and discrepancies solved by discussion until consensus was reached. For each cluster, a heading was agreed upon. Subsequently, we included the view of practitioners about the definition and concept of DC at work. For this end, we developed a half-structured interview guideline based on the critical incidents technique (Flanagan, 1954). Eleven graduate students with prior knowledge about definitions and concepts of DC used these interview guidelines to interview practitioners with diverse expertise in digitalisation processes within the context of work about their definitions of DC at work. To cover a broad range of DC in many diverse work settings of white-collar workers, we attached importance to the heterogeneity of the sample, particularly with regard to the educational background, hierarchical level, job position, and the branch of the practitioners. The hierarchical level of the practitioners varied between general manager (n = 1), upper management (n = 1), middle management (n = 2), lower management (n = 2) and employee without managerial functions (n = 5). The job positions of the practitioners were as diverse as HRM (n = 4), research and development (n = 2), IT (n = 2), company management (n = 2) and marketing (n = 1). Also, the branches of their companies were a heterogeneous mix of industry (n = 5), finance (n = 2), tourism (n = 1), marketing (n = 1), and other branches (n = 2). Additionally, we chose a mixed sample in terms of age and gender to prevent any biases based on these factors.

The first part of the interview consisted of demographic questions (e.g., What is your job position?), the second part was about the definition of DC (e.g., Asking in a general way: What do you understand by DC?) and in the third part, we asked the practitioners about basic and specific DC at work. Except for the first three questions, we used an open-answer format. We aimed to make the practitioners look at DC from various angles to cover a broad range of behaviours. To generate more diverse answers, we asked the practitioners to change their perspectives and describe their supervisors' and subordinates' perspective on which DC are needed at work, too (e.g., Which DC are needed at most workplaces, in your opinion?).

Parallel to the process of extracting and sorting descriptions from the literature, the graduate students extracted content-related descriptive units about the definition and concept of DC at work from the interviews with the practitioners and sorted these units by similarity. Then, they chose a heading for each cluster, too.

To combine the insights from the scientific literature with those from the practitioners at work, we combined the two sets of clusters from the scientific literature and the interviews to formulate dimensions of DC at work with a heading and anchor samples for each dimension. However, it was not the aim to define a model with distinct categories. Instead, we intended to formulate a comprehensive and encompassing definition of DC that considers the vast variety of different aspects, aiming at a medium-sized abstraction level.

Finally, we invited five researchers from the field of social sciences with prior knowledge of competencies and digitalisation processes to validate the dimensions. We asked them to assign units from the literature and the interviews to the headings we chose for the dimensions. We compared the results with our first allocation of the units to the headings and the dimensions and made adjustments if necessary.

3.2.2 Results

The clustering process resulted in 25 dimensions of DC at work. In total, 946 content-related units describing DC were extracted. From the literature, we extracted 265 units. The clustering and subsequent discussion of the clusters resulted in twelve clusters of DC from the literature. From the interviews, the graduate students extracted 681 units and clustered these units into fifteen clusters (with 30 facets). Merging the clusters from the literature with those from the interviews resulted in 25 dimensions of DC at work. Table 2 depicts a summary of the results of the clustering process. The content of the clusters from the literature and from practice showed a huge overlap. First, we matched the clusters from the literature and interviews that included the same or very similar wording in the headings (e.g., security, communication) to form one dimension. Afterwards, we scanned the remaining clusters for similar keywords in the description and examples, marking similar intended meanings (e.g., data management and organisation of digital information), and matched those clusters to form one dimension. Nevertheless, the input from the practitioners resulted in nine clusters that were not found in the literature (e.g., *Networking*), while six of the clusters were not mentioned in the interviews but found in the literature (e.g., *Creating content: Creative, innovative)*. Finally, we formed dimensions of these remaining clusters with input, either from the literature (e.g., *Ethics and moral*) or the interviews (e.g., *Sharing data with others*), too.

In the following, the 25 interrelated dimensions are outlined shortly (see detailed descriptions in the supplementary material). *Handling of hardware* is the competency to appropriately deal with hardware at work. *Handling of software* is the competency to use at least basic software that is relevant for one's work. At office workplaces, these are typically mail and text programmes as general applications and more specific programmes depending on the workplace. *Programming* is the competency to use at least one programming language to customise work-relevant programmes, create digital content or maintain systems. *Handling of applications* is the competency to know which application and which medium is suitable for which task and have the skills to deal with it. *Innovative capability and creativity* is the competency to get creative and promote digital innovation to fix problems and increase efficiency. *Information processing: Recognizing one's own knowledge gaps* is the competency to recognise what one does not know or cannot do on one's own with digital media. *Information processing: Search* is the competency to perform an efficient digital information search at work independently. This includes knowing where to find the required information, working with

databases and online search engines, and selecting suitable search results. *Information processing: Data analysis* is the competency to systematically analyse and interpret digital data and information. *Information processing: Evaluating* is the competence to critically scrutinise and weigh up digital information by assessing quality, appropriateness and credibility. *Data organisation* is the competency to archive and organise digital data in a useful, structured manner. *Effective usage* combines the basic knowledge, skills, motivation and creative abilities to recognise and use the potential of digital media and applications to increase efficiency in the workplace. *Communication* is the competency to use appropriate digital communication channels to communicate with others at work. *Collaboration* is the competency to use digital media for business collaboration, for example with business partners and customers. *Networking* is the competency of being well-connected in one's business environment with the help of digital media. It is getting in touch with relevant people inside and outside one's company through digital networks to discuss topics and get help. *Netiquette* is the awareness that there are certain rules of digital communication and the competency to comply with them by behaving in the appropriate social manners in work-related digital exchanges. *Sharing data with others* is the competency to share data, for example, to work synchronously by using digital media and to be willing to work online with others. *Cultural aspects* are the competency to participate in digital intercultural communication, to accept it and to appreciate diversity in a digital context. *Security and law* is the competency to respect existing laws in a digital context (e.g., copyright) and to adequately protect work-related private and corporate data from disclosure. *Responsibility* is the competency to consider the consequences of one's actions in online contexts and to act responsibly in dealing with each other, and with private and corporate data (e.g., visibility of information to others). It also includes a reflective attitude to the influences of digital media and a sensitive attitude towards possible problems with the medium used. *Goals and motivation* is the competency to have the patience to try new digital applications, pursuing one's goals perseveringly and making an effort. It also includes the motivation to use digital media at work and showing endurance when dealing with digital devices and applications. *Willingness to learn and openness* is the competency to be willing to learn new things about digital media and applications and to be open to change the workplace through digitalisation. *Ethics and moral* is the competency to behave online in accordance with ethical and moral convictions and to observe them in daily work. *Autonomy and independence* is the competency to be able to make meaningful and profitable use of the flexible framework conditions through digitalisation at work. *Problem-solving* is the competency to develop possible solutions to a problem, try it out and apply the best solution while identifying the core of the problem and preventing it from occurring again. *Train others* is the competency to communicate one's knowledge and thus to strengthen others in their DC.

Table 2

Dimensions of digital competencies at work as the result of the clustering process from the literature review and interviews with practitioners.

	Dimensions	Literature Cluster	Practice Cluster
1	Handling of hardware	-	Handling hardware
2	Handling of software	-	Handling software/ programmes
3	Programming	-	Programming
4	Handling of applications	-	Handling Office, Internet
5	Innovative capability and creativity	Creating content: creative, innovative	-
6	Information processing: Recognizing one's own knowledge gaps	-	Detecting lack of knowledge
7	Information processing: Search	Information processing: searching and finding	Search, research
8	Information processing: Data analysis	Information processing: analysing	-
9	Information processing: Evaluating	Information processing: evaluating	Data management: filtering
10	Data organisation	Data management	Storing data Organising data
11	Effective usage	Technical know-how: Ability to effectively use ICT	-
12	Communication	Communication	Communication
13	Collaboration	Collaboration	Virtual collaboration
14	Networking	-	Connectivity Networking
15	Netiquette	-	Dealing with each other
16	Sharing data with others	-	Sharing data with others
17	Cultural aspects	Cultural aspects	-
18	Security and law	Security	Security: awareness of danger, knowledge about security Legal basics/ fundamentals Privacy Data security/ safety

Table 2 (continued)

19	Responsibility	Responsibility	-
20	Goals and motivation	Motivation, goals, self-regulation capabilities, adjust actions to one's own goals	Attitude and motivation
21	Willingness to learn and openness	Learning, adaptability, change	Willingness/ readiness to learn Openness Adaptability
22	Ethics and moral	Ethics/ moral	-
23	Autonomy and independence	Autonomy/ independence	Self-management
24	Problem-solving	Problem-solving	Problem-solving Capability to learn Gather knowledge about problem-solving/ solution strategies Precaution Basic knowledge about problem-solving
25	Train/ educate others	-	Train/ educate others

Our validation approach of these 25 dimensions of DC supports the chosen structure. The content of the units from the literature review and the interviews were very similar in each of the dimensions *Communication*, *Collaboration*, *Information processing: Search*, and *Willingness to learn and openness*. Out of the 946 total extracted units, 774 units were assigned to one dimension unambiguously (e.g., "being able to work with MS Office" was assigned to the dimensions *Handling of software*). Especially the assignment of units to *Cultural aspects* was very clear as none of the units assigned to these dimensions was assigned to another dimension. Fifty-five units were assigned to two different dimensions (e.g., "being able to work together with others using one drive" was assigned to *Collaboration* and *Sharing data with others*). The remaining units were assigned to more than two different dimensions (e.g., "being able to use the internet responsibly for communicating, socializing and learning" was assigned to *Effective usage*, *Netiquette*, *Security and law*, and *Responsibility*). Overall, most of the units were assigned to *Handling of software* (105 first assignments, 9 second assignments), and least units were assigned to *Cultural aspects* (8 first assignments). Many of the units assigned to *Communication* were also assigned to one or more of the dimensions *Collaboration*, *Networking*, or *Netiquette* (e.g., "choose the best media for the target group").

3.3 Discussion

Following the call for clarification of the concept of DC at work, we proposed a definition and framework, based on concepts of competencies encompassing KSAOs to be applied by researchers, practitioners, and politicians. While prior research greatly neglected the work context or solely focused on workers from the educational sector (Aesaert, van Nijlen, Vanderlinde, & van Braak, 2014; Brevik, Gudmundsdottir, Lund, & Strømme, 2019), we managed to integrate two different perspectives by combining the findings of the literature review with the ideas of practitioners. We identified 25 dimensions of DC at work that seem to be important in theory and practice. Besides the vast similar content from the literature and the interviews, which confirms the importance of those dimensions at work, each perspective added unique content, too. While the dimensions that are based on a cluster from the literature only (e.g., *Ethics and moral*) represent considerations on a meta-level; other dimensions that are based on a cluster from the practice only (e.g., *Handling of hardware*) represent competencies that are important to accomplish daily tasks at work. This results at least partly from the focus on daily tasks that we chose on purpose for the interview questions. The consideration of both perspectives – a global meta-level and detailed micro-level – is necessary to capture all DC possibly needed at work.

The results of this research indicate that the dimensions of DC at work are composed of a specific combination of knowledge, skills, abilities, and other characteristics that are needed to perform at today's digital workplaces. Hence, our suggested framework of DC at work is in line with the concept of KSAOs. For instance, *Handling of Hardware* requires basic knowledge about the devices and hardware at hand, and the physical and cognitive ability to operate them. Additionally, the skills to

handle the hardware appropriately and the motivation to do so are basic requirements for this competency. However, a clear allocation of the dimensions of DC at work to the KSAO facets is not sensible. Not all of the dimensions include all of the KSAO components. Instead, the importance of the KSAO components varies between the dimensions. For example, while *Information processing: Recognizing one's own knowledge gaps* is based on the knowledge facet mainly, *Goals and motivation* is mainly based on other characteristics, like motivation. Otherwise, *Problem-solving* and *Train others* are dimensions of DC at work that integrate all of the KSAO facets.

Although we obtained a comprehensive list of relevant dimensions of DC by our approach, some of the dimensions we obtained still include greatly overlapping content and cannot be defined distinctly (e.g., *Communication*, *Collaboration*). However, our aim was not to find distinctive dimensions but to outline as many different aspects of the concept of DC at work as possible to contribute to the concept clarification. Thus, a greater number of dimensions illustrates that the emphasis is on the vast variety of DC at work. With our findings, we hope to lay ground for future discussion and research on the dimensionality of the construct. Therefore, future research is urged to empirically test for similarities and differences of DC for different workplaces.

Building upon our results and in line with prior research (Markus, Cooper-Thomas, & Allpress, 2005), we suggest that DC at work can be divided into basic and specific DC. Basic DC are needed at most office workplaces to accomplish everyday tasks. Examples are writing e-mails, using text processing programmes or conducting internet research. Additionally, there are DC that are specific for a workplace, occupational training, or a company, for example, and they are needed by some workers in special positions for specific tasks only (e.g., using in-house software programmes or communicating results of a workgroup). Following this approach implies that the required DC of an individual worker also depend on many external factors such as the structure and size of the company or the specific work tasks. For instance, the dimension *Cultural aspects* is very important in global companies with an international background. However, employees in local companies do not necessarily need this competency to accomplish their daily work tasks. There is probably no job position that requires the maximum of all 25 dimensions of DC at work, but each job position requires a unique set of basic and specific DC at work.

4. Conclusions and Implications

4.1 Conclusions

Our research provides important insights into the construct of DC at work by providing an overview of existing definitions and frameworks. A thorough analysis of the available literature revealed

a lack of scientific research on DC of adults and a neglect of the work context. However, the large variety of terms and proposed frameworks shows the interest in DC in many different contexts such as education, politics, or media and communication. While acknowledging the important contributions that these publications can make, we addressed the science-practice gap by integrating different perspectives in our research. Therefore, in addition to the systematic literature review, we conducted eleven half-structured interviews with practitioners from the work context. After analysing the results, we were able to identify and validate 25 dimensions of DC for workers that are not only based on the literature but also on insights of practitioners. The involvement of many diverse groups of people with different background knowledge and multiple opportunities to discuss the findings during the analysis supports the objectivity of these dimensions. The findings indicate that even though there are similarities in the definitions of DC between practitioners and researchers, there were also notable differences, whereas each perspective added unique content to the framework. For example, practitioners focus more on the details and the application of the concept at work, while researchers highlight the importance of aspects on a more general level. Furthermore, our results suggest that the concept of DC is multi-faceted and can be based on knowledge, skills, abilities, and other characteristics. With our research, we hope to broaden and clarify the scope of the concept of DC and encourage further research that adds to the understanding of the concept of DC with a focus on adults at work.

Furthermore, our findings contribute to the research field by putting the prior neglected work context in the focus of research about DC. In comparison to the existing literature (e.g., Janssen et al., 2013), we provide an updated review of the literature on DC, and combine different methods and approaches, thereby not only focussing on the DC of teachers and students, but on white-collar workers (e.g., Aesaert et al., 2014; Brevik et al., 2019). Moreover, our framework is based on validated models about competencies from industrial and organisational psychology. Nevertheless, we enhance the applicability of the findings in the work context by integrating different perspectives from research and practice. Furthermore, we managed to provide a holistic view of the concept that encompasses detailed descriptions of the 25 dimensions of DC at work.

4.2 Limitations of the Study and Implications for Future Work

Although this research represents a systematic effort to consider different perspectives and combine various research methods, there are methodological and content-related limitations. For instance, our results do not generalise to the whole workforce and all workplaces as we focused on a specific group of the working population (white-collar workers) when developing relevant dimensions of DC. Even though we purposefully chose a broad range of practitioners with different educational backgrounds and job positions, all of them are knowledge workers with office jobs (located in the south of Germany). These restrictions of the target group are needed to conduct a detailed analysis of DC at specific workplaces leading to specific and applicable results. For instance, by narrowing down the

target group to white-collar workers we obtain a framework that is specific enough to meet the requirements for a job demands analysis. However, therefore we do not know yet which dimensions of our suggested framework might generalize to other working populations.

Additionally, we do not know yet how exactly the different suggested dimensions of the framework are interrelated. Future empirical research needs to address this question to reveal the underlying factor structure of DC at work. Merging similar dimensions, for example, according to the results of factor analysis could improve the structure of the framework of DC at work. For example, it appears plausible that the dimensions that refer to interpersonal behaviour (e.g., *Communication*, *Collaboration*, *Sharing data with others*, and *Networking*) show more overlapping content than other dimensions (e.g., *Handling of hardware*, *Security and law*) and therefore might form an aggregated factor. Also, dimensions like *Problem-solving* or *Willingness to learn and openness*, seem to affect many other dimensions and might, therefore, be on another level in a competency hierarchy. However, while there is face validity to merge dimensions to aggregated factors, a larger number of dimensions has the advantage of highlighting different aspects of DC, which was a goal of this research. Moreover, future research is encouraged to investigate the nomological network of the competencies we found, for example, by separating them from other competencies needed at work or more general concepts like motivation, knowledge or personality factors.

Finally, a limitation of this research revolves around the fast-changing nature of the subject itself. DC are linked to the fast-paced technological progress very closely as they evolve with the implementation of new tools and applications that change the way we work. Therefore, the timeliness of the research results and the flexibility of frameworks are crucial to keep them applicable in changing workplaces (Ala-Mutka, 2011; Bawden, 2001). Dynamic frameworks of DC at work that consider future-oriented job requirements are needed. Hence, the DC that are needed in the future world of work can be more or less imprecise given that they are based on predictions. Nevertheless, to prepare the workforce for the demands of their work in the future, the DC that are needed in the long run have to be trained now.

4.3 Applications and Utility

The findings of this research imply several theoretical and practical applications. First, we provide the field with a definition and a framework of DC at work. By combining multiple perspectives, stemming from literature about DC and insights of practitioners, we foster the common understanding, broaden the scope of the concept and lay ground for applications in practice. We drew particular attention on the specifics of the work context, which is a major field of application for this topic.

Practitioners may use our framework of DC to identify the DC needed at specific workplaces. For instance, HR managers may use our framework to identify the requirements of a job or developmental

potential in the current and future workforce. Adding specifically relevant DC for each job profile on basis of our framework could enhance needs analyses in personnel recruiting by providing a more realistic view of the current level of DC of the workforce (Caldwell & O'Reilly, 1990). Knowing the specific DC that job applicants need at the workplace they are applying for could enhance the curricula of talent management programmes, for example, and lead to the development and implementation of more effective and efficient customized training (Chen & Naquin, 2006). Based on our findings, future research could develop specific models of DC that are adjusted to the requirements of specific workplaces. For these specific models, for example, the job profile, the prior knowledge and education of the workers could be taken into account. However, the effectiveness of possible applications of this research in practice has yet to be evaluated.

Furthermore, we recognise the developmental potential of DC at work. Even though the coming generations are referred to as digital natives, it is wrong to assume that there would be no need to develop DC for adults in the future anymore (e.g., Li & Ranieri, 2010; Ng, 2012). The composition of DC needed at different workplaces is mostly specific. Therefore, the results of this research can be used as a basis to develop specific training for the individually needed dimensions of DC adjusted to the prior knowledge, time available, and other individual circumstances of the learner.

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Supplementary Material: Dimensions of Digital Competencies

1. Handling of hardware

The competency to appropriately deal with hardware at the workplace.
For example:

- Connecting a laptop to a projector
- Using a telephone, for example in a conference call with many different attendees
- Using and maintaining a printer at the workplace
- Safe handling of devices while considering fire regulations

2. Handling of software

The competency to use basic software that is relevant for one's work.
Important aspects at most workplaces are the use of text and calculating programmes and a mail programme. Additionally, there is software specific to the workplace or the company that workers have to use and understand.
For example:

- Be able to choose the appropriate software for learning or special tasks
- Know and use relevant software, install software on a computer
- Use and operate PowerPoint, Excel, Word, Outlook
- Every worker is well versed in his or her special programmes
- Basic understanding of the structure, processes and functionality of programmes

3. Programming

The competency to understand at least one programming language to programme and customise work-relevant programmes.
For example:

- Create, customize, design and maintain systems
- Be able to digitise processes
- Create digital content

4. Handling of applications

The competency to know which application and which medium are suitable for which task and how to deal with it.
For example:

- I know how a homepage is structured
- Can use various digital applications for my purposes

5. Innovative capability and creativity

The competency to get creative and promote digital innovation. This helps to fix problems and increase efficiency with new applications for digital products and media. It describes the mindset to understand and test digital innovations instead of insisting on previous methods.
For example:

- Become creative yourself, stay flexible in your thinking and do not get stuck on always the same approach.
- Develop and understand new technologies, understand and apply them earmarked
- Just try it and do it

6. Information processing: Recognising one's own knowledge gaps

The competency to recognise what you do not know or cannot do yourself in the field of the digital and knowing that there are others who know and can do more in this field.

For example:
- Important to know where you might still have gaps
- Know your own weaknesses and knowledge gaps
- To admit to oneself that one does not know something

7. Information processing: Search

The competency to perform an efficient digital information search at work independently. This includes the knowledge of where to find the required information, working with databases and online search engines, and selecting suitable search results.

For example:
- Search within digital databases
- Knowing where to look for information and doing it as efficiently as possible
- Filter which source is the right one
- Knowing where to find the right information in the huge information pool

8. Information processing: Data analysis

The competence to systematically analyse and interpret digital data and information.

9. Information processing: Evaluating

The competency to scrutinise digital information critically, to be able to weigh up which information is relevant and to deal with it accordingly by assessing quality, appropriateness and credibility and to deal with it accordingly.

For example:
- Critical questioning of search results/ contents of the digital world
- Thinking and questioning programmes: Does the programme give you the right answer?
- Managing data flood: weigh up and assess what is relevant and what is not
- Ability to critically evaluate digital technologies
- Thinking critically when searching, evaluating, developing a cycle of action for digital information
- Assess the relevance and credibility of the data
- Reflective and analytical attitude towards the media influence
- Being able to critically reflect on their own use of digital information and media for information gathering

10. Data organisation

The competency to archive ad organise digital data in a useful and understandable structured manner.

For example:
- Archive, save and store data
- Organisation system for data, good structuring
- Develop personal information strategy with filters

11. Effective usage

The competency to use digital media in order to increase efficiency in the workplace.

For example:
- Understand the relationships in the digital world of work.
- Recognizing and using the potential of digital applications and media to increase workplace efficiency.

12. Communication

The competency to use appropriate digital communication channels to communicate with colleagues, supervisors and business partners.

For example:
- Chat with colleagues
- Write mails to customers and choose the most appropriate words
- To have one’s fingers on the pulse of the time and addressing the relevant target group wherever they are

13. Collaboration

The competency to use digital media and programmes for business collaboration, for example with colleagues, supervisors, business partners and customers.

For example:

- Use sharepoints and shared folders for collaboration

14. Networking

The competency of being well-connected in one's business environment with the help of digital media. It includes to know several relevant people inside and outside one's company whom one can contact through digital networks to discuss topics and get help.

For example:

- Know the contact person for different topics within the company and beyond
- The awareness that one can contact other people via online networks to discuss issues and get help
- Establish a personal system to benefit from the relevant people in the networks

15. Netiquette

The competency to be aware that there are different rules of digital communication and to comply with/ follow/ observe them. Behave in the special social manners of the digital communication with others in work-related exchanges.

For example:

- Netiquette: How to behave in the digital context and to know that manners are important
- Comply with netiquette by following rules similar to those used in direct communication, such as respect, appropriate language and choice of words and avoiding misinterpretation and misunderstandings
- Act like a role model

16. Sharing data with others

The competency to master the sharing of data using digital media. This includes working with colleagues on shared spreadsheets or sharepoints, use shared data systems and share drives for synchronous work and being willing to work with others online.

For example:

- Use spreadsheets, dropbox or E-Mail
- Handling common, shared data systems
- Synchronous working, shared drive
- Feeling comfortable with publishing and communicating information

17. Cultural aspects

The competency to participate in digital intercultural communication, to accept it and to appreciate diversity in a digital context.

For example:

- Appreciation and acceptance of perspectives of different people from different cultures
- Pay attention to cultural diversity and generational diversity

18. Security and law

The competency to respect existing laws in a digital context (i.e. data protection ordinance, copyright) and to adequately protect work-related private and corporate data from disclosure.

For example:

- Use secure passwords and change them regularly
- Send encrypted emails if they contain secret private or in-house information
- Know and recognise dangers in dealing with (sensitive) data, act accordingly to protect these data
- Functioning firewall, security filter in mail program, encrypted emails,…
- Know the legal rules and regulations regarding digital media in the workplace (i.e. know and use data protection ordinance)

19. Responsibility

The competency to consider the consequences of ones actions in online contexts and to act responsibly in dealing with each other, with private and corporate data (e.g., visibility of information to others, concerns about potential consequences for people involved, oneself and the company). It includes an attitude towards digital activity that is sensitised to possible problems with the medium and its properties.

For example:

- To be aware of the responsibility by using various online applications and media
- Having a reflective attitude to the influence of digital media

20. Goals and motivation

The competency to have the patience to try new digital applications, pursuing my goals perseveringly and being ready to make an effort. It includes being motivated to use digital media at the workplace, too.

For example:

- Self-interest in the topic of digitalization
- Showing endurance when dealing with digital devices and applications

21. Willingness to learn and openness

The competency to being ready to learn new things about digital media and applications, and open to getting involved in changing the workplace through digitalization. Be open to change, engage in something new, readiness for change

For example:

- Be able to quickly acquire new knowledge
- Willingness to learn, try new programmes and get to know new functions
- Motivation to learn something new
- Willingness to rethink
- Inquisitive and curious, so you are ready to acquire knowledge of digital media and applications yourself
- Attend trainings

22. Ethics and moral

The competency to behave online in accordance with ethical and moral convictions and to observe them in daily work.

For example:

- To have an understanding of social and technical inequalities
- Respect others and their privacy online
- Observe copyright and avoid plagiarism

23. Autonomy and independence

The competency to be able to make meaningful and profitable use of the flexible framework conditions through digitalisation in the workplace.

For example:

- Self-organisation through flexible scheduling
- Good time management
- Keep track of one's own goals and pursue them despite rapidly changing working environment
- Use home office purposefully
- Compatibility of work and leisure

24. Problem-solving

The competency to develop possible solutions to a problem, try it out and apply the best solution to the problem while identifying the core of the problem and preventing it from occurring again.

For example:

- Anticipate potential problems beforehand and have knowledge to solve them
- It's more important to ensure that the problem does not occur again
- Think in digital solutions
- Do not be afraid to solve the problem yourself
- Readiness to solve problems
- Read instructions, watch help videos (online)
- Strive to understand the cause of the problem
- Learning by doing

25. Train others

The competency to communicate one's knowledge of digital competencies to others and thus to strengthen others in their digital competencies.

For example:

- To project one's thoughts into the difficulties of employees
- Learn and develop skills on how to deal with employees in order to teach them new programmes
- Being able to help others to improve their digital competencies
- Give others the right tools to implement change well
- How to spread or show others digital solutions

Chapter 3 – Paper 2

Do Digital Competencies and Social Support Boost Work Engagement during the COVID-19 Pandemic?

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Abstract

In today's world of work, the need for digital communication and collaboration competencies became even more prevalent during the ongoing COVID-19 pandemic. Yet, research and practice are lacking solid measurement instruments assessing digital communication and collaboration competencies of workers so far. Furthermore, it is yet unknown if digital communication and collaboration competencies and other so far known resources indeed act as drivers of work engagement during the pandemic. Based on the *Job Demands-Resources* (JD-R) model and the *conservation of resources theory*, we hypothesized that personal (digital communication and collaboration competencies) and job (social support) resources positively influence each other over time, also boosting work engagement. In a cross-lagged study design during the pandemic, we investigated our hypotheses in a sample of German workers (N = 231). Against our expectations, we did not find support for effects from personal or job resources on work engagement over time or effects of the resources influencing each other. Instead, we found high stabilities of digital communication and collaboration competencies, social support, and work engagement. Our results provide important insights into the motivational process of individuals working during a pandemic. The theoretical and practical implications for the JD-R model in times of crisis are discussed.

***Keywords*:** Digital communication and collaboration competencies, social support, work engagement, working during COVID-19 pandemic

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Do Digital Competencies and Social Support Boost Work Engagement during the COVID-19 pandemic?

Technological innovations and the endeavour to maximize the efficiency of workflows result in fast and constantly changing workplaces for most workers (e.g., DeShon & Gillespie, 2005). Consequently, the need to use digital information and communication technology (ICT) to accomplish work tasks gained pace rapidly. Already in 2016, 83% of the participants in a large representative German workforce sample confirmed to use digital ICT daily (Arnold et al., 2016). As job tasks become more complex in such an increasingly global and technology-based work environment, people have to communicate and collaborate online to solve crucial problems using interactive work forms (DeShon & Gillespie, 2005; Gilson et al., 2014). Therefore, especially digital communication and collaboration competencies are essential assets needed to get work done efficiently, which is why we concentrated on these two digital competencies in this current research. The importance of such competencies became even more prevalent during the COVID-19 pandemic (Wang et al., 2021) since social distancing is required as an important measure to fight the worldwide crisis. Overnight, face-to-face meetings are not happening anymore and all communication and collaboration at work shifted online. Yet, research and practice are lacking solid measurement instruments assessing these important digital competencies of workers so far (e.g., Murawski & Bick, 2017).

Therefore, the first aim of our current research was to develop a questionnaire measuring digital communication and collaboration competencies at work, using two samples of German workers. By this, we aimed to enable organizations and workers themselves to assess and evaluate the status of these important competencies in the workforce. Second, we investigated the potential role of digital communication and collaboration competencies as a personal resource in times of crisis in the motivational process outlined by the Job Demands-Resources (JD-R, Demerouti et al., 2001) model in a cross-lagged study design during COVID-19. Besides personal resources, the job resource social support gained importance during the COVID-19 crisis that requires workers to social distance and work remotely (Wang et al., 2021). This leads to our third aim, which was to examine if personal (digital communication and collaboration competencies) and job (social support) resources have positive reciprocal effects over time when faced with the specific demands of working under COVID-19 conditions, ultimately boosting work engagement. Finally, we tested for positive reciprocal effects between personal and job resources and work engagement over time during the COVID-19 pandemic. Thereby, our research offers important insights into the motivational effects of personal and job resources on work engagement in times of crisis.

1. Digital Communication and Collaboration Competencies at Work

In line with prior definitions, we understand digital competencies as a combination of knowledge, skills, abilities, and other characteristics, such as motivational aspects (Aamodt, 2009). Digital competencies encompass a range of different competencies, which are central in the accomplishment of regular job tasks involving digital media, such as the handling of hardware, analysing and evaluating data, or networking online. Building on a comprehensive model of digital competencies that has been suggested recently (Oberländer et al., 2020), we concentrated on digital communication competencies on the one hand and digital collaboration competencies on the other hand.

In detail, digital communication competencies are defined as "the competency to use appropriate digital communication channels to communicate with colleagues, supervisors and business partners" (Oberländer et al., 2020, in the supplementary material, SM, p. 3). This includes knowing all of the digital communication channels that are used frequently in the organization or chatting with colleagues or writing e-mails in appropriate form and language in the work context, for example. Workers with high digital communication competencies can choose the best medium for (digital) communication and bring across their messages adequately.

Digital collaboration competencies are defined as "the competency to use digital media and programmes for business collaboration, for example with colleagues, supervisors, business partners, and customers" (Oberländer et al., 2020, SM, p. 3). This could require the use of shared team calendars, accessing work results of team members, or simultaneously working on the same documents or data with colleagues. Digital collaboration competencies enable professionals working in a wide range of industries and having different tasks and jobs to interact with others and distribute work between people regardless of their location (Schulze & Krumm, 2016). Workers with high digital collaboration competencies can access and share relevant information with team members quickly, for example by choosing the medium supporting the needs best.

Digital communication and collaboration are central competencies at work, both in theory and practice. First, these two competencies are not just included in most theoretical models about digital competencies but often take a prominent role within such models (e.g., Hertel et al., 2006; Hwang, 2011). However, empirical studies that contribute to the understanding of the nature of digital competencies and effects in the work context are still largely lacking (e.g., van Laar et al., 2019), even though there is a pressing need for the use and understanding of digital competencies at the workplace (e.g., Raghuram et al., 2019).

Second, in the modern world of work for organizations, both, digital communication and collaboration competencies are important assets in practice as they are inevitable in most office-based jobs to complete even basic job tasks. Therefore, digital communication and collaboration competencies

are mentioned as core competencies in the twenty-first century frequently (Makarius & Larson, 2017; Schulze et al., 2017). Organizations rely on the digital competencies of their employees to improve the quality, effectiveness, and efficiency of their work (Derks et al., 2008). Indeed, successful communication has been linked positively to important and desirable organizational outcomes, such as performance (Hertel et al., 2006; Schulze & Krumm, 2016), interpersonal relations (Degbey & Einola, 2019; Hwang, 2011), or motivation (Lee et al., 2015).

Even though many aspects of digital communication and collaboration are similar to face-to-face situations in which co-workers or supervisors are collaborating and communicating, it must be considered a different theoretical construct posing unique challenges to the workforce (Degbey & Einola, 2019; Schulze et al., 2017). Oftentimes, digital communication is described as more challenging to workers than face-to-face interactions (Raghuram et al., 2019). Most obviously, any digital conversation or collaboration requires a basic understanding of the technology used, even though these competencies are not part of most official job training (Schulze et al., 2017). Expressing emotions, resolving conflicts, or building relations with colleagues or supervisors gets more difficult online, especially in asynchronous forms of communication, like texting (Ayoko et al., 2012; Liao, 2017).

1.1 Digital Communication and Collaboration Competencies in Times of COVID-19

The urgent need for digital communication and collaboration competencies became even more prevalent under the very recent changes in the world of work due to the global COVID-19 pandemic that caused nationwide lockdowns which abruptly forced the vast majority of workers to work from home (Imöhl & Ivanov, 2021; Wang et al., 2021). These governmental measures caused temporal halts in production, short-time work in many industries, the closure of nurseries and day- cares for children, and supply shortages of important goods among others. Workers had to adjust to the new pandemic situation rapidly and manage childcare and working from home without a chance to establish thought-out concepts for digital collaboration (Weigelt et al., 2021).

Digital communication and collaboration replaced almost all in-person work settings wherever possible to comply with the social distancing rules that were in place in many countries (Meske & Junglas, 2020). Research from earlier epidemics indicates that communicating is an essential resource reducing strain (Chan & Huak, 2004; Matsuishi et al., 2012). With regard to work motivation, social support as an important, well-researched job resource (e.g., Nasurdin et al., 2018; Xanthopoulou et al., 2008), especially in times of crisis, was probably only easy to access for those with sufficient digital communication and collaboration competencies, as in-person meetings were not possible. Indeed, successful digital communication has been identified as a key challenge of the workforce during COVID-19 (Dirani et al., 2020; Wang et al., 2021). Against this background, we set out to develop a measurement instrument for individual digital communication and collaboration competencies at work.

Furthermore, we tested the suggested central role of such competencies during the COVID-19 pandemic for employees and investigated their effect within a well-validated model of work motivation.

1.2 Resources at Work and Work Engagement

The JD-R model (Demerouti et al., 2001) is used to explain the positive effects of job resources on desirable organizational outcomes, such as motivation, well-being, and performance. In the motivational process of the JD-R model, it is assumed that job (e.g. social support) or personal (e.g. emotional competences) resources trigger motivational processes at work by satisfying basic human needs (Bakker et al., 2007; Lorente Prieto et al., 2008; Xanthopoulou et al., 2009). In the frame of the JD-R model, motivation as a desirable work-related state is often represented by the construct of work engagement (Bakker et al., 2007; Mauno et al., 2007). Work engagement is defined as a fulfilling, affective, and work-related state of mind, characterized by its three facets vigor, dedication, and absorption (Xanthopoulou et al., 2009). In previous studies, work engagement has been positively associated with desirable work outcomes on the individual and organizational level, such as financial outcomes for organizations or customer satisfaction (Schneider et al., 2018). The positive impact of job resources on work engagement has been widely acknowledged (Bakker et al., 2007). For instance, Schaufeli et al. (2009) found that increases in job resources such as social support, autonomy, learning opportunities, and feedback predict work engagement. Especially under highly demanding circumstances, job resources foster work engagement (Bakker et al., 2007). As the COVID-19 pandemic is an unprecedented global crisis, it changed the work situation fundamentally. Thus, workers need resources to handle this extraordinarily demanding situation.

As the JD-R model is rather open and heuristic, the (job and personal) resources are not restricted to specific constructs (Schaufeli & Taris, 2014). Demerouti et al. (2001) defined job resources as physical, social, organizational, and psychological aspects of the job that mitigate negative effects of job demands, are beneficial to achieve goals at work, and foster personal learning and development. More recently personal resources were included as part of an extended JD-R model (Schaufeli & Taris, 2014). Personal resources are those characteristics that individuals bring into the work situation that function as coping mecha- nisms, or foster work-related well-being. This is supported by findings of various personal resources boosting work engagement, such as stable characteristics in terms of core self-evaluations (Bipp et al., 2019), or optimism (Xanthopoulou et al., 2012). More importantly, the competencies of teachers have been shown to significantly predict work engagement over time in a way that more emotional competencies led to higher vigor and dedication (Lorente Prieto et al., 2008). Based on the outlined relevance of digital competencies at work, and in line with these prior findings, we expected that digital communication and collaboration competencies function as personal resources, boosting work engagement during the pandemic. Thereby, we assume that digital communication and

collaboration competencies fulfil the basic human need for competence and foster intrinsic motivation at work (Bakker & Demerouti, 2008).

H1: *Digital (a) communication and (b) collaboration competencies each have positive lagged effects on work engagement.*

Besides investigating the role of communication and collaboration competencies as resources, we looked at the potential prominent role of another resource in times of crisis – social support. This job resource has been linked successfully in numerous, prior studies to increases in work engagement in the frame of the motivational process of the JD-R model (e.g., Bakker et al., 2004; de Jonge & Dormann, 2006). Social support at work includes support from supervisors and co-workers. For example, Xanthopoulou et al. (2008) surveyed flight attendants and showed the unique positive effects that colleague support had on work engagement. In addition to the established research on social support boosting work engagement, very recent research highlights the important role of social support during the ongoing pandemic. For example, social support was found to play a central role as a positive job resource, helping to cope with the demands during the crisis among healthcare professionals (Britt et al., 2020; Kisely et al., 2020). Moreover, Wang et al. (2021) conducted interviews with Chinese workers that were forced to work from home without any preparation or consent in advance due to governmental social distancing measures after the outbreak of COVID-19 in Wuhan. They noted that social support is not only a "necessary job resource to accomplish tasks" (p. 30) but also the "most powerful virtual work characteristic" while working from home during this special situation (Wang et al., 2021, p. 46). On the flip side, Wang et al. (2021) found workers feeling socially isolated during the COVID-19 outbreak to be a major challenge. In line with the JD-R model and prior findings, we argue that social support boosts work engagement, also during times of crisis.

H2: *Social support at work has a positive lagged effect on work engagement.*

According to the *conservation of resources theory* (COR, Hobfoll, 2011), people deeply aim to obtain and sustain the resources they value. The theory also proposes that those who possess more resources can gain further resources and protect them more easily. Thus, various resources foster each other in a reciprocal dynamic interplay over time, tend to accumulate, and ultimately lead to work engagement (Bakker & Demerouti, 2008; Hakanen et al., 2008). For instance, Simbula et al. (2011) observed reciprocal effects between job (social support) and personal (self-efficacy) resources and work engagement among schoolteachers in a longitudinal study. Moreover, Llorens et al. (2007) showed reciprocal effects between task resources, efficacy beliefs, and engagement in university students. However, to our knowledge, no study has shown if such reciprocal effects between resources and work engagement also show throughout the crisis. Such an effect can indeed be anticipated, as it is known that job resources become particularly salient when job demands are high (Bakker & Demerouti, 2008). Dirani et al. (2020) argue that communication and supporting workers are both among the most

important competencies of leaders during times of crisis. However, it is yet unknown, if they really stimulate work engagement during a crisis and how they affect each other. Moreover, Britt et al. (2020) argue that personal resources are less examined within pandemics than job resources and if so, job and personal resources are investigated separately. By investigating the interrelationship between personal and job resources, we shed light on their interplay in times of crisis. In line with the theoretical reasoning, we expected that the job resource social support, and the personal resources digital communication and collaboration competencies affect each other positively over time during the COVID-19 pandemic.

H3: *Digital (a) communication and (b) collaboration competencies each have positive lagged effects on social support.*

H4: *Social support has a positive lagged effect on digital (a) communication and (b) collaboration competencies.*

In addition to direct links from resources on motivation, our research model (Figure 1) also posits that a high engagement in workers can positively influence the building of new resources. Empirical studies conducted before the pandemic suggest such reversed lagged effects of work engagement on job and personal resources (e.g., Bakker & Demerouti, 2008). The findings indicate that work engagement facilitates the activation of resources and helps create new resources. For instance, Xanthopoulou et al. (2009) showed that work engagement is related to both job and personal resources (e.g. self-efficacy, feedback). Additionally, Hakanen et al. (2008) found positive reciprocal cross-lagged relationships between job resources, personal initiative, and work engagement. Thus, we predict that engaged workers are better able to protect their job and personal resources and build new ones, in times of crisis.

H5: *Work engagement has a positive lagged effect on resources in terms of a) digital communication, b) collaboration competencies, and c) social support.*

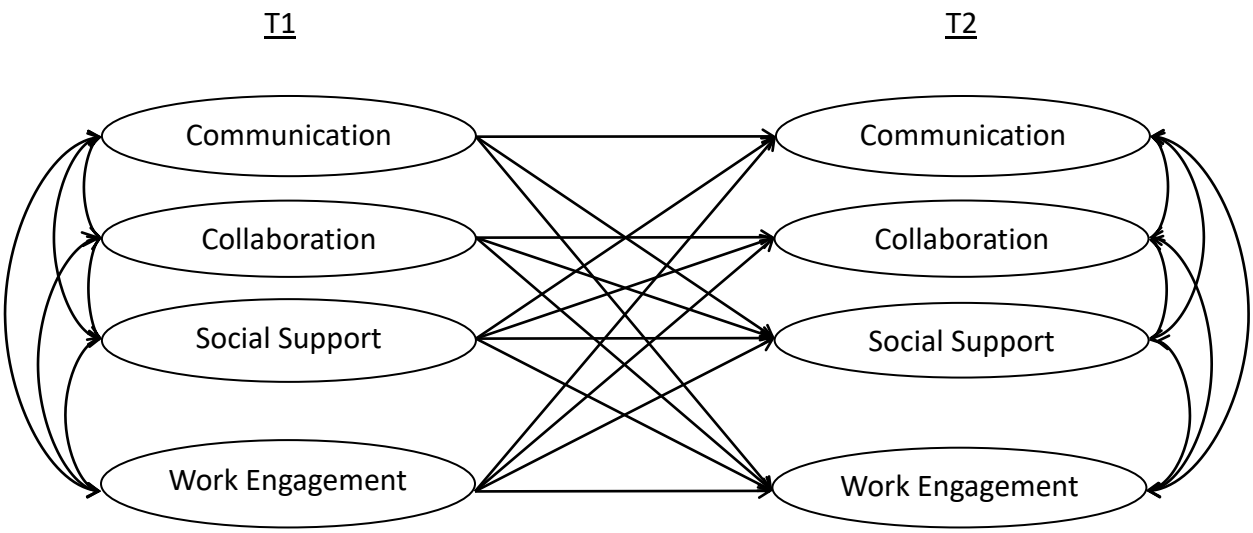

Figure 1. Reciprocal model of latent variables uniting paths of all of the other models to test reciprocal effects of resources and work engagement as research model.

2. Prestudy: Initial Questionnaire Development

To our knowledge, there is no reliable and valid measurement instrument for digital communication competencies (DCM) and digital collaboration competencies (DCL) at work, yet. To test our hypotheses in the main study, we first conducted a prestudy to develop such a questionnaire based on the knowledge, skills, abilities, and others (KSAO) framework (Aamodt, 2009; Krumm et al., 2012) and the definition and framework of digital competencies at work (Oberländer et al., 2020).

2.1 Method

The five general steps that we took to the development of a self- report questionnaire reflecting workers' perception of their DCM and DCL are shown in Figure A (in the SM). perception of their DCM and DCL are shown in Figure A (in the SM).

2.1.1 Initial Item Pool

In a first step, we formulated items that represent the main content of DCM and DCL at work. On the one hand, the items were theoretically based on extracts from the existing literature about the definition of digital competencies at work (e.g., Janssen et al., 2013; van Laar et al., 2017). On the other hand, they were supplemented with a practical view by incorporating the definitions of DCM and DCL at work obtained from eleven interviews with practitioners. For the interviews, we focused on white-collar workers with office jobs using digital media frequently as a target group. Furthermore, we made an effort to formulate the items distinctively according to the KSAO framework, so that knowledge, skills/abilities, and other competencies were included. We drew particular attention to the wording of the items to avoid descriptions of job-specific tasks. This was due to the aim to use the items for white-collar workers in various jobs. Our efforts resulted in an initial formulation of 42 items.

2.1.2 Item Revision

One of the authors of this study and a research assistant each rated the initial items on how close they were to the definitions of the respective competencies, and therefore the core of the constructs (following the recommendations of Clark & Watson, 1995). Another researcher with expertise in this area checked the wording of the items on clarity, transparency, redundancy, and conciseness and decided on the items with widely deviating ratings. This resulted in 19 items rep- resenting the facets of DCM (e.g. "I know which type of digital communication I should use in different work-related situations.") and eight items representing the facets of DCL (e.g. "I can collaborate with others also online."). This initial pool of 27 items, including the original German items, and back- and forth-translated English wordings, is depicted in Table A (SM).

2.1.3 Measures and Procedure

To pretest the items, we recruited various workers from private and professional networks to participate in an online survey in December 2019. After a general introduction and their agreement to participate voluntarily, we asked the participants to answer the 27 items on a 5- point-scale (1 *doesn't apply at all* to 5 *fully applies*), all presented in random order. Participants were asked to answer questions about their use of digital media at work and working hours, among other demographic questions.

2.1.4 Sample

The sample consisted of 89 women, 49 men, and one person with unspecified gender. The age of the participants ranged from 18 to 67 years with a mean age of 41.04 years (*SD* = 12.82). The mean of the self- reported average weekly working hours was 35.62 (*SD* = 10.30) and participants spent five to 100% of their working time with digital media (*M* = 74.10, *SD* = 23.50). Only one participant stated that neither a computer nor a laptop was available for them to do their work, in this case the only digital device was a smartphone. Just over half of the participants (50.3%) used smartphones at work. A majority of the participants (71.3%) had a degree from a university or college of higher education.

2.1.5 Analyses Procedure

We evaluated the 27 items based on a combination of approaches from Classical Test Theory (CTT) and Item Response Theory (IRT). In detail, we analysed the items by looking at descriptive statistics based on CTT (e.g. mean values, standard deviations, item difficulties, kurtosis, skewness). Concurrently, we followed an IRT-based approach for the selection of the items using R and looked at the item information curves (IIC) and item response category characteristic curves (CCC) to assess if the item thresholds were sorted. The advantage of using IRT to complement the results of the CTT is the additional information that we get about every single item, which is overlooked by the methods of the CTT.

To test the factor structure of the questionnaire, we conducted an exploratory factor analysis (EFA) using IBM SPSS Statistics 25. Then, we conducted confirmatory factor analyses (CFA) using AMOS version 27.0.0 (Arbuckle, 2020) to validate the factor structure of the preliminary questionnaire. For this, we considered two different solutions: A one-factor model with all items as indicators for one latent variable, digital competencies, and a two-factor model with two latent variables, DCM and DCL. For all models, we used different goodness-of-fit indices to assess the fit of the data with the proposed model: The absolute goodness-of-fit indices χ^2, degrees of freedom, and Root Mean Square Error of Approximation (RMSEA). According to Browne and Cudeck (1993), RMSEA values below 0.05 indicate a very good fit and values smaller than 0.09 indicate an acceptable fit. Because the χ -statistic is sensitive to sample size, we additionally calculated the relative goodness-of-fit indices Normed Fit

Index (NFI), Incremental Fit Index (IFI), and the Comparative Fit Index (CFI, Marsh et al., 1988). For the relative goodness-of-fit indices values greater than 0.90 indicate an acceptable fit (Hoyle, 1995).

2.2 Results and Discussion

In a first step, we evaluated descriptive statistics of all 27 items based on CTT. The mean values for the CM and CL items were rather high in the sample, ranging between 3.21 and 4.47. Only for eighteen items, the whole rating scale was used by the participants. The distribution of responses for five items of the CM scale and two items of the CL scale was substantially skewed and the distribution of responses for eight items on the CM and one item on the CL scale were peaked. With regard to the IRT results, most of the items of the initial pool showed ordered thresholds, except six items on the CM and two items on the CL scale. For example, for item CM8 and CM15, the rating category 2 (does rather not apply) and for item CL2 the rating category 3 (applies somewhat) had lower probabilities than expected. In item CM12, the probability to choose the rating category 5 (fully applies) was very high for any ability. A look at the item information curves of the 27 items revealed that four items offered little information according to the item information curves. Three items offered to differentiate information in the higher part of the scale, whereas seven items offered good information in the lower part of the scale.

Furthermore, we conducted an exploratory factor analysis (EFA) using maximum likelihood and an oblimin rotation with all of the 27 items (Hinkin, 1995). Horn's parallel analysis showed that two factors should be extracted, which fits the theoretical expectations. Two factors could explain 45% of the variance. All items from the CL scale showed substantial estimated loadings on factor 1 and most of the items from the CM scale showed substantial estimated loadings on factor 2. However, contrary to the expected structure, six items of the CM scale were loading higher on factor 1, and item CM1 showed substantial loadings on both factors. To further test the factor structure with CFAs, we contrasted a one-factor model (all items loading on a single factor) with a two-factor model (items of DCM and DCL loading on separate factors) for the initial 27 items. Table 1 displays the results. A chi-square difference test revealed a significantly better model fit for the two-factor solution ($\Delta\chi2(1) = 1103.22$, $p < .001$). Nonetheless, fit indices indicated that there was still room for improvement in terms of model fit.

Taking all of this information based on CTT and IRT approaches into account and also considering the contextual overlap of some items, we decided to delete eleven items. This led to a reduced version of the questionnaire with 16 items (see items with * in Table A, SM). Consequently, we conducted two CFAs for the 16 items of the reduced questionnaire, contrasting a two-factor and a one-factor model. The best model fit was achieved with the two-factor model of the 16-item version ($\Delta\chi2(1) = 180.97$, $p < .001$), which was also superior to the two-factor model with 27 items

($\Delta\chi2(220) = 652.05$, $p < .001$). According to the standards, however, the indices were still unsatisfactory ($\chi2/df = 2.33$, CFI = 0.87, RMSEA = 0.10).

Table 1

Goodness-of-fit statistics of the digital communication and collaboration competencies scales for the prestudy and main study (T1 and T2).

Model	χ^2	*df*	$\Delta\chi^2(\Delta df)$	NFI	IFI	CFI	RMSEA
Prestudy (*N* = 145)							
One factor (27 items)	1995.27	324		.39	.43	.43	.19
Two factors (27 items)	892.05	323	1103.2(1)	.73	.81	.81	.11
One factor (16 items)	420.97	104		.64	.70	.70	.15
Two factors (16 items)	240.00	103	180.97(1)	.80	.87	.87	.10
One factor (10 items)	106.35	35		.80	.86	.85	.12
Two factors (10 items)	55.12	34	51.23(1)	.90	.96	.96	.07
T1 (*N* = 231)							
One factor (16 items)	507.90	104		.62	.68	.67	.13
Two factors (16 items)	446.02	103	61.88(1)	.68	.73	.73	.12
One factor (10 items)	116.47	35		.79	.84	.84	.10
Two factors (10 items)	65.68	34	50.79(1)	.88	.94	.94	.07
T2 (*N* = 170)							
One factor (10 items)	190.01	36		.67	.71	.70	.13
Two factors (10 items)	73.43	34	116.58(1)	.87	.93	.92	.07

Note. χ^2 = chi-square fit index; *df* = degrees of freedom; NFI = Normed Fit Index; IFI = Incremental Fit Index; CFI = Comparative-Fit-Index; RMSEA = Root-Mean-Square-Error-of-Approximation. Chi-Square Difference test compares to the previous model. All tests are significant with $p < .001$.

In sum, based on the results of the prestudy and CTT and IRT approaches, we reduced the set of items from 27 to 16. Empirical investigation and analyses confirmed the theoretically anticipated two-factor structure, representing the two scales for DCM and DCL. Although we were able to develop a preliminary questionnaire to assess digital competencies at work, the overall results implied that there was still potential to optimize it. Therefore, we tested the obtained 16 items from the preliminary questionnaire at T1 of our main study with another sample. Additionally, to counteract the high mean values, we adapted the rating scale to a 7-point Likert scale in the following.

3. Main Study: The Interplay of Digital Competencies, Social Support, and Work Engagement

In the main study, we cross-validated the scales for DCM and DCL with another sample of workers and improved it by further reduction of items. Furthermore, we tested our hypothesis about the role of DCM and DCL and social support at work as positive resources in the motivational process in times of crisis (H1-H5).

3.1 Method

3.1.1 Settings and Participants

Data were collected from German workers in two waves with a minimum time lag of ten weeks. The first wave of data collection lasted from April 09th to June 14th, 2020, starting after the German government imposed drastic measures to condemn the COVID-19 pandemic and many companies established stay-at-home policies. The second wave of data collection took place from August 3rd to September 16th, 2020, when most measures were relaxed and many workers returned to the offices. Participants were recruited from different sources, including the extended private and professional network, social networks, and a press release of the University. The survey was implemented at the platform Unipark, where interested individuals could participate via a link. Participants were informed about the procedure of the survey and asked for consent. The only prerequisite for participation was a professional activity using digital media at least for some tasks at work. The participation was voluntary and unpaid, but participants were offered a handout with practical information about working from home based on scientific results and information about the results after completing the surveys.

During the first wave of data collection, 265 persons started to answer the questions. Of the 252 participants who finished the survey, 231 provided complete data at T1. The sample consisted of 147 persons identifying as female, 79 persons identifying as male, and five persons who did not specify their gender. The participants' ages range from 21 to 64 (M = 38.04, SD = 11.71). The mean tenure is 12.76 years (Mdn = 8.00, SD = 11.72) and the participants' mean weekly work time is 34.63 hours (Mdn = 40.00, SD = 11.71). A majority of the participants (71%) are working full-time. At T1, most of the participants (66.5%) stated that they work from home the whole time, some (23.3%) of the participants work from home temporarily and only ten percent of the participants do not work from home at all. All of the participants work with a computer and participants' self-reported time working with any kind of digital media makes between ten and 100 percent of their whole working time (Mdn = 99.00). Most participants work in the IT sector (N = 40), freelancing, scientific and technological

services (N = 32), public administration (N = 29), education and teaching (N = 25), or healthcare and social services (N = 23).

We examined whether the participants who answered the survey at T2 (N_{T2} = 175) differed from the participants who dropped out (N = 54) to control for potential (self) selection bias. We used a MANOVA to check for differences in the study variables (digital communication, digital collaboration competencies, social support, work engagement) and demographic variables (prior working from home experience, working hours, working from home, working time spent with digital media). Results revealed that there was no sign for systematic dropout in our study, $F(11, 184) = 1.61$, $p = .10$.

3.1.2 Measures

Digital communication and collaboration competencies. We used the preliminary 16-item-questionnaire developed in the prestudy to assess DCM and DCL. Given that the 16 items from the prestudy did not show satisfactory model fit indices, we evaluated again the scales with the data of the full sample from T1 (N = 231).

First, we looked at the descriptive psychometrics of the items based on CTT. The mean values for the 16 items on DCM and DCL ranged between 5.36 and 6.52. Only for six items, the full range of the rating scale (from 1 to 7) was used, while for five items the minimum rating category used by the participants was category 3 (*does rather not apply*). The distribution of responses was substantially skewed to the left for all items. Additionally, we considered IRT-based results using the data of T1. For three items, more than two thresholds were not ordered. The item information curves revealed that four items offered differentiated information, especially in the lower part of the scale.

Taking all of this information into account, we excluded six items from the further analysis (see Table A, SM). The final ten items (five items for each scale) were tested for their factor structure, using a CFA to test a two-factor model against a one-factor model. The two-factor model of the 10-item questionnaire showed a good fit with the data of the prestudy ($\chi 2/df = 1.62$, CFI = 0.96, RMSEA = 0.07) and T1 ($\chi 2/df = 1.93$, CFI = 0.94, RMSEA = 0.07) that was also superior to all of the other solutions (cf. Table 1). The internal consistency for DCM (*Cronbach's* α = 0.70) and DCL (*Cronbach's* α = 0.77) competencies indicated acceptable reliability of the two scales in the final version (Field, 2009; Kline, 1999). The correlation between the two latent factors in the model was $r_{T1} = 0.67$, $p < .001$, and $r_{prestudy} = .68$, $p < .001$.

Social support. To measure social support at work, we used the 3- item scale from the well-established and validated German Short Work Analysis Questionnaire ("Kurzfragebogen zur Arbeitsanalyse", Prümper et al., 1995) assessing social support at work from others (e.g., colleagues, supervisor). A sample item is "I can rely on my colleagues when it gets difficult at work". The items were rated on a 5-point Likert scale (1 = *doesn't apply at all* to 5 = *fully applies*).

Work engagement. Work engagement was measured with the German version of the three items of the validated short-version of the Utrecht Work Engagement Scale (UWES-3), which has been shown to be as reliable and valid as the 9-item version (Schaufeli et al., 2019). Each item represents one of the underlying dimensions vigor, dedication, and absorption (e.g., "I am enthusiastic about my job."). The items were rated on a 7-point Likert scale (1 = *never* to 7 = *always*).

3.1.3 Analytic Strategy

To test our hypotheses, we fitted four different models to the data consecutively using structural equation modelling (SEM) techniques in AMOS version 27.0.0 (Arbuckle, 2020) with maximum likelihood. The first model (stability model) included paths of the study variables between T1 and T2 as well as correlations between the constructs measured at T1 and T2. Measurement errors of corresponding items of T1 and T2 were allowed to covary over time as their wording was identical (Llorens et al., 2007). In the following, we compare this stability model to three nested models to test our hypothesis about reciprocal effects and stability over time. The second model included all paths of the stability model and additionally the cross-lagged paths from the resources to work engagement as well as the paths from digital competencies to social support. In detail, we included paths from DCM and DCL T1, and social support T1 to work engagement T2, and from DCM and DCL T1 to social support T2 (causality model). The third model was identical to the stability model but included additional paths from social support T1 and work engagement T1 to DCM T2, DCL T2, and social support T2 (reversed causation model). The fourth model included all of the previously mentioned paths in one model (reciprocal model, cf. Figure 1).

3.2 Results and Discussion

Descriptive statistics for the study variables at T1 and T2 are depicted in Table 2. The internal consistencies were all satisfactory. The mean values for DCM and DCL and social support were high for T1 and T2. Differences in means between T1 and T2 were not significant for any study variables, except for social support which was significantly decreasing from T1 to T2, $t(162) = 3.24$, $p < .01$, *Cohens d* = 0.53. In general, the pattern of correlations shows that, as expected, all study variables are significantly positively related to each other at each measurement point (T1 and T2).

With regard to the fit indices of the tested models, the stability model is superior to all other models (Table 3). According to the recommendations, the fit indices indicate a very good fit of the stability model with the data. The autocorrelations between T1 and T2 are .83 for DCM, .72 for DCL, .80 for social support, and .87 for work engagement (cf. Figure 2). All manifest variables loaded significantly on the intended latent factors. Covariances between study variables were all significant

with $p < .01$, except for work engagement and DCL (T1), which were significant with $p = .03$, and social support and DCM (T2), which were not significant.

Table 2

Mean values, standard deviations, internal consistencies and intercorrelations of all study variables (T1 and T2).

	M	*SD*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*
T1 (*N* = 229)										
1 Digital communication	5.92	.65	(.70)							
2 Digital collaboration	5.81	.80	.45**	(.77)						
3 Social support	4.23	.65	.21**	.17**	(.72)					
4 Work engagement	4.50	1.19	.16*	.15*	.29**	(.91)				
T2 (*N* = 161)										
5 Digital communication	5.87	.66	.58**	.42**	.25**	.14	(.71)			
6 Digital collaboration	5.85	.81	.31**	.58**	.17*	.03	.46**	(.81)		
7 Social support	4.11	.71	.15	.18*	.68**	.26**	.20*	.24**	(.75)	
8 Work engagement	4.49	1.21	.17*	.07	.30**	.80**	.24**	.16*	.42**	.93)

Notes. Digital communication and collaboration and work engagement were measured on a 7-point scale, social support was measured on a 5-point scale. Cronbach's α are the values in brackets. Missings were excluded listwise.

*$p < .05$. **$p < .01$.

Table 3

Goodness-of-fit statistics comparing the stability model to models testing reversed lagged effects between digital competencies, social support, and work engagement.

Model	χ^2	*df*	$\Delta\chi^2(\Delta df)$	NFI	IFI	CFI	RMSEA
(1) Stability model	566.13	432		.83	.95	.95	.04
(2) Causality model	562.05	427	4.08(5)	.83	.95	.95	.04
(3) Reversed causation model	564.53	427	1.60(5)	.83	.95	.95	.04
(4) Reciprocal model	557.91	420	8.22(12)	.83	.95	.95	.04

Notes. $N = 231$

χ^2 = chi-square fit index; *df* = degrees of freedom; NFI = Normed Fit Index; IFI = Incremental Fit Index; CFI = Comparative-Fit-Index; RMSEA = Root-Mean-Square-Error-of-Approximation. Chi-Square Difference test compares with the stability model.

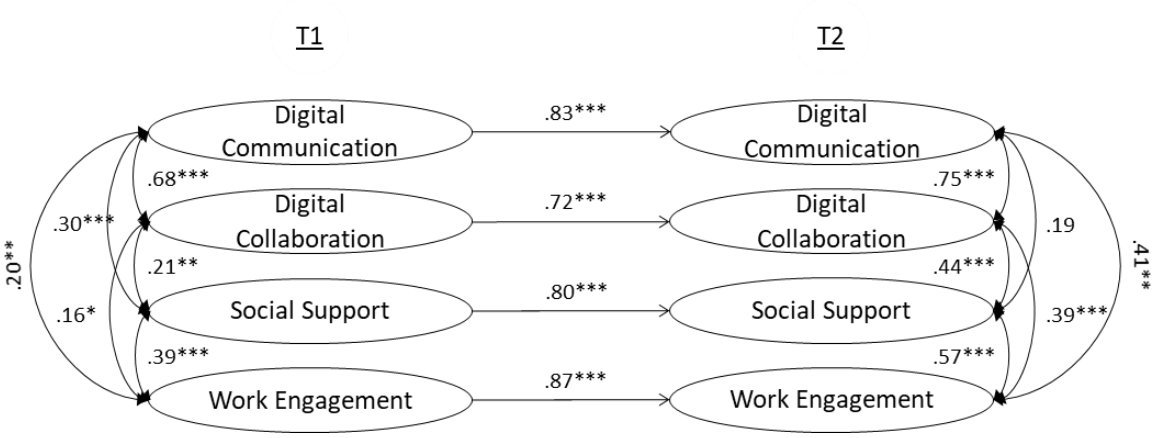

Figure 2. Structure analysis model of stability model (SEM).
N = 231. *p < .05. **p < .01. ***p < .001.

The causality model also displayed a very good fit with the data. However, none of the cross-lagged paths from resources to work engagement (H1, H2) and DCM or DCL to social support (H3) were significant. A chi-square difference test revealed no significant difference between the stability and the causality model ($\Delta\chi2(5) = 4.08$, $p = .54$). Following the parsimony principle that suggests choosing more parsimonious models over models with more presumed paths, the stability model is superior (Vandekerckhove et al., 2015).

The fit indices also showed a very good fit of the reversed causation model to the data. Nevertheless, the expected cross-lagged paths from social support (T1) to DCM and DCL (T2) were not significant (H4). Additionally, none of the cross-lagged paths from work engagement (T1) to the resources (T2) were significant (H5). In sum, the reversed causation model was not significantly better than the stability model, a chi-square difference test revealed ($\Delta\chi^2(5) = 1.60$, $p = .90$).

The reciprocal model including all hypothesized paths at once also showed a very good fit to the data. However, again neither the cross-lagged paths from the resources (T1) to work engagement (T2, H1, H2), nor the cross-lagged paths from social support (T1) to the personal resources (T2, H4) or from work engagement (T1) to the resources (T2, H5) were significant. Again, a chi-square difference test revealed that the reciprocal model was not significantly better than the stability model ($\Delta\chi^2(12) = 8.22$, $p = .77$).

Contrary to our expectations, we could not find cross-lagged effects of job or personal resources on work engagement (H1, H2) in the current study. Unlike assumed, we did not find evidence for DCM and DCL having the role of personal resources boosting work engagement during the pandemic, neither did we find evidence for social support boosting work engagement in times of crisis. This is surprising, given that, at least for social support, a vast amount of research findings before the pandemic provided evidence for such an effect (e.g., Xanthopoulou et al., 2008). Moreover, we neither found significant

cross-lagged effects from DCM or DCL on social support (H3) nor from social support on DCM or DCL (H4). Therefore, we found no evidence for reciprocal effects between personal and job resources in times of crisis. Furthermore, we found no support for reciprocal effects between work engagement and resources during times of crisis (H5). However, all study variables showed very high autoregressive effects over the two time points, with only social support showing a substantial decline over time. The stability model showed the best fit with the data and was superior to all other models. Therefore, against our hypotheses, the model including only temporal stabilities and synchronous correlations shows a better fit with the data than all other models including relationships between job and personal resources and work engagement over time.

4. General Discussion

Our findings from two different studies contribute to the under-studied area of digital competencies at work and extend the scope of previous work by examining the motivational processes during a pandemic. We were able to develop a reliable questionnaire measuring digital communication and collaboration competencies at work by combining CTT and IRT approaches. We then cross-validated the intended two-factor structure in a second sample. In our main study, the majority of our hypotheses about the motivational effects, based on the well-established JD-R model and COR theory, were not supported by our data, that was collected during the COVID-19 crisis. Still, our findings provide important insights into the motivational processes at work during this time. In a cross-lagged study with a sample of office-based workers, we found no evidence for positive effects of digital communication or collaboration competencies in terms of a resource, under the special circumstances caused by the COVID-19 pandemic. Our results neither provided evidence for personal and job resources influencing each other over time, nor effects between work engagement and job or personal resources over time. In contrast, we found high stabilities of the variables at two times during the COVID-19 pandemic, indicating the maintenance of high levels of digital competencies, and work engagement, despite the crisis.

Therefore, we can conclude, that digital competencies and social support do not boost work engagement during the COVID-19 crisis – at least not for the mainly office-based workers included in our study at two time points during different phases of the pandemic. Yet, our findings bear important theoretical and practical implications for digital communication and collaboration competencies at work and for maintaining the motivation of workers during times of crisis.

4.1. Theoretical Implications

By developing a measurement instrument for digital communication and collaboration competencies at work, we contribute to the existing research by refining the construct. Whereas most prior studies on digital competencies used imprecise definitions and terminology describing different constructs under the same terms (overview in Oberländer et al., 2020), we provide a clear definition and scope of the construct. In particular, our findings support that digital communication and collaboration competencies are two separate but highly related dimensions of digital competencies. Therefore, our results add a new perspective to prior conceptualizations of digital communication and collaboration competencies that focused on their overlapping content and often merged these two dimensions (Murawski & Bick, 2017). By providing a reliable and valid assessment tool for research and practice, we hope to enable further research adding to the knowledge about digital competencies at work that is much needed (e.g., Murawski & Bick, 2017).

The stability coefficients in our study imply that prior results on the stability of work engagement over time can be replicated in times of COVID-19 and that our results about missing time-lagged or reciprocal effects between study variables suggest that we need new models or theories to explain their interplay in times of crisis. In detail, our results showed that stability coefficients overall were relatively high. Besides a high level of digital communication and collaboration competencies across the two measurement points during the COVID-19 pandemic, workers who reported high work engagement at T1 also reported high work engagement at T2. The latter seems in line with prior findings for a high stability of work engagement even for longer periods than the one implemented in the current study (e.g., Seppälä et al., 2014). Also, the meta-analysis of Young et al. (2018) supports the high stability of work engagement, given that personality variables were able to explain 48% of the variance in work engagement. Moreover, Mauno et al. (2007) found that work engagement is generally higher in professionals compared to less professional groups. As our sample mainly consisted of white-collar workers with a high percentage of academic degrees, this could be another explanation for these results. However, results about the stability or variation of work engagement during the COVID-19 pandemic seem to be inconsistent. While our findings of high levels of work engagement during the pandemic seem to match results reported from Spanish frontline healthcare workers in March and April 2020 (Gomez-Salgado et al., 2021), Dutch employees reported a significant decrease in work engagement between January and May 2020 (Syrek et al., 2021). An explanation for these varying findings could be that the time frames of data collection were chosen differently, with different measures and actions taken in different countries. However, in particular, concerning the issue of time lags, the field requires detailed theories that can provide explanations and guidance about temporal issues at work (Weigelt et al., 2021).

Even though our results provide no support for the role of digital communication and collaboration competencies as personal resources boosting work engagement, it is too early to reject their potentially positive role concerning work motivation or outcomes in the current work situation. Significant correlations at each time point of the main study show that there are important relationships between these competencies and work engagement. Moreover, within the JD-R model, resources are also expected to contribute to goal achievement and foster personal learning and development (Bakker & Demerouti, 2008). It could be that digital communication and collaboration competencies are especially beneficial as personal resources to gain knowledge and promote learning of such skills that are much needed at work during a pandemic. This seems in line with van Laar et al. (2019), who outlined how digital competencies as 21st-century skills are pivotal for learning and knowledge creation at work nowadays. Furthermore, it could be that the effects of digital competencies on other resources or motivational variables during COVID-19 depend on other variables. Recent findings suggest a role of prior experience in working from home (Kniffin et al., 2021), social support of the partner, or having younger kids at home (Meyer et al., 2021; Syrek et al., 2021). Besides, the JD-R model offers a range of alternative options on how personal resources can affect motivation and work outcomes, for example, in terms of a moderating role (overview in Schaufeli & Taris, 2014). However, neither the JD-R model nor the COR theory offer a systematic indication on which role would be appropriate but refer to additional theories to answer this question. Unfortunately, though, the literature on the theoretical construct of digital competencies is scarce and diverse (Murawski & Bick, 2017). Therefore, further systematic research on the construct of digital competencies is needed to expand existing knowledge about possible combined effects with current demands and resources at work. Our findings and measurement instrument form a basis to investigate potential effects on motivation or well-being comprehensively in the future, contributing to much-needed theory development in this field. So far, evidence about the particular role of competencies as personal resources in the motivational and health process outlined in the JD-R model is scarce.

In our data, we did not find evidence for social support and digital communication or collaboration competencies influencing each other over time. Moreover, our study did not provide evidence for the well- known reciprocal effects between social support and work engagement in times of crisis (Xanthopoulou et al., 2008). Especially in the complex and demanding situation of a pandemic, additional variables should be considered to display the combined impact of different resources in the motivational process. Examples could be person variables (e.g., need for autonomy, Van Yperen et al., 2014) or effective strategies to deal with specific technological demands or to facilitate job crafting (e.g., Harju et al., 2016). In a recent study, Hakanen et al. (2021) showed that the three job resources skill discretion, job feedback, and team empowerment are the most important drivers of work engagement among the eight job resources they looked at. Therefore, these resources could also be more important for the level of work engagement during the pandemic. However, neither social support nor digital

communication and collaboration competencies were included in their study, and data were collected before the pandemic. Furthermore, the JD-R model does not offer a theoretical frame to decide which resource is helpful to cope with which demand. On top, the COVID-19 pandemic is an unprecedented crisis and can be seen as a new demand on its own within the JD-R model. Additionally, Syrek et al. (2021) argue that forced working from home full-time during the crisis can be interpreted as a threat that impairs important resources, such as social support, needed to handle the demands effectively. Therefore, it is unclear yet which resources are helpful in dealing with the impact of COVID-19 on work.

We found a significant decrease in social support from T1 to T2, which is in line with findings of other studies during the pandemic (Anicich et al., 2020; Meyer et al., 2021; Syrek et al., 2021). The decline might be explained by the difficulties of having informal chats at work while working from home. In contrast to the countless occasions where workers meet at the hallways or coffee kitchens in office buildings, workers have to take the time and energy to deliberately reach out for informal chats with colleagues to get social support when working from home. Already prior studies show that a shift from office-based work to virtual work leads to an unsatisfied need for social connection or lack of social support (Zhang, 2016). This could be even more so after the outbreak of the COVID-19 pandemic required workers to avoid face-to-face meetings at all, contributing to a less important role of social support as potential job resource as we found in this research. Another explanation could be offered by the phenomenon of zoom fatigue (Fauville et al., 2021). Workers are exhausted by the number of video calls that are scheduled already and think twice if they would start another call to ask for social support. Furthermore, as we did not differentiate between co-worker and supervisor support but used an overall measure for social support, it could also be that these different potential sources of social support had different effects in the pandemic work situation (Jolly et al., 2020). Also, we did not measure social support by the partner that Meyer et al. (2021) showed to have a significant main effect on exhaustion during the pandemic, but only for women.

4.2. Practical Implications

In terms of practical implications, our questionnaire can help managers and organizations to assess and monitor current levels of digital communication and collaboration competencies of their employees for optimal support in developing their potential also during times calling for high levels of such competencies.

Our study provides evidence that workers with high shares of office tasks stay highly motivated despite such difficult and unpredictable circumstances and working from home during a pandemic, with no indication for potential negative effects. We found that a high initial level of work engagement stays stable, even in times of crisis. This is in line with prior findings: Schaufeli et al. (2009) found that

changes in demands do not affect future levels of work engagement as much when the initial level of work engagement was high. High stable work engagement can have positive effects, for individuals and organizations, leading to improved job performance and more personal and job resources (e.g., job feedback or team empowerment) over time (Bakker & Demerouti, 2008; Hakanen et al., 2021). Thus, organizations should consider improving work engagement for all workers at all times, and not just in highly skilled professionals or in times of crisis.

In our study, we found that workers rated their social support to be high at both times of measurement during the crisis, even though we found a significant decrease in social support over time. These findings imply that it is especially important to help those workers working from home not to feel isolated but keep socially connected with others at work. As long as workers cannot meet each other naturally in the office environments, for example in the coffee kitchen, there is a pressing need for other possibilities to have informal chats and bond with colleagues. Managers should be aware of this and build up social support systems especially for those who perceive social support to be low.

On the bright side, digital communication and collaboration competencies were rated as extraordinarily high and did not show a decrease over time in our study. These findings imply that situational demands during the pandemic do not seem to have the expected negative effects on personal resources of workers. Rather, workers stayed motivated in resourceful work environments despite demanding challenges in times of crisis. Remote work environments are becoming more common, a trend that is likely to last beyond the working from home policies to condemn the COVID-19 pandemic. The experiences made during this time of extensive practice of working from home could help workers to manage upcoming challenges in the future. However, even though workers rated their digital communication and collaboration competencies to be sufficiently high in our study, they could profit from further learning and training their competencies to be prepared for the challenges of the future world of work.

4.3. Limitations and Further Research

Our research inevitably has limitations that suggest directions for future research. We collected data in two samples of German workers, before and during two critical phases in the course of the COVID-19 pandemic. Although the unique timeframe of the data collection is a strength of this research, concerns about the generalizability of the results could be raised. However, despite the extraordinary circumstances during data collection, we believe our findings yield important insights into the motivational processes at work. Future studies might benefit from integrating data from different countries and cultural backgrounds, at different time points and under varying working circumstances of the crisis. Also, the question remains, if our anticipated effects will emerge again, once the pandemic is over. Moreover, we have to acknowledge that working from home was probably mandatory and non-

optional for most of the participants, but we do not have details about the individual working circumstances, job characteristics, or specific organizational regulations from the moment of data collection.

Another limitation forms the exclusive reliance on self-report measures. Although they are a valid technique to draw conclusions on the inner perceptions of the individuals about their resources, additional objective measures should be considered in future research. In particular, given that prior research has shown that digital competencies measured with self-assessment overrate the actual competencies of undergraduates (McCourt Larres et al., 2003), future research could complement these by alternative measurement methods (e.g., colleagues or supervisors' ratings, knowledge or performance tests). Also, our sample size did not allow us to test for differences in further subgroups.

Although we adjusted the answering format for our scales, the levels of digital communication and collaboration competencies measured in both our studies were very high, indicating potential ceiling effects. This might be due to a potential self-selection bias of the participants as the studies were conducted online and aimed at professionals with office-based jobs. This could have affected the external validity of our measure (Schulze et al., 2017). It could also be possible that workers with high levels of digital communication and collaboration competencies, who were also highly motivated and dealing well with working from home during the pandemic, were more likely to participate in our surveys. Therefore, future studies should strive for more diverse samples, for example, also aiming at less professional workers to expand the existing knowledge about digital competencies and motivational processes for different kinds of workers.

5. Conclusions

In sum, we developed a valid measurement of digital communication and collaboration competencies at work but found no evidence for these competencies to function as personal resources in times of crisis. We neither found the well-known reciprocal effects between social support and work engagement nor the resources influencing each other over time as expected based on theories and models developed to explain the motivation of employees before the pandemic. Thus, the results of our studies raise the question of whether the COVID-19 pandemic ended the world of work, as we know it in terms of effects of resources on work engagement as proposed by the JD-R model.

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Table A

Items in German and English with means and standard deviations of the 27-item-version (prestudy) and the final 10-item-questionnaire (main study, T1).

Item	German version (original) *English version (translated)*	*M*[1]	*SD*[1]	reasons for exclusion
CM1**	**Ich weiß, welche Art der digitalen Kommunikation ich in unterschiedlichen Situationen bei der Arbeit wählen muss.** ***I know which type of digital communication I should use in different work-related situations.***	**4.12 (5.93)**	**0.77 (.90)**	--
CM2	Ich weiß, wie ich Kollegen und Kolleginnen über digitale Kanäle informieren kann. *I know how to inform colleagues via digital channels.*	4.29 (--)	0.73 (--)	IRT, MW, crossloadings
CM3**	**Die üblichen Umgangsformen in der digitalen Kommunikation sind mir unklar. (R)** ***I am not aware of the common etiquette in digital communication. (R)***	**4.07 (5.81)**	**0.95 (1.39)**	--
CM4*	Ich kenne alle relevanten Funktionen der digitalen Kommunikationstechnologien, die ich nutze. *I know all relevant functions of the digital communication technologies I use.*	3.50 (5.36)	0.97 (1.27)	Model fit, crossloadings
CM5*	Ich kann effizient online kommunizieren. *I can communicate efficiently online.*	4.10 (5.92)	0.74 (.90)	Model fit, crossloadings
CM6**	**Ich nutze angemessene Sprache, wenn ich online kommuniziere.** ***I use appropriate language when I communicate online.***	**4.47 (6.28)**	**0.68 (.72)**	--
CM7	Bei der Formulierung von E-Mails oder Textnachrichten verwende ich stets angemessene Formulierungen. *I always use appropriate wording when writing emails or text messages.*	4.36 (6.10)	0.79 (.85)	Model fit, IRT, kurtosis
CM8	Ich nutze häufig unpassende Formulierungen, wenn ich online kommuniziere. *I often use inappropriate wording when communicating online.*	4.30 (--)	0.78 (--)	High content similarity with CM6 but worse fit
CM9**	**Ich kann meinen Schreibstil dem jeweiligen digitalen Medium und Anlass anpassen.** ***I can adjust my way of writing to the digital medium and occasion.***	**4.26 (6.19)**	**0.79 (.80)**	--
CM10*	Ich bin in der Lage, in digitalen Nachrichten respektvoll und höflich zu kommunizieren. *I am able to communicate respectfully and politely in digital messages.*	4.60 (6.52)	0.62 (.63)	Model fit, mean
CM11	In meiner digitalen Kommunikation bei der Arbeit kommt es häufig zu Missverständnissen. *A lot of misunderstandings occur in my digital communication at work.*	3.88 (--)	0.76 (--)	IRT, low factor loadings
CM12	Meine digitale Kommunikation ist für meine Kollegen und Kolleginnen einfach zu verstehen. *My colleagues can easily understand my digital communication.*	4.04 (--)	0.79 (--)	IRT
CM13	Ich kann mein Anliegen in digitalen Nachrichten weniger gut ausdrücken als in einer persönlichen Konversation. *I can express my concerns not as well in digital messages as in personal conversations.*	3.22 (--)	1.10 (--)	IRT, low factor loadings
CM14	Ich bin in der Lage, das jeweils passende digitale Kommunikationsmedium auszuwählen. *I am able to choose the appropriate digital communication medium for the given situation.*	4.19 (--)	0.70 (--)	3 as minimum

Table A (continued)

CM15**	**Ich bin gut darin, den richtigen Zeitpunkt für eine digitale Nachricht zu wählen.** ***I am good at choosing the right moment for a digital message.***	**3.75 (5.36)**	**0.77 (1.15)**	--
CM16*	Ich befolge die Umgangsregeln der digitalen Kommunikation. *I follow the etiquette for digital communication*	4.28 (6.07)	0.74 (.79)	Model fit, mean
CM17*	Ich bin motiviert, digitale Kommunikation bei der Arbeit zu verwenden. *I am motivated to use digital communication at work.*	4.15 (6.04)	0.88 (1.05)	Model fit, crossloadings
CM18	Ich bin offen dafür, neue Informations- und Kommunikationstechnologien kennenzulernen. *I am open to learning about new information and communication technologies.*	4.12 (--)	0.89 (--)	IRT, minimum 2, crossloadings
CM19	Ich informiere mich gerne über neue Anwendungen und Technologien um noch effektiver mit meinen Kollegen und Kolleginnen kommunizieren zu können. *I like to inform myself about new applications and technologies in order to be able to communicate with colleagues even more effectively.*	3.21 (--)	1.19 (--)	Crossloadings, IRT
CL1**	**Ich kenne digitale Technologien, die mir die Zusammenarbeit mit Kollegen und Kolleginnen erleichtern.** ***I know digital technologies that facilitate collaboration with colleagues.***	**4.00 (5.99)**	**0.97 (.97)**	--
CL2	Ich kann mithilfe digitaler Technologien gleichzeitig mit mehreren Kollegen und Kolleginnen an einer Datei arbeiten. *I can work on a document with several colleagues at the same time when using digital technologies.*	3.79 (--)	1.30 (--)	IRT
CL3**	**Ich kann mithilfe digitaler Medien nicht effizient mit meinen Kollegen und Kolleginnen zusammenarbeiten. (R)** ***I cannot collaborate efficiently with colleagues using digital technologies. (R)***	**4.04 (5.60)**	**0.95 (1.36)**	--
CL4**	**Ich nutze gerne digitale Medien um effizienter mit Kollegen und Kolleginnen zusammenzuarbeiten.** ***I like to use digital media to collaborate with colleagues more efficiently.***	**3.79 (5.61)**	**1.05 (1.18)**	--
CL5**	**Ich kann mir arbeitsrelevante Informationen schnell über digitale Kanäle von anderen beschaffen.** ***I can obtain work-relevant information from others via digital channels quickly.***	**4.11 (5.82)**	**0.88 (1.00)**	--
CL6**	**Ich kann auch online mit anderen zusammenarbeiten.** ***I can collaborate with others also online.***	**3.85 (6.06)**	**1.17 (1.01)**	--
CL7	Ich weiß, wie ich mithilfe digitaler Medien arbeitsrelevante Informationen zu einem gemeinsamen Arbeitsprojekt bekommen kann. *I know how to get the relevant information concerning a shared work project using digital media.*	4.05 (--)	0.98 (--)	IRT
CL8	Ich bin in der Lage, digitale Medien zu nutzen, um arbeitsrelevante Daten mit meinen Kollegen und Kolleginnen zu teilen. *I am able to use digital media to share work related data with my colleagues.*	4.35 (--)	0.82 (--)	IRT, mean

Note. $N_{\text{Prestudy}} = 145$, $N_{\text{T1}} = 231$. (R) reverse item

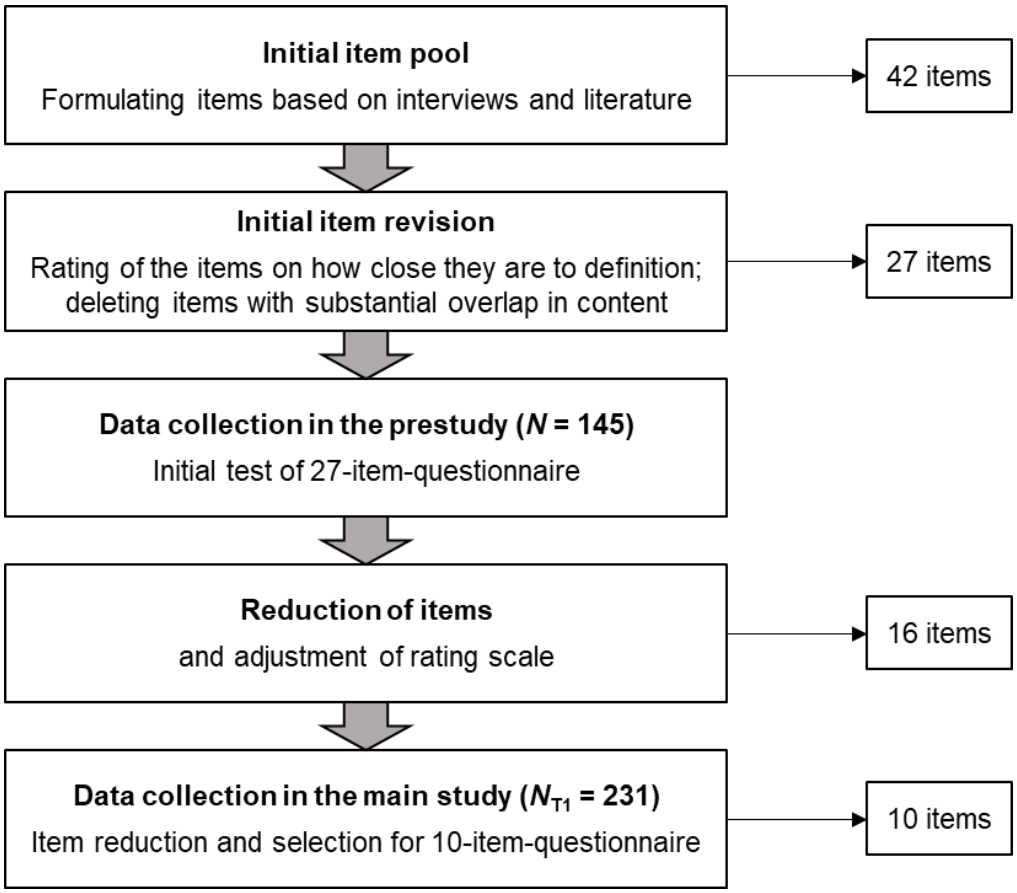
* Preliminary 16-Item-Questionnaire

** Final 10-Item-Questionnaire.

[1] Values in Brackets are Means and Standard Deviations with the Data from the Main Study (T1)

Figure A

Overview of steps taken in questionnaire development.



Chapter 4 – Paper 3

Assessing Digital Competencies at Work

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Abstract

Digital communication and collaboration competencies are needed by most workers to successfully and efficiently accomplish their job tasks. In several studies, we advanced and validated a short version of an initially developed scale by Oberländer and Bipp (2022) measuring these competencies. Based on work in three prestudies, we inspected the nomological net of digital communication and collaboration competencies at work by outlining its convergent and discriminant validity with face-to-face communication and computer efficacy in Study 1 ($N = 209$). In Study 2 ($N = 178$), we found no significant effects of varying instructions for the assessment of digital communication and collaboration competencies at work in an experimental study. Unexpectedly, data revealed a positive relationship between the assessment of digital communication and collaboration competencies and training motivation of workers across the experimental groups. With this research, we build a solid base for much-needed theory building and expansion in this field by providing insights into the nomological net and effects of varying assessments of the construct of digital communication and collaboration competencies on the one hand. On the other hand, we contribute to practice by providing a free, available, and valid short-scale to measure digital communication and collaboration competencies at work.

***Keywords*:** Digital communication and collaboration; self-assessment; competencies; work context; future of work; training motivation; measurement instrument; scale validation

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Assessing Digital Competencies at Work

In today's digital world, technology becomes more and more important in all of our lives (Colbert et al., 2016). The ongoing digitalization processes and constant technical innovations require a digitally competent workforce that can adapt to the increasing demands of the fast-changing work environments (e.g., Murawski & Bick, 2017). It is therefore not surprising that the need for digital competencies at work has been formulated repeatedly and it appears plausible that digital communication and collaboration competencies are mentioned as core competencies in the twenty-first century frequently (Makarius & Larson, 2017; van Laar et al., 2017). Yet in 2016, most workplaces required at least basic digital competencies (Arnold et al., 2016). Thus, employers rely on the digital competencies of their employees to improve the quality, effectiveness, and efficiency of their work on a daily basis (Degbey & Einola, 2019; Derks et al., 2008). Therefore, even though there is a pressing need for the use and understanding of digital competencies in the workplace, systematic research on digital competencies is still scarce, which might be partly due to missing reliable and valid measurement instruments assessing those competencies in theory and practice (e.g., Raghuram et al., 2019).

The goal of the current research is three-fold: First, we aim to validate a practicable scale based on the initial work of Oberländer and Bipp (2022) and provide much-needed insights into the nomological net of this highly relevant construct. Consequently, we strive towards the development and validation of a free and available short-scale that can be included in large-scale surveys or diary research and reduces the burden on respondents by saving completion time. By demonstrating convergent and discriminant validity of the scale, we contribute to the expansion of theory on digital communication and collaboration competencies at work. Second, we aim to refine the initial scale and tackle the problem of potential over-estimation of digital competencies by workers. Therefore, we test the effect of varying instructions on the self-assessment of digital communication and collaboration competencies in an experimental setting. Third, we aim to investigate the role of those varying instructions on training motivation with the goal to help encourage learning and development when realizing knowledge gaps in digital competencies. By testing the effect of varying instructions, we explore how self-assessment of digital competencies might be changed to stimulate motivation to learn in the work context.

1. Assessing Digital Communication and Collaboration Competencies at Work

In line with prior definitions, we understand digital competencies as a combination of knowledge, skills, abilities, and other characteristics, such as motivational aspects (Aamodt, 2009; Oberländer et al.,

2020). These competencies enable workers to accomplish regular job tasks involving digital media efficiently and successfully. Even though the relevance of all aspects of digital competencies at work has increased, we focus on the two aspects of digital communication and collaboration competencies in the current studies. Oberländer et al. (2020, ESM, p.3) defined digital communication competency as "the competency to use appropriate digital communication channels to communicate with colleagues, supervisors and business partners". A person with high digital communication competencies would be able to write e-mails in appropriate form and language for any occasion and purpose, for example. Digital collaboration competency is defined as "the competency to use digital media and programs for business collaboration, for example with colleagues, supervisors, business partners, and customers" (Oberländer et al., 2020, ESM, p.3). For instance, a person with high digital collaboration competencies would be able to use shared team calendars and share the results of their work with others in any required form. Both forms of digital competencies are highly relevant in today's world of work as people have to communicate and collaborate online with colleagues spread over dispersed locations to solve substantial and complex problems at work. This is because job tasks became more complex due to fast-changing work propelled by globalization and technological innovations (DeShon & Gillespie, 2005; Gilson et al., 2014). Recently, the COVID-19 crisis accelerated the need for such competencies even more, since work shifted online almost overnight and many employers made the change permanent by offering flexible work arrangements (Meske & Junglas, 2020; Wang et al., 2021). Therefore, especially digital communication and collaboration competencies are essential assets needed to get work done efficiently. Moreover, these two competencies are mentioned in most theoretical models as integral parts of digital competencies (e.g., Hwang, 2011; Makarius & Larson, 2017).

However, little research has focused on digital competencies in the work context so far (Murawski & Bick, 2017). One reason for this could be the inconsistency in definitions used for the construct and different approaches to the specific content, such as dimensions. Accordingly, only a minority of studies on digital competencies have collected quantitative empirical data. Even adding the studies that reported qualitative evidence, a substantive number of studies remain theoretical, not collecting data at all (Oberländer et al., 2020). This could be because appropriate measurement scales, that can be used to assess digital competencies directly across different settings and jobs, are lacking (Olszewski & Crompton, 2020). Most studies relied on open questions or expert interviews on the digital competencies of students or citizens, measurement techniques that are not transferable to contexts without additional testing. For example, Guzmán-Simón et al. (2017) investigated digital competencies in a university setting taking a convenience sample of Spanish undergraduate students. They used ten main and several sub-questions to interview the undergraduates about their information and communication technology literacy to research their digital competencies. These questions were very context-specific focusing on reading, writing, library culture, and academic literacy, for example. Other approaches, like assessing competencies indirectly (e.g. via personality inventories) might not reflect the core of the construct in

question either, and therefore provide only limited insights into the construct for workers and employers in practice.

In a first attempt to provide a feasible measurement tool for the work context, Oberländer and Bipp (2022) used two scales to measure digital communication and collaboration competencies for white-collar workers with office jobs. The development of the two scales was based on interviews with practitioners about their definition of digital competencies at work as well as on the framework suggested by Oberländer et al. (2020). Initial findings of this scale suggest relatively high stability, even in pandemic times (Oberländer & Bipp, 2022). Although their research closes an important gap in the literature on digital competencies by providing a direct measurement instrument for the work context, the scale by Oberländer and Bipp (2022) still has potential shortcomings. First, so far, they provided evidence about the internal structure of the scale solely. So, further evidence about its construct validity is needed before the scale can be evaluated comprehensively for use in research and practice. Hence, we aimed to provide insights into the validity of the scale of digital communication and collaboration competencies in a sample of workers, by providing empirical evidence for its nomological net. Second, the two scales showed high interrelationships in all measurement instances so far, indicating a common core behind digital communication and collaboration competencies. Moreover, the introduced scales appear quite long. Thus, we aim to provide a short-scale that can be included in large-scale surveys or research demanding multiple measurement times and reduces the burden on respondents by saving completion time. Third, the authors mention high mean values of all items, indicating potential ceiling effects of the scale and therefore lower precision when measuring these competencies of employees at medium to high levels. Therefore, we tested if different instructions to assess one's own digital competencies tackle the potential problem of over-estimation. Thus, the aim is to differentiate medium to high values of digital communication and collaboration competencies at work better and thereby help workers get a more realistic assessment of their own digital competencies.

1.1 Nomological Net: Convergent and Discriminant Validity

The assessment of the nomological net of a fairly new construct offers essential advantages for theory and practice. On the one hand, knowledge about the relations to and distinction from other constructs contributes to theory formation in this field. Given the various definitions and models that have been suggested about digital competencies (Janssen et al., 2013; van Laar et al., 2020a), this seems crucial for this research field to move forward. Insights into the nomological net can, for example, provide support for theoretical frameworks or their extensions, connect different streams of literature and thereby offer a more holistic research approach, or highlight important research gaps. Concurrently, as an advantage for practice, knowing the relations of the focal construct with other well-known

constructs can help to understand the interplay of different competencies in various situations and guide evidence-based decisions, for example in terms of investment in training programs for employees.

On the theoretical level, we identified two constructs that we consider to share conceptual overlap with the digital communication and collaboration competencies at work but can be distinguished from the focal construct: Face-to-face communication (FtfC) and computer efficacy (CE).

Face-to-face Communication (FtfC). FtfC can broadly be described as people meeting in real life and having a conversation without the help of enabling technological devices. People with high communication skills can express ideas, feelings, and thoughts while avoiding misunderstandings, thereby inspiring and convincing others. In competent communication, the outcomes derived from the conversation are satisfactory with regard to mutual understanding for all persons involved (Schulze et al., 2017). Digital communication and collaboration require similar competencies as face-to-face situations, but beyond that, the digital environment poses unique challenges. Therefore, digital communication and collaboration competencies must be considered a different theoretical construct (Ayoko et al., 2012; Degbey & Einola, 2019; Schulze et al., 2017). Oftentimes, digital communication is described as more challenging to workers than face-to-face interactions (Raghuram et al., 2019). Most obviously, any digital conversation or collaboration requires a basic understanding of the technology used, even though these competencies are not part of most official job training (Schulze et al., 2017). Expressing emotions, resolving conflicts, or building relations with colleagues or supervisors gets more difficult online, for example in asynchronous forms of communication (Ayoko et al., 2012; Liao, 2017). Also, sharing informal knowledge becomes a deliberate action in digital environments, for example by arranging a meeting and consciously joining it, compared to just meeting at a coffee table and talking to colleagues in the office (Wang et al., 2021).

In sum, we expect digital communication and collaboration competencies and FtfC at work to be correlated positively, as successfully communicating and collaborating in the digital world also requires basic communication skills in general. However, we expect the two theoretical constructs to be clearly distinguishable, as the digital work environment provides unique challenges so that someone effective in face-to-face interactions does not necessarily score high on digital communication and collaboration competencies, too.

H1a: *Digital communication and collaboration competencies at work correlate positively with FtfC.*

H1b: *Digital communication and collaboration competencies can be clearly distinguished from FtfC.*

Computer efficacy (CE). Self-efficacy is defined as the belief "in one's capabilities to organize and execute the courses of action required to produce given attainments" (Bandura, 1997, p.3). Accordingly, CE describes the extent to which an individual considers him- or herself capable of using specific computer technology (Wrench & Punyanunt-Carter, 2007). In general, self-efficacy is known

to influence the behaviors one chooses to engage in, the estimated effort needed to overcome challenges, and eventually master certain behaviors (Bandura, 1997). It is not a measure of an actual skill but the individual assessment of one's personal ability to exercise a specific behavior. The construct of CE, therefore, differs from computer-related competencies as it describes the confidence to engage in technology use rather than the actual competencies required to do so. In line with such reasoning about the distinction of the constructs, Wrench and Punyanunt-Carter (2007) did not find a positive association between computer-mediated communication competencies and computer self-efficacy. The authors draw attention to the possibility of competent online communication without being confident about computer use (Wrench & Punyanunt-Carter, 2007). However, the constructs of CE and digital competencies do indeed share similarities. Individuals with high CE are less anxious about working with computers and enjoy it more (Patterson & Gojdycz, 2000). Consequently, CE is associated with a higher likelihood to engage in computer usage in the future (Compeau & Higgins, 1995), which might contribute to the development of effective competencies to use these technologies at work. Also, self-efficacy concerning information and communication technologies was found to be a significant determinant of digital communication competencies (van Laar et al., 2020a). CE and digital competencies being similar but distinct constructs, we expect them to be inter-correlated, yet statistically distinguishable.

H2a: *Digital communication and collaboration competencies at work correlate positively with CE.*

H2b: *Digital communication and collaboration competencies can be clearly distinguished from CE.*

1.2 Assessing one's own Digital Competencies

Findings of prior research on digital competencies showed high mean values and rather low ranges in several data collections (Oberländer & Bipp, 2022; Schulze et al., 2017). This is in line with the general finding that people tend to assess their competencies, skills, and abilities to be better than average (e.g., Guenther & Alicke, 2010; Zell et al., 2020), leading to higher ratings and lower ranges in the assessment context. For example, research on computer literacy among undergraduates found a vast majority of the participants over-estimating their computer knowledge (McCourt Larres et al., 2003). Concerning digital competencies, Schulze et al. (2017) showed that adults generally rate their computer-mediated communication knowledge, skills, abilities, and other characteristics at the higher end of the rating scale. With regard to a specific work context, Maderick et al. (2015) found that teachers overestimated their digital competencies, too.

However, completely abandoning self-ratings from competencies assessment would not be a solution to this problem either. As Freund and Kasten (2012) stated, self-assessment can provide information that goes beyond the information we receive from objective testing, for example. Indeed, self-assessments can provide useful information on the self-concept and confidence level of the

participants (Huang, 2011). Beyond that, self-assessments are crucial for several important outcomes in the work context. For instance, self-assessments can influence learning outcomes, as they help in personal monitoring, reflection on past performance, and adjustment of future learning and behavior (Carver et al., 2021; Maderick et al., 2015; Yan, 2019). By making and strengthening connections between new learning points and already existing competencies and understandings, self-assessments are essential components for knowledge construction in a learning process (McMillan & Hearn, 2008). Additionally, self-assessments can empower learners to guide their learning by helping them to perceive it to be more meaningful (McMillan & Hearn, 2008) and promote self-reflection on what one has learned and still need to learn (Schunk, 2012). This in turn leads to self-assessments promoting intrinsic motivation and engagement in learning (Gikandi et al., 2011; Schunk, 2012; A. C. M. Yang et al., 2022).

This body of research on the effects and benefits of self-assessments shows that solely relying on objective measures of competencies would neglect the huge part of self-beliefs about one's competencies influencing important outcomes in behavior and attitudes. Therefore, it is not enough to improve the competencies of the workforce, but the self-beliefs about one's competencies need to be improved just as much, as Huang (2011) rightly claimed. In this research, we take a new approach by investigating the effects of varying instructions on the self-assessment of digital communication and collaboration competencies at work to add more insights into the field of self-assessments. To do so, we investigated if a focus on either social comparison or a reminder of the increasing future requirements of the job changes the self-assessed competencies of the workers. In the following, both approaches are described in detail.

1.2.1 Social Comparison

According to the meta-analyses by Mabe and West (1982) and Freund and Kasten (2012), the consistency of self-assessment and objective measures can be improved by instructing participants in self-assessments to social comparison with clearly specified others. When instructed to social comparison, people consider their competencies or performance in relation to relevant others during self-assessment, which can also be abstract targets such as the average worker (Zell et al., 2020). In contrast to physical comparison standards, social comparison processes are available in a multitude of everyday situations. Therefore, a plentitude of information from relevant comparison situations is readily available when instructed to social comparison. Beyond that, instructions for social comparison have been shown to give people better orientation in self-assessments with comparative ratings (Zell & Strickhouser, 2020) as the instruction to compare with others helps people to focus on relevant (such as results of previous comparisons) rather than irrelevant (such as the current mood) information (Freund & Kasten, 2012). However, as Festinger (1954) states in his social comparison theory, if physical standards are unavailable, people tend to compare themselves to others to self-assess their competencies anyways. Based on this theory, comparative ratings have been found to engender generally stronger

criterion-related evidence of validity than absolute ratings, where verbal anchors (e.g. “very unlikely”, “likely”) are typically used (Carver et al., 2021; Goffin & Olson, 2011). For example, Carver et al. (2021) found significantly lower mean scores in comparative rather than absolute ratings in their study, where they used semi-structured interviews to investigate the thought processes of workers during performance self-assessment. Against the background of the theoretical reasoning, this result implies that the instruction to social comparison could be an adequate method to curb over-estimation in self-assessment.

When instructed to use other people as a reference, two different effects can be differentiated: Assimilative and contrastive effects. Contrastive comparison effects are found when the self is compared to the other, while assimilation occurs when the other is compared to the self (Mussweiler, 2001; Tsai, 2010). Another dimension of social comparisons is the characteristics of the comparison target. The closer the target is perceived to resemble oneself, the stronger the effect of the social comparison (Zell & Alicke, 2010). We expect workers, who are instructed to social comparison with another worker with very high digital communication and collaboration competencies to show contrastive effects and therefore rate their digital competencies to be lower.

H3: *Workers, who are instructed to social comparison in contrast to a specific, better worker as a target, rate their own digital competencies at work lower than workers, who are not instructed to such a social comparison.*

1.2.2 Future Work Requirements

According to prognoses, working time spent with information and communication technology will increase while less time will be spent on tasks requiring physical competencies (Bughin et al., 2018). This leads to job tasks becoming more complex, and therefore workers have to engage in continuous learning to solve crucial problems (DeShon & Gillespie, 2005; Gilson et al., 2014). Workers are required to improve their digital competencies constantly to keep pace with future job requirements, even if the digital competencies of the workforce are sufficient for today’s job requirements. In personnel development, one important task is the assessment of current competencies and qualifications and the comparison of those with the competencies and qualifications needed to master future work requirements (Kozlowski & Salas, 2012). However, prior research found that people are not very good at predicting their future abilities or performance (Mabe & West, 1982). Therefore, our goal is to help workers reach an understanding that their current digital competencies might be good to meet the current requirements, however, the same competencies might not be sufficient for future work requirements due to the changes in the workplace. We expect participants, who are highly aware of the changes in their workplace and the associated increasing future requirements to realize the gap between their current

digital competencies and the future requirements of their jobs. Therefore, we expect those participants to self-assess their current digital competencies with reference to future work requirements to be lower.

H4: *Workers, who estimate their own digital competencies with reference to future work requirements, estimate their digital competencies to be lower, than workers, who estimate their current digital competencies without relation to future requirements.*

Moreover, we combined the approaches in making future job requirements regarding the digital competencies at work salient and using a comparative rating scheme by instructing comparisons between actual and expected future competencies at the within-level. In a study on the thought processes during self-assessment of performance, Carver et al. (2021) showed that workers spontaneously used previous performance as a reference for the evaluation of their current performance. Therefore, we expect participants to self-assess their current digital competencies at work to be lower when asked to rate these with regard to future requirements after they were instructed to rate their current digital competencies with regard to the current requirements at their workplace.

H5: *Workers, who are first instructed to estimate their digital competencies with regard to current requirements and afterward with regard to future requirements at work, report lower digital competencies over time.*

1.3 Training Motivation

As the job requirements are increasing constantly, the workforce needs to participate in lifelong learning and stay motivated to keep improving crucial competencies (Trenerry et al., 2021). Prior research has shown the importance of the self-assessment of one's competencies for training motivation (Wang et al., 2008; Zell & Strickhouser, 2020). For example, Mason and Brougham (2020) found that the self-evaluation of a person and what they believe about learning significantly impact their motivation to learn. Moreover, prior research showed a significant relationship between learning motivation and competencies on the one hand, and between learning motivation and self-assessment in distance learners on the other hand (Wang et al., 2008). In addition, Chang et al. (2013) found an influence of internet self-efficacy on motivation to learn in online training.

Training motivation describes the tendency of a person to value learning as an important good and to benefit from it in a work setting. Therefore, training motivation also indicates the direction, intensity, and persistence of learning behavior (Chung et al., 2021). A high training motivation has a positive effect on training effectiveness, affect, and turnover intentions, for example (Shih et al., 2011; Stanhope et al., 2013). Training motivation, therefore, is an important measure for proximal and distal workplace outcomes. Additionally, the willingness to train and further self-develop is one of the most

critical prerequisites of the workforce in times of fast-changing technological advances to counter increasing competency gaps (Mason & Brougham, 2020; Trenerry et al., 2021).

Recently, Chung et al. (2021) proposed a model of training motivation theory including antecedents and outcomes of motivation to learn in a workplace setting. Following this model, digital communication and collaboration competencies can be understood as comparable to knowledge and skills, which are categorized as a set of antecedents of motivation to learn. For example, Chung et al. (2021) found a negative relation between cognitive ability as knowledge and skills, and motivation to learn. We argue that instructing participants to social comparison or to think about the future job requirements changes their perspective on their self-assessments of digital competencies and helps them realize a gap between their current and future required digital competencies, thereby affecting their motivation to learn. In line with the findings of Chung et al. (2021), and our previous predictions about the effects of social comparison and future job requirements for digital competency assessment (H3-H5), we expect the training motivation of the participants to be higher in these conditions, as those participants should realize a competency gap that fuels their motivation to close it.

H6: *Workers, who rate their own digital competencies*

(a) in contrast to a specific, better target

(b) with regard to future requirements

(c) comparing their competencies to future and current work requirements

report higher training motivation than workers, who estimate their own digital competencies without any specific instructions.

Based on our argumentation above that instructing participants to social comparison or to highlight future job requirements lowers their self-assessments of digital competencies, which in turn affects training motivation, we tested if the effect of the instructions on training motivation is indeed transported via the ratings of digital competencies.

H7: *We expect the effect of the experimental design on training motivation to be mediated by the lowered ratings of the digital competencies in the three experimental groups compared to the control groups.*

1.4 Overview of Current Studies

In the current research, we conducted two main studies to further develop a scale to directly measure the digital communication and collaboration competencies of workers (Oberländer & Bipp, 2022) and provide much-needed insights into its nomological net. Additionally, we tested if the issue of ceiling effects can be tackled by different instructions in an experimental setting with four groups. Finally, we investigated the relationship between these different instructions to self-assess digital

communication and collaboration competencies and training motivation. All studies in this paper were conducted in German with the prerequisite of German as the native language. Prior steps taken in the development of the short-scale measuring digital communication and collaboration competencies at work, based on the initial work by Oberländer and Bipp (2022), are described in the following prestudies section. An overview of the steps taken in the development of the short-scale is depicted in Figure A (ESM).

2. Prestudies: The Development of a Short-Scale

The existing scale by Oberländer and Bipp (2022) measures digital competencies at work with two scales, digital communication, and collaboration competencies. Each scale is composed of five items asking workers with office jobs to rate their digital competencies on a seven-point Likert scale from 1 = *doesn't apply* at all to 7 = *fully applies*. In total, we conducted three prior studies to further develop this initial scale into a more feasible short-version and assess the psychometric properties of this new short-version in three steps.

In step 1 (item generation), we extended the existing item pool of the original scale with more difficult versions of the original ten items. In two samples of University students (N_1 = 117, N_2 = 102), we tested if the new items tapped the construct at a higher competency level. Consequently, in step 2 (item selection) we selected six of the items from the original scale to be replaced by the more difficult item versions based on a mix of indicators from Item Response and Classical Test Theory. The indicators included item information curves, item response category characteristic curves, and t-tests for differences in mean values between original and difficult items, among others (see Table A in ESM for item wordings and results of mean difference tests between the original and difficult items).

In step 3 (reduction of scale), we used a stepwise procedure to reduce the scale to a more feasible short-version by excluding items based on their loadings on the single factor and content of the items in another sample of 201 workers, recruited via a research panel. The final six items selected showed positive and significant loadings on the common factor, ranging from .55 to .75. The single extracted factor explained 42.91% of the variance in the digital communication and collaboration construct. Taking these results together, we assume a unidimensional nature of digital communication and collaboration at work measured by three of the original and three of the more difficult item versions. With Cronbach's α = .73, the internal consistency of the final six-item short-scale was above the recommended cut-off of .70 (Hinkin, 2016) and indicated acceptable reliability (Nunally & Bernstein, 1994). The wording of all items of the final six-item short-scale is depicted in Table 1.

Table 1

Goodness-of-fit statistics of the digital communication and collaboration competencies scales with the six-item short-scale in prestudy.

Model	χ^2	*df*	$\Delta\chi^2(\Delta df)$	NFI	CFI	RMSEA
One factor	15.19	9		.86	.93	.07
Two factors	14.84	8	0.35(1)	.87	.92	.08

Note. $N = 137$. χ^2 = chi-square fit index, *df* = degrees of freedom, NFI = Normed Fit Index; CFI = Comparative-Fit-Index; RMSEA = Root-Mean-Square-Error-of-Approximation
Chi-Square Difference test compares to the previous model.

In step 3 (cross-validation of factor structure), we tested for the factor structure of the six-item short-scale measuring digital communication and collaboration competencies with confirmatory factor analyses using AMOS version 27.0.0 (Arbuckle, 2020). For this, we recruited another sample of 137 workers via an online platform, who were employed at least part-time. We contrasted a one-factor model with all items as indicators for one latent variable and a two-factor model with digital communication competencies and digital collaboration competencies as two latent variables. Different goodness-of-fit indices were used to examine the fit of the data with the underlying models: The absolute goodness-of-fit indices χ^2, degrees of freedom, and Root Mean Square Error of Approximation (RMSEA). Because the χ^2-statistic is sensitive to sample size, we additionally calculated the relative goodness-of-fit indices Normed Fit Index (NFI), and the Comparative Fit Index (CFI, Marsh et al., 1988). Table 1 shows the results of the model tests comparing a one-factor with a two-factor model. The indices of the one-factor model were satisfactory overall ($\chi^2/df = 1.69$, NFI = .86, CFI = .93, RMSEA = .07). A chi-squared difference test comparing the one-factor with the two-factor model revealed no significant difference between the two models ($\Delta\chi^2(1) = 0.35$, $p = .55$). Following the parsimony principle, the one-factor model is considered to be superior (Vandekerckhove et al., 2015). All items demonstrate large and significant loadings onto the single factor representing the focal construct.

In sum, building on the initial work of Oberländer and Bipp (2022), we refined the scale measuring digital communication and collaboration competencies at work to a more feasible six-item short version. Consequently, we used this adapted short-scale in our two main studies.

3. Study 1: Validity and Nomological Net

The aim of Study 1 was the investigation of the nomological net of the six-item short-scale assessing digital communication and collaboration competencies at work. To investigate the convergent validity, we inspected the correlations of this scale with both related constructs, FtfC (H1a) and CE (H2a), in a large sample. To provide evidence for discriminant validity, we tested whether a model including all of the items for digital communication and collaboration competencies, and the validation construct, respectively, in one common factor, or a two-factor model with separate factors for the underlying constructs fits the data better (H1b, H2b; Kline, 2005).

3.1 Method

Sample. The participants were recruited from various organizations and industries via an online platform as well as private and professional networks. The final sample consisted of N = 209 white-collar workers (60.8% female). Participants were between 18 and 61 (M = 31.84, SD = 10.14) years old, and their mean working time was 35.18 hours per week (SD = 24.49). On average, participants spent 73.88% of their working hours with digital media and therefore used computers/laptops (95.7%), smartphones (56.9%), tablets (25.8%), and other devices (4.3%).

3.2 Measures and Procedure

Digital communication and collaboration competencies. We used the short-scale with six items measuring digital communication and collaboration competencies (see Table 2) on a seven-point Likert rating scale ranging from *1 = doesn't apply at all* to *7 = fully applies*. The internal consistency was satisfactory with Cronbach's α = .71.

Face-to-face communication (FtfC). To measure FtfC in a work context, we used the four items of the communication competencies subscale (e.g. "I am easily capable of convincing other members of my team from my ideas") from the well-established and validated Virtual Team Competency Inventory (Hertel et al., 2006). The items were rated on a 5-point Likert scale (1 = *doesn't apply at all* to 5 = *fully applies*). The internal consistency was satisfactory with Cronbach's α = .75.

Computer efficacy scale. We measured computer efficacy with the ten-item scale by Wrench and Punyanunt-Carter (2007), which was adapted to German using forward-backward translations by two researchers. A sample item is "I understand how my computer works". Participants rated their computer skills on a five-point Likert scale (1 = *strongly disagree* to 5 = *strongly agree*). The internal consistency was satisfactory with Cronbach's α = .90.

Table 2

Items of the final short-scale in the original German version and translated to English.

	Item Wording
1.	I always know what kind of communication I have to choose in different situations at work. *Ich weiß immer, welche Art der digitalen Kommunikation ich in unterschiedlichen Situationen bei der Arbeit wählen muss.*
2.	I can adjust my writing style to the digital medium and occasion. *Ich kann meinen Schreibstil dem jeweiligen digitalen Medium und Anlass anpassen.*
3.	I am very good at choosing the best possible moment for a digital message. *Ich bin sehr gut darin, den bestmöglichen Zeitpunkt für eine digitale Nachricht zu wählen.*
4.	I like to use digital media to collaborate more efficiently with colleagues. *Ich nutze gerne digitale Medien um effizienter mit Kollegen und Kolleginnen zusammenzuarbeiten.*
5.	I can obtain work-related information quickly using digital channels. *Ich kann mir arbeitsrelevante Informationen schnell über digitale Kanäle von anderen beschaffen.*
6.	I can collaborate online with others just as well as face-to-face. *Ich kann online mindestens genauso gut mit anderen zusammenarbeiten wie in Präsenz.*

Note. German wording in italics.

3.3 Results and Discussion

Convergent validity. To explore the nomological net of digital communication and collaboration competencies at work, we assessed the bivariate correlations between digital communication and collaboration and FtfC as well as CE, respectively. The positive and significant, but small to moderate zero-order correlations between digital communication and collaboration at work and both related constructs, depicted in Table 3, provide evidence for the assumed relationships and thus convergent validity. Therefore, H1a and H2a are supported.

Table 3

Descriptive statistics and zero order correlations for digital communication and collaboration competencies and validity constructs in study 1.

	Variable	*M*	*SD*	1	2
1.	Digital competencies	5.47	.75		
2.	Face-to-face communication (FtfC)	3.61	.59	.25**	
3.	Computer efficacy (CE)	4.08	.59	.41**	-.01

Note. $N = 209$.

**$p < .01$.

Discriminant validity. We fitted a one- and a two-factor measurement model to the data, including the validity construct (FtfC or CE, respectively) and digital communication and collaboration competencies at work. For the one-factor model, all items of digital communication and collaboration competencies and the validity construct loaded on one common factor, for the two-factor model, the items of each validity construct loaded on separate factors. The one- and two-factor models were compared statistically with a chi-square difference test. The results are depicted in Table 4. As expected, for both validity constructs, FtfC, and CE, the two-factor models were superior, according to significant chi-square difference tests. The intercorrelations in the latent models between the digital competencies and the validity constructs were $r = .53$, $p < .001$ with CE and $r = .38$, $p < .001$ with FtfC, respectively. Therefore, digital communication and collaboration competencies at work, and FtfC, as well as CE, can be considered separate, yet related constructs. In support of H1b and H2b, we were able to provide evidence for the discriminant validity of digital communication and collaboration competencies at work and related constructs. We thus assume the focal construct to be unique.

Table 4

Test for discriminant validity of digital communication and collaboration competencies with face-to-face communication (FtFC) and computer efficacy (CE) in study 1.

Model	χ^2	*df*	$\Delta\chi^2(\Delta df)$	NFI	CFI	RMSEA
Face-to-face communication (FtfC)						
One factor	184.99**	35		.58	.61	.14
Two factors	70.67**	34	114.32(1)**	.84	.91	.07
Computer efficacy (CE)						
One factor	322.54**	104		.77	.83	.10
Two factors	222.27**	103	100.27(1)**	.84	.91	.08

Note. $N = 209$. χ^2 = chi-square fit index, *df* = degrees of freedom, NFI = Normed Fit Index; CFI = Comparative-Fit-Index; RMSEA = Root-Mean-Square-Error-of-Approximation
Chi-Square Difference test compares to the previous model.
**$p < .01$.

The results of our first study provide much-needed insights into the nomological net of digital communication and collaboration competencies at work. In a large sample of white-collar workers, we found significant, but moderate correlations of the focal construct with FtfC and CE, demonstrating convergent validity. The correlation between the digital competencies and CE was stronger than the correlation between digital competencies and FtfC. However, our results also clearly support the

assumption of empirical distinctiveness of digital communication and collaboration competencies at work from FtfC and CE, respectively. Taken together, we provide evidence for the reliability and validity of a short-scale measuring digital communication and collaboration competencies at work. This new scale can be used to measure the low to high digital competencies of white-collar workers conveniently. Nevertheless, the results of all our data collection efforts so far still showed very high mean values of the self-assessed digital competencies by workers indicating potential over-estimation effects.

4. Study 2: Varying Instructions for Assessment and Training Motivation

To gather knowledge on how workers can be triggered to self-assess their competencies more realistically, we tested the effect of different instructions on the ratings of the digital communication and collaboration competencies at work in an empirical experiment. To this end, we investigated the effect of social comparison (H3) and the reference to future work requirements (H4, H5) on the self-assessment of digital competencies. Additionally, we inspect the effects of varying instructions for the self-assessment of digital competencies at work with regard to training motivation (H6, H7).

4.1 Method

The aims, hypotheses, and methods for this study were pre-registered before the data collection in February and March 2022 (https://tinyurl.com/7xf2ze8w).

4.2 Experimental Design and Procedure

To assess the influence of different instructions on the assessment of one's own digital communication and collaboration competencies and training motivation, we realized an experimental design with four groups: Two between-subject-groups (social comparison, future requirements), one within-subjects-group (future requirements within), and a control group (standard instructions for assessing digital competencies).

Participants were randomly assigned to one of the four experimental conditions. Participants in the control group were asked to answer the scales on digital communication and collaboration competencies and training motivation with the standard instructions. Participants of the experimental groups got to read a short, but detailed description for at least thirty seconds of either social comparison or future requirements. A time lag of at least thirty seconds was built into the online experiment, to ensure careful reading of the instruction in each of the three conditions with adapted instructions.

Social comparison. In this condition, we followed well-researched principles for social comparison (e.g., Zell & Strickhouser, 2020). Participants were asked to read about a fictitious person with very high digital communication and collaboration competencies and imagine this person as a colleague and working with this colleague at their current job. In the following, participants received the items of the digital communication and collaboration scale with the instruction to answer the items about their current digital competencies in comparison to the described fictitious person.

Future requirements. We realized the manipulation of the self-estimated digital communication and collaboration competencies, following a realistic scenario of office workplaces in about five years. Participants were asked to imagine this future scenario of a fast-changing work environment due to technological advances and digitalization leading to an increase in requirements, especially on the digital competencies of workers in detail. In the following, participants received the items of the digital communication and collaboration scale with the instruction to answer the items on how their current digital competencies meet the requirements of their job in about five years.

Future requirements within. Participants in this condition answered the digital communication and collaboration competencies scale with the instruction to consider the current requirements of their job. Then, they got the same scenario text and instructions as the participants in the future requirements group but were asked to assess their digital competencies again, afterward.

Check questions. To ensure careful reading and understanding of the scenario texts, we asked the participants several check questions on a rating scale from 1 (*doesn't apply at all*) to 4 (*fully applies*). In the social comparison group, we asked participants if the digital competencies of the fictitious person are generally very high. In both future requirements groups, we asked participants if the future requirements of digital competencies for workers were rising steadily.

Finally, all participants were asked some demographical questions. In the end, participants got the chance to leave a comment about the survey, we thanked them for their participation and offered them the chance to sign up for a raffle to win one of twenty 10€ vouchers.

4.3 Participants

Based on a priori estimation of sample size, we aimed to collect data from 230 participants. Participants were recruited from different sources, including the extended private and professional and social media networks via a link to the platform *Unipark*, where we implemented the survey. During the five weeks of data collection, 546 persons clicked on the start page, and 252 persons finished the whole questionnaire. Out of those, 56 participants had to be excluded because they failed the inclusion criteria, we determined in advance (e.g., German as a native language, working with digital media at least 30% of their time). In line with pre-registration, 18 participants, who failed the attention checks or check

questions (answers below 3) were excluded. The final sample consisted of 178 participants (see Table 5 for *n* per group) between 21 and 62 years (M = 38.02, SD = 11.98) with an average work experience of 13.42 years (SD = 11.72), 108 of them identifying as female. More than three-quarters of the participants have a degree from a university or university of applied sciences. Most participants work as teachers (20), 21.9% work in education and training, 14 % in the health sector, and 7.9 % either in IT or public administration and government. On average, participants work 38.79 hours per week (SD = 8.84) and spend most of their working time with digital media (M = 78.55%, SD = 21.26%, *min* = 30%). A large majority of the participants work from home at least partly (31 all the time, 101 partly), on average for 23.29 hours per week (SD = 12.85).

4.4 Measures

Digital communication and collaboration competencies. Participants answered the six-item short-scale measuring digital communication and collaboration competencies (see Study 1). The instructions for the scale were adjusted to the aims of the experimental groups. The scale showed good reliability across all experimental groups with Cronbach's α = .78.

Training motivation. We adopted the newly acquired KSAOs as learning outcome scale that Nikolova et al. (2016) applied successfully (originally developed by Taverniers, 2011). We changed the instruction slightly to fit our experimental design by asking participants about their intention to participate in training at work in the next six months ("In the next six months, at my workplace, I want to…") instead of past learning behavior. Additionally, we specified the formulation of the items to fit digital (communication and collaboration) competencies (e.g. "…develop new digital skills, which enable me to do my work more efficiently."). Participants were asked to answer each of the four items on a five-point Likert scale ranging from *1 = doesn't apply at all* to *7 = fully applies*. The scale has shown very good reliability with Cronbach's α = .91.

After the participants answered the digital communication and collaboration competencies short-scale and the scale measuring training motivation, we asked for their age, gender, job title, working hours, and digital devices that they use at work.

4.5 Results and Discussion

Table 5 provides the means and standard deviations of the different self-assessments of digital communication and collaboration competencies and training motivation according to the four experimental groups. On a descriptive level, participants in the future requirements within group obtained the highest ratings of digital competencies at T2 (M_{T2} = 5.79, SD_{T2} = .72), whereby participants in the social comparison group obtained the lowest ratings of digital competencies (M = 5.25, SD = .92). The highest level of training motivation was reported by participants in the social comparison group

(*M* = 3.82, *SD* = .83), while participants in the future requirements group reported the lowest level of training motivation (*M* = 3.57, *SD* = .94). Overall, we found a positive significant zero-order correlation between digital communication and collaboration competencies and training motivation across all four experimental groups, $r = .195$, $p = .0045$. The higher the workers estimate their digital competencies, the higher they rated their intention to train those. However, when estimated separately, this positive relation between digital competencies and training motivation could only be confirmed in the future requirements within group at T2 ($r = .395$, $p = .0035$), but not in the other groups. Notably, only the self-assessed current digital competencies in view of the future requirements at their job are significantly positively related to training motivation.

Table 5

Mean descriptives and differences between the experimental groups with regard to digital competencies and training motivation in study 2.

Experimental group	*n*	*M*	*SD*	*t(df)*	*p*	*Cohens d*
AV = Digital competencies						
Control group	43	5.43	.76			
Social comparison	47	5.25	.92	1.43(84)	.08	.31
Future requirements	47	5.23	.81	1.35(87)	.09	.29
Future requirements within T1	45	5.59	.65			
Future requirements within T2[a]	45	5.79	.72	-2.93(44)[a]	.0025*	|.44|
AV = Training motivation	183	3.72	.88			
Control group	44	3.75	.83			
Social comparison	43	3.82	.83	-.39(85)	.34	|.08|
Future requirements	46	3.57	.94	.96(88)	.17	.20
Future requirements within T1	45	3.77	.93	-.09(87)	.46	|.02|

Notes. $N = 178$. Digital communication and collaboration and work engagement were measured on a 7-point scale, training motivation was measured on a 5-point scale.

* $p < .025$.

[a] For the Future requirements within group a within t-test was used, comparing T1 with T2.

Digital competencies. To test H3, we compared the self-assessed digital communication and collaboration competencies at work in the control group with the self-assessment in the social comparison group using a t-test. We found no significant mean difference in the assessment, therefore rejecting H3, $t(84) = 1.43$, $p = .08$ *ns*, $d = .31$. Another t-test revealed no significant difference between

the control group and the future requirements group. Therefore, we did not find support for H4, $t(87) = 1.35$, $p = .09$ *ns*, $d = .29$. For the future requirements within group, we used a paired sample t-test to test if there are mean differences between the assessment of one's digital competencies with regard to current work requirements compared to with regard to future work requirements. Contrary to H5, we found that participants rated their digital competencies with regard to current work requirements significantly lower than their digital competencies with regard to future work requirements, reporting higher instead of lower competencies over time, $t(44) = -2.93$, $p = .0025$, $d = |.44|$.

Training motivation. We conducted a comparable series of t-tests to test our hypotheses about the differences in training motivation between the experimental conditions. Overall, we did not find systematic significant differences in the training motivation between the control group and the experimental groups (H6a, H6b). Workers in the control group did not assess their training motivation differently than either workers in the social comparison group (H6a), $t(85) = -.39$, $p = .34$ *ns*, $d = |.08|$, or workers in the future requirements group (H6b), $t(88) = .96$, $p = .17$ *ns*, $d = .20$. Contrary to H6c, we also did not find significant differences in the training motivation of the future requirements within group at T1 and the control group, $t(87) = -.09$, $p = .46$ *ns*, $d = |.02|$. Consequently, we did not find support for H7 as the statistically significant indirect effect of the experimental design on training motivation through the lowered ratings of digital competencies in the three experimental groups compared to the control group did not appear, $z = .11$, $p = .90$, 95%-CI[-.076-.058].

In Study 2, we targeted potential ceiling effects by experimentally testing varying instructions for the ratings on the scale. Against our expectations, our manipulations showed none of the expected effects for the assessment of digital competencies. We took two different approaches to close the knowledge gap in how workers can be triggered to assess their digital competencies more realistically: Social comparison and referring to challenging future work requirements. Despite our specific instructions with the aim to lower the self-assessments of digital communication and collaboration competencies at work, we found that workers still rated their digital competencies to be high in all groups. This result implies that the self-assessment of digital competencies seems to be fairly stable, and not majorly influenced by these specific instructions. However, unexpectedly, we found an effect in the opposite direction in the future requirements within group: When asked to first self-assess their digital competencies with regard to current and afterward with regard to future and more challenging work requirements, workers self-assessed their digital competencies higher over time. A possible explanation for this finding can be found in prior research on unrealistic optimism that shows people seeing their future (including their future competencies) unrealistically optimistic (Shepperd et al., 2013). This bias serves motives like self-appraisal to construct and maintain a positive view of oneself and self-enhancement (Guenther & Laudi, 2020). Especially for events that are in the distant future, and outcomes that are perceived as controllable, people are more likely to display such an unrealistic optimism (Shepperd et al., 2013).

Therefore, it could be that participants assessed their digital competencies with respect to future challenges more optimistically, because they included the idea of constantly improving their digital competencies, which is perceived to be under their control, already in their thought process, thereby overlooking the instruction to assess their current digital competencies with respect to future requirements. This is also supported by our findings that training motivation is high overall, too. Even though we did not find significant differences in training motivation of the workers based on the varying instructions for digital competencies, we found that workers, who estimated their digital competencies to be high also showed high intentions to train those, especially in the future requirements within group. Considering these findings, it seems plausible that the participants imagined improving those competencies constantly and therefore will be able to handle challenging requirements in the future. On the one hand, prior research showed that trainees with high motivation to learn were willing to improve their competencies and more likely to search for challenging tasks (Chung et al., 2021). On the other hand, feeling capable of one's own competencies is also beneficial as it fuels the drive to partake in developmental opportunities (Chung et al., 2021; Meske & Junglas, 2020). This could lead to an upward spiral of high digital competencies and high training motivation mutually promoting each other if workers get enough opportunities to further develop their digital competencies in the workplace.

4.6 Exploratory Analyses

To examine our collected data further, we explored the pre-registered research question of whether working from home has an impact on the estimation of digital competencies. In detail, we used a one-way ANOVA to test for potential differences in the self-assessment of one's digital competencies depending on the extent of currently working from home in three groups: working from home every day, never working from home, and working from home and the office, each some days. We found that the estimation of one's own digital communication and collaboration competencies differed significantly for the different extents of currently working from home, $F(2, 174) = 4.35$, $p = .014$. Subsequent Tukey post-hoc analyses revealed that participants, who are working from home every day ($n = 31$, $M = 5.75$, $SD = .70$) assessed their digital competencies significantly higher than participants who never work from home ($n = 45$, $M = 5.19$, $SD = .83$, $p = .01$, 95%-CI = [.11,1.01]). Moreover, we found a significant positive correlation between digital competencies across all groups and the percentage of work time spent with digital media ($r = .229$, $p = .002$). Workers who spend more time with digital media during their workday also assessed their digital communication and collaboration competencies to be higher. However, we did not find significant correlations between digital competencies and age or digital competencies and gender. The finding of workers assessing their digital competencies independently from their age and gender seems especially interesting for organizations for potential applications in practice.

5. General Discussion

Although prior research has started to address the under-studied area of digital competencies (e.g., Murawski & Bick, 2017), empirical studies and measurement instruments for the work context are still scarce. With this research, we add to both, the theoretical development of the construct of digital communication and collaboration competencies at work on the one hand and practical applicability on the other hand. Building on the initial scale development of Oberländer and Bipp (2022), we demonstrated the reliability of a short-scale measuring digital communication and collaboration competencies at work across different samples of German workers. In detail, our results provide evidence for a reliable and valid short-scale measuring digital communication and collaboration competencies at work. The scale is valid for white-collar workers with various levels of digital communication and collaboration competencies and offers a fast and functional tool to measure these essential competencies. Furthermore, we shed light on the nomological net of the understudied construct, as we were able to demonstrate crucial relationships with two related, yet distinct constructs in terms of face-to-face communication and computer efficacy. However, contrary to our expectations, we found that different instructions on how to answer the scale in terms of social comparison or future work requirements did not show the expected effects on the self-assessment of digital communication and collaboration competencies. Nevertheless, independent of the varying instructions on the assessment of digital competencies, we found that training motivation of the participating workers is stable and high and positively associated with digital competencies at work.

5.1 Practical and Theoretical Implications

The resulting six-item short-scale measuring digital communication and collaboration competencies at work, that we validated and investigated in this current study, inherits both practical and theoretical implications. Concerning theory, our findings provide evidence for the uni-dimensionality of digital communication and collaboration competencies at work, measured by the six-item short-version. Furthermore, we were able to demonstrate construct validity as the short-scale is significantly correlated with face-to-face communication and computer efficacy, but is also clearly distinguishable from these related constructs. As such, our findings provide the base for much-needed theory building in the field of digital competencies at work. In particular, our findings suggest that it is necessary to take a close look at existing models and measurement instruments that have been suggested for the construct of digital competencies (e.g., Guzmán-Simón et al., 2017; Janssen et al., 2013; Oberländer & Bipp, 2022). Therefore, we hope this research contributes to the expansion of theory building on digital competencies at work and fosters more research in this under-studied area. Beyond that, we were able to show that digital communication and collaboration competencies at work are linked with training motivation at work. This finding adds to the vast literature on training motivation and its

antecedents in the work context. In their meta-analytic review, Chung et al. (2021) found mixed results in their category knowledge and skills influencing training motivation: While they found a negative link between cognitive ability and motivation to learn, education showed a significant positive relationship with the motivation to learn. It is therefore in line with these prior findings, that we found high training motivation in our highly educated sample. In line with this model, we argue that self-assessed digital communication and collaboration competencies could be important antecedents including knowledge, skills, and abilities that are beneficial for training motivation, especially in the digital age. Therefore, further expansion of the theory on training motivation might consider digital competencies as possible antecedents in digital learning environments.

For practice, the validated short-scale does not only save completion time compared to more lengthy measures but also reduces the burden on respondents and thus improves further commitment of participants. These are advantages for researchers using diary formats or large-scale surveys and practitioners dealing with impatient participants at work, alike. For example, Ohly et al. (2010) suggest that daily assessments in a diary format should not exceed five to seven minutes, and short scales should be preferred. Beyond that, our short-scale is free and available for researchers and practitioners to use and can provide important insights, during and after the pandemic, about the state and impact of digital communication and collaboration competencies at work. One notable advantage of the scale is that it does not test the knowledge of employees about specific tools or current technologies that might differ to a great degree between jobs, or change over time. Therefore, the chances that the assessment tool will outdate in the future is rather low. In addition, our short-scale builds upon self-report of these competencies across different (white-collar) occupations in general and hence, there does not seem to be the need to adapt the scale to specific settings.

When workers were asked to assess their digital communication and collaboration competencies with respect to future requirements after they were asked to rate their digital competencies with respect to actual requirements, they gave significantly higher estimates. This yields the practical implication that the effects of assessing competencies should also be kept in mind as workers may think these competencies are important if they are asked about them more often, which might lead to self-enhancement tendencies. Moreover, as the self-beliefs about one's competencies are important for behavioral outcomes (Huang, 2011), the digital communication and collaboration competencies scale could be used to evaluate if workers need to enhance their self-efficacy before they can fully cherish developmental opportunities. More general, Carver et al. (2021) found that self-assessments can help obtain a representation of one's performance that is more accurate and ultimately helps to better accept feedback. Therefore, in the context of personnel development or 360-degree feedback systems, this scale might provide useful insights, too.

Following the call of Colbert et al. (2016), we meet the need for more research on digital competencies on the one hand and the need for potential practical applications on the other hand. With our results, we provide a basis for research that explores the variance in digital competencies and how this affects collaboration and communication in the digital workforce in research and practice. For example, Yee (2014) argues that task completion in digital teams functions best with team members possessing complementary competencies and a leader with managerial competencies. Based on these results, it could be beneficial in practice to measure digital communication and collaboration competencies at the workplace to form digital teams with complementary competencies that succeed in the digital work environment. Beyond that, our scale offers the opportunity to measure intraindividual differences over time in digital communication and collaboration competencies. This could be used to gather more information on the malleability of the digital competencies of workers, for example through training interventions, over time.

5.2 Limitations and Future Research

Despite the strengths of our research, which are, among others, the multi-study and experimental design in high-powered, diverse samples of workers, we have to note several limitations that suggest directions for future research in this area. As the measurement of digital communication and collaboration competencies at work is completely based on self-reports, this implies the risk of common method bias. At the same time, this offers the advantage of using their introspection to get useful information about their self-concept (Huang, 2011) and attitudes (McCourt Larres et al., 2003) or promote self-reflection on one's performance, for example. Prior research has shown that the self-assessment of competencies is more relevant than objectively measured competencies for important outcomes, such as making critical life choices or shaping professional interests (Neubauer & Hofer, 2021; Zell & Krizan, 2014). In addition, it also seems to be important how the workers themselves assess their digital communication and collaboration competencies for their training motivation as well, even though, we did not find significant effects of the varying instructions on ratings of training motivation in this research. However, prior research has shown an influence of the internal attribution of learnings, such as the belief to be able to achieve the learning goal, on the motivation to learn (e.g., Chiaburu & Harrison, 2008; Chung et al., 2021; Wang et al., 2008). Therefore, future research could investigate if the self-assessment of digital communication and collaboration competencies influences the motivation to learn important new competencies at work, especially in an online learning environment. Also, future research could explore other methods to help workers gain a realistic assessment of their digital competencies. For example, different approaches to promoting specific comparisons with others or one's own past performance have been shown to show strong criterion-related evidence of validity, even though those were experienced to be more demanding (Carver et al., 2021; Freund & Kasten, 2012). Another approach that has been applied successfully to reduce potential over-estimation of one's own

competencies could be used by instructing workers to elaborate on ideal (future) competencies first and afterward, self-assess the actual (expected) competencies (Tanner & Carlson, 2009). Additionally, more research on other influencing factors, such as the familiarity with the competencies of the comparison target, motives behind, and relevance of the self-assessment is needed (c.f. Goffin & Olson, 2011).

Beyond that, future research must examine the predictive validity of the digital competencies scale for other important outcomes in the workplace, such as competency-based performance or training participation. Barley et al. (2011) found that the more time employees spent handling e-mails, the greater they felt overloaded. However, they did not consider the individual digital communication and collaboration competencies of the employees, which might bring new insights to the field of occupational health and well-being at work. It might be that these competencies function as individual resources helping to deal with the particular demands of the digital workplace. However, such a potential moderating role of digital communication and collaboration competencies needs to be examined on different levels (e.g. daily work level, or longitudinal effects), as prior findings on the construct in question do not seem to support a direct motivational effect in times of crisis (Oberländer & Bipp, 2022).

Moreover, digital communication and collaboration competencies combined with the motivation to train those might be highly beneficial for acquiring other helpful competencies to master the challenges of the workplace. Trenerry et al. (2021) propose digital competencies and engagement in learning to be essential factors to cope with digital transformations at work that change the core of how we work. To understand the underlying processes better, more research is needed to examine how digital communication and collaboration competencies and training motivation facilitate self-directed online learning, for example.

Additionally, practitioners, as well as researchers, could profit from further studies aiming to validate the measurement at hand translated into other languages. Empirical support for an equivalent cross-cultural measurement (van de Vijver & Tanzer, 2004) of digital communication and collaboration competencies is still missing, as the available questionnaire was only validated with German-speaking workers so far. Furthermore, the empirical development of norm values for different jobs or branches is needed, so that the competencies of individual workers can be evaluated in comparison to a relevant group with similar tasks and challenges at work. As we expect the competencies needed at the workplace to change constantly, research about the circumstances of the wider change process could offer important information for theory development and management in practice alike.

5.3 Conclusion

In sum, we validated a short-scale measuring digital communication and collaboration competencies at work and found a positive relationship between those and training motivation in the current study. In using multiple heterogeneous samples, and a combination of mixed empirical methods,

we offer a solid theoretical and empirical base to foster research on digital communication and collaboration competencies at work and possible applications in practice.

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Table A

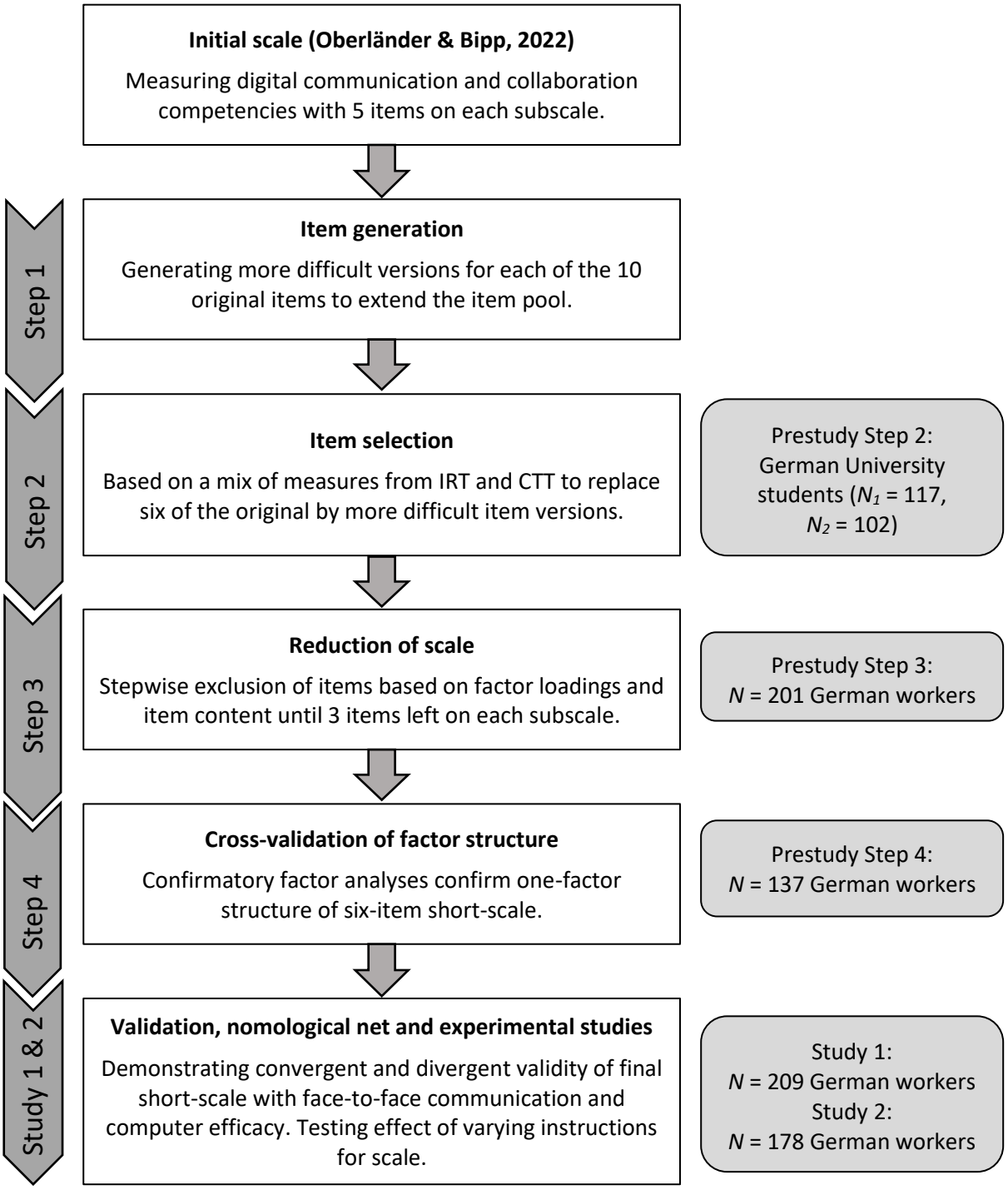
Means (M), standard deviations (SD), and results of mean difference tests between original and difficult items (translated to English) in prestudies.

	Original Items			Difficult Items			Mean Difference	
	Item description	*M*	*SD*	Item description	*M*	*SD*	*t(df)*	*p*
K1	I know what kind of communication I have to choose in different situations at work.	5.51	1.23	**+ I always know what kind of communication I have to choose in different situations at work.**	5.08	.98	2.07(*103*)	.04*
K2	**The usual manners in digital communication are unclear to me. (r)**	5.22	1.50	I adopted the wrong tone in my digital communication before. (r)	5.10	1.46	.46(*115*)	.64
K3	I use appropriate language when communicating online.	6.11	.91	**I use impeccable language when communicating online.**	4.48	1.31	7.76(*97*)	.00**
K4	**+ I can adjust my writing style to the digital medium and occasion.**	6.19	.79	I can communicate efficiently in every work situation.	5.58	.86	3.92(*115*)	.00**
K5	I am good at choosing the right moment for a digital message.	4.71	1.08	**+ I am very good at choosing the best possible moment for a digital message.**	4.20	1.17	2.42(*115*)	.02*
Z1	I know numerous technologies that facilitate my collaboration with colleagues.	5.92	.94	**I know numerous technologies that facilitate my collaboration with colleagues in every detail.**	4.20	1.55	6.84(*89*)	.00**
Z2	I cannot collaborate efficiently with my colleagues via digital media. (r)	5.55	1.17	**I do not always manage to find the most efficient way to collaborate with my colleagues. (r)**	3.88	1.49	6.27(*95*)	.00**
Z3	**+ I like to use digital media to collaborate more efficiently with colleagues.**	5.66	1.47	I love to use digital media to collaborate more efficiently with colleagues.	4.58	1.27	3.99(*100*)	.00**
Z4	**+ I can obtain work-related information quickly using digital channels.**	5.89	.86	I can obtain work-related information via digital channels at any time as quickly as possible.	5.36	1.25	2.54(*100*)	.01*
Z5	I can also collaborate with others online.	5.92	.99	**+ I can collaborate online with others just as well as face-to-face.**	3.84	1.51	8.19(*82*)	.00**

Note. (r) = reversed item. **Bold** items were selected in step 2 for 10-item version of the scale.
+ final six items of the short-scale.
**p < .05, **p < .01.*

Figure A

Overview of steps taken in the development of the digital communication and collaboration competencies scale.



Chapter 5 – General Discussion

In the following, I present a brief overview of the major research topics of this dissertation with the main focus on the investigation of the construct of digital competencies at work. Following the research aims and questions, a literature review, eleven qualitative interviews, and eight empirical data collections, including a repeated measures design and an experimental manipulation study, were conducted. The respective findings were channelled into three papers.

(1) By providing an appropriate framework and comprehensible descriptions of basic dimensions for digital competencies at work, a solid theoretical base to foster further research and expand theory building on this topic is implemented. The general understanding of digital communication and collaboration competencies as relevant dimensions of digital competencies at work is enhanced by providing clear definitions.

(2) With the development, refinement, and validation of the scale measuring digital communication and collaboration competencies at work, a free, feasible, valid, and reliable measurement tool is available in German language.

(3) The demonstration of discriminant and convergent validity of digital communication and collaboration competencies at work yields valuable insights into the nomological net of the construct.

(4) The role of digital communication and collaboration competencies as potential resources, and part of a potential gain spiral, boosting work engagement during the pandemic were investigated. This provides important information on digital competencies at work, resources, motivation, and the interplay of these variables in times of crisis.

(5) Testing varying instructions on the self-assessment of digital communication and collaboration competencies in an experimental setting and exploring the effects on training motivation implies a stable and positive self-assessment of digital competencies that is associated with a high motivation to train those.

In the following sections, I summarize the main results of the studies included in this dissertation and discuss these with regard to the research topics. In the integrated discussion of this dissertation, limitations are addressed and avenues for future research building on the present findings are outlined. Finally, I set out theoretical and practical implications and sum it up with an overall conclusion.

1. Main Findings

To address the need of gathering more scientific knowledge on digital competencies at work, expressed by different researches (e.g., Janssen et al., 2013; Murawski & Bick, 2017), an extensive review of the literature and interviews with practitioners were conducted in Paper 1. The initial analysis of the literature revealed that empirical studies on digital competencies of workers were limited, even though a variety of frameworks and definitions were proposed in different research streams. The literature review as well as the answers of the interviewed professionals supported the assumption that there are common basic digital competencies needed at most office workplaces to accomplish daily tasks. Clustering statements from both sources resulted in a framework of digital competencies at work encompassing 25 dimensions that cover a broad range of knowledge, skills, abilities, and other characteristics (Krumm et al., 2012) needed for completing digital work tasks. Following the aim to strengthen a common understanding of the concept in further research and application in practice, I formulated a definition of digital competencies at work. Furthermore, in an effort to shed more light on two particularly relevant competencies at work nowadays, digital communication and collaboration were defined in Paper 2. By integrating different perspectives, an up-to-date view on the concept of digital competencies is provided, channelled into a comprehensive and broad framework and definitions with a focus on the work context.

The elaborate development of a short-scale measuring digital communication and collaboration competencies at work that is based on the findings of an extensive literature review, insights of practitioners, and empirical studies in eight different samples, spans all three papers included in this dissertation. In a first attempt to measure the constructs, an initial questionnaire was developed based on the proposed framework and definition of digital competencies at work. Noteworthy, the study in Paper 2 used mixed methods and combined approaches from *Classical Test Theory* and *Item Response Theory* and provided satisfactory results on the internal factor structure. However, further studies showed consistent findings of high mean values indicating a lowered precision in measuring medium to high levels of digital competencies. Therefore, the initial scales were refined and a more feasible six-item short version was developed. The reliability of this short-scale is demonstrated in Paper 3. The resulting fast and functional short-scale measuring digital communication and collaboration competencies at work makes contributions to practical applications and theory alike. The new short-scale is valid for office workers with any level of digital communication and collaboration competencies and is freely available to use. While studies with the new short-scale showed a slightly broader range in the mean values, possible ceiling effects cannot be excluded. These results are in line with prior research showing that competencies, abilities, and skills tend to be over-estimated in self-assessment (Schulze et al., 2017; Zell et al., 2020). Using another approach to address the potential ceiling effects, an

experimental study was conducted to investigate the research question of whether varying instructions for the self-assessment of digital competencies would tackle the potential overestimation of those in Paper 3. Thereby we built on findings from prior research on improving the consistency of ability self-assessments with instructions for social comparison (Freund & Kasten, 2012; Zell & Strickhouser, 2020). Unexpectedly, the results showed no differences in the self-assessment of digital communication and collaboration competencies depending on the instructions on how to answer the scale. Neither the instruction to social comparison nor to focus on future work requirements led to a lower self-assessment of digital competencies at work, and the restricted ranges of the mean values remained. Furthermore, the varying instructions on the self-assessment of digital competencies did not affect training motivation either. However, overall workers' self-assessed motivation to train their digital competencies remained stable and high, indicating that the workers were highly motivated to learn and develop. This is in line with prior findings on high training motivation in highly educated workers (Chung et al., 2021), which resembles the results of our studies with high levels of formal education in all samples.

To extend insights into the nomological net of the so far under-studied construct of digital communication and collaboration competencies at work, the relation with similar constructs was examined. The results, depicted in Paper 3, demonstrate convergent and discriminant validity, supporting the assumption that digital communication and collaboration competencies were moderately related to but empirically distinct from face-to-face communication and computer efficacy, respectively.

Besides the development and scientific establishment of digital competencies at work as a construct in the field of industrial and organizational psychology, I also focused on the relations of digital communication and collaboration competencies with important work outcomes in this dissertation. The research question of whether digital communication and collaboration competencies play a role as potential resources in the well-established *Job Demands-Resources model* (Demerouti et al., 2001) and boost work engagement in times of crisis was investigated. Consequently, an empirical study with a repeated measures design was realized during the beginning of the COVID-19 pandemic. However, unlike assumed, digital communication and collaboration competencies did not act as personal resources boosting work engagement during the pandemic. Additionally, this study did not show supporting results for the job resource social support boosting work engagement contrary to established findings of this effect in a large amount of studies before the pandemic (e.g., Halbesleben, 2010; Nielsen, 2017). The study results neither provided evidence for personal and job resources influencing each other over time in terms of a gain spiral, nor effects between work engagement and job or personal resources over time. Instead, the mainly office-based workers maintained high levels of digital communication and collaboration competencies and work engagement during the pandemic. Additionally, we found that the self-assessed digital competencies and work engagement were significantly related at each point of measurement. Moreover, the investigation of motivational effects

in the experimental setting in Paper 3 showed that workers who assessed their digital competencies to be high also indicated high motivation to train those over all groups. This supports prior findings indicating that self-assessments can promote intrinsic motivation and enhance learner engagement in digital environments (Gikandi et al., 2011; A. C. M. Yang et al., 2022) and findings of a significant relationship between self-assessed competencies and motivation in distance learners (Wang et al., 2008). With this research presented in Papers 2 and 3 of this dissertation, the gap of studies devoting attention to possible associations of digital competencies with relevant work outcomes was addressed.

2. Limitations and Directions for Future Research

This dissertation has several strengths and makes remarkable contributions to theory and practice in terms of theory building, scale development, and exploration of the nomological net of a highly relevant construct: digital competencies at work. However, some limitations must be taken into consideration when interpreting the findings presented in this dissertation. In this section, I address general and overarching aspects regarding the conceptual and methodological issues of this dissertation and outline avenues for future research.

Although this research presents a systematic and elaborate effort to provide a valid and reliable short-scale measuring digital communication and collaboration competencies at work efficiently, the assessment is solely based on self-report data in all studies. On the one side, the use of self-report data comes with advantages: information on how someone sees their own competencies provides insights into their inner perceptions and self-concepts (Huang, 2011). As a result, self-assessment can promote intrinsic motivation, confidence, and self-efficacy for engagement and learning (Gikandi et al., 2011; Schunk, 2012; A. C. M. Yang et al., 2022). This, in turn, influences future behaviour and shapes essential life choices, like the decision to apply for challenging job positions, pursue one career over another or invest time and resources to attend training (Freund & Kasten, 2012; Neubauer & Hofer, 2021; Zell & Krizan, 2014). For example, Yan (2019) showed that self-assessment promotes self-reflection on one's performance, which influences feedback-seeking behaviour that in turn, positively predicts academic achievement. On the other side, the reliance on self-report data in research also brings limitations to the findings such as the risk of common-method bias (Podsakoff et al., 2003) or subjectivity (Hoyt, 2000). Concerning prior studies on the self-assessment of abilities and competencies (e.g., Freund & Kasten, 2012) and the results of the studies included in this dissertation constantly showing ceiling effects, it can be assumed that at least some of the participants may have overestimated their digital competencies. Therefore, future studies could enhance explanatory power and complement the findings at hand with additional measures including other-ratings by colleagues and supervisors. However, it has to be noted that other-ratings can be biased, too (Hoyt, 2000; Viswesvaran et al., 2005). For example, the limited

insights of others on inner processes and thoughts, a limited number of incidents where the behaviour was observed, common biases in other-ratings like the halo effect, or restricting environments could hamper the assessment of others' competencies (Hoyt, 2000). Additionally, it oftentimes seems elusive to find objective outcomes that are sound indicators of the underlying competencies, but if they are not, validity is compromised (Schulze et al., 2017). Some of the problems could be eliminated by combining multiple other-ratings in 360-degree-feedback systems or by the use of performance tests like work samples in future studies. Moreover, systematically contrasting self-assessments and other measures of digital competencies at work in future studies could shed light on this issue and enrich the knowledge about the construct. Additionally, organizations could benefit from the scientific development of alternative situation-specific measures of digital competencies to supplement the rather general self-assessment scale, such as simulations of tangible challenges at the workplace. Beyond that, future research on other factors influencing the assessment of digital competencies and the effects on important work outcomes is needed. Research questions investigating additional factors that potentially influence the self-assessment of digital competencies, such as the motivation behind the self-assessment or the relevance of the assessment to the person, should be investigated (e.g., Jansen et al., 2022; Tsai, 2010).

Another limitation of this dissertation refers to the generalizability of the research findings. Although this dissertation provided evidence for the validity of the scale, further studies with larger sample sizes and different populations would help to establish the utility and validity of the scale. Most studies included in this dissertation were restricted to white-collar workers spending substantial parts of their working time with digital media. Especially, since digitalization also alters tasks in production, the boundaries between typical blue- and white-collar jobs blur (Waschull et al., 2022). Hence, many blue-collar workers are facing new challenges as well as opportunities requiring digital competencies to succeed. Future studies examining different groups of participants, such as blue-collar workers, or aiming at large samples that are representative of the whole workforce, would contribute to a deeper and more comprehensive understanding of the concept, and improve external validity of digital competencies. Building on that, norm values for different populations based on jobs, branches, educational background, or age would allow for better estimation of individual digital competencies and offer a practicable guiding frame in practice.

While narrowing the population to a more homogenous cohort facilitates drawing coherent conclusions, the sample composition could also be an explanation for the ceiling effects found. As all studies were conducted online, the participation was voluntary, and the subject of the studies – digital competencies – was not concealed in the recruiting of participants or during the studies, a self-selection bias could have contributed to the above-average self-assessments. Future studies investigating cohorts of workers that are not based on self-selection or using alternative recruiting techniques could add value and increase the generalizability of the results. Moreover, the scale for digital communication and

collaboration competencies was validated with German-speaking workers in the studies of this dissertation. This limits the areas of application in further research and practice. Yet, this opens a research avenue for future studies to translate the scale into other commonly used languages and test reliability and validity in other cultures.

Besides the strengths of this research, such as the unique timeframe and timely research topic, we have to note that the findings might be partly limited to special working conditions during the peak of the pandemic. Other factors influencing the findings of the studies, such as blurred work-family boundaries, increased job insecurity, or social isolation cannot be ruled out. However, although the future of work is difficult to predict, the pandemic likely caused some permanent changes in the way we work (Kniffin et al., 2021), making the findings in this dissertation that reflect the new normal even more valuable. Furthermore, a multitude of study designs were used to cumulate manifold insights on digital competencies at work throughout this dissertation. Yet, a longitudinal design would allow causal statements about the associations between digital competencies and other study variables and directions of effects. On top, results from a longitudinal study covering a larger time frame would add knowledge to the stability of the construct over a longer period and in changing work environments. Research questions such as whether different patterns in digital competencies at work occur over time comparing experienced workers to newcomers could be explored.

Even though a great step towards construct validation was made in this dissertation, by demonstrating convergent and discriminant validity and identifying outcomes, the nomological net of digital communication and collaboration competencies needs to be explored in greater detail, taking into account variables on the individual, group, and organizational level. Further research questions on digital competencies could evolve around individual differences in learning behaviour and job satisfaction on the individual level (Mason & Brougham, 2020; Xanthopoulou et al., 2012). On the group level, the investigation of digital competencies in social networks and with team innovation could give interesting insights (Chen et al., 2013; L. Yang et al., 2022). On the organizational level, future research could explore the role of digital competencies in work design, organizational culture and support, or strategic human resource management (e.g., Allen et al., 2015; Meske & Junglas, 2020; van Laar et al., 2020b). In the framework of digital competencies at work, 25 dimensions were proposed. Although the dimensions are thought to be interconnected, the interdependencies between the proposed dimensions or the extent to which they overlap have not been investigated yet. Factorial analysis is necessary to explore potential overlap and if not available yet, measurement tools for the dimensions need to be developed and validated, too, so that reciprocal relationships can be investigated and digital competencies can be further explored as a broad and multi-faceted construct. Moreover, further systematic research on the construct of digital competencies is urged to expand existing knowledge about possible effects on relevant work outcomes. Another timely topic of research would be the

exploration of the role of digital competencies in the health impairment process outlined in the *Job Demands-Resources model*, preventing burnout and stress at work (Britt et al., 2020; Demerouti et al., 2001). Persistent insufficient levels of digital competencies, for instance, could act as excessive demands at work leading to burnout and stress. Moreover, according to the *Job Demands-Resources model*, resources contribute to the achievement of work goals on the motivational path outlined by the theory (Bakker & Demerouti, 2008). Even though the findings did not provide evidence for digital communication and collaboration competencies boosting work engagement as personal resources, these competencies could play a mediating or moderating role in the context of digital learning at work, influence goal achievement, or act as buffers against burnout or stress at work (Bakker & Demerouti, 2008). Further research could contribute to the extension of the *Job Demands-Resources model* by exploring potential roles of competencies in detail.

In this dissertation, it was found that workers with high levels of digital competencies were also highly engaged and motivated to further expand their digital competencies. However, the direction and quality of this relationship remain unclear. Future studies are thus urged to pursue the research question of whether digital competencies at work are antecedents of motivation at work. Especially in a digital work environment, digitally competent workers in communication and collaboration could be more confident to partake in training and show motivation to engage in complicated work tasks that involve the use of digital media. Therefore, the predictive validity of digital communication and collaboration competencies at work in terms of motivation needs to be investigated further.

3. Implications and Outlook

Despite the aforementioned limitations of the presented research offering opportunities for still much-needed further studies on digital competencies at work, the conducted research has theoretical and practical implications.

3.1 Theoretical Implications

In providing clear definitions and empirical evidence for construct validity of digital competencies at work, and the two inter-twined dimensions communication and collaboration, this research promotes a common understanding and offers a guiding structure to unravel the diverse prior conceptualizations of digital competencies at work. A common understanding of the construct is the basis to convey comprehension and encourage dialogue within science and stimulate knowledge transfer between science, politics, and practice, for example. This research thus serves the demand for more systematic approaches and a generally applicable concept of digital competencies (e.g., Murawski &

Bick, 2017). The solid foundation for much-needed further theory building and extension in this field, provided by this dissertation, may guide research efforts aimed at empirically investigating potential gain spirals of different dimensions of digital competencies at work, fostering each other and additional relevant resources. The findings of this research support the conceptualization of digital competencies at work as a multi-faceted construct. The provided framework contributes to a more exhaustive examination of specific dynamics and processes caused by and related to digital competencies at work. As broad competency models were not available so far (Schulze et al., 2017), the proposed framework offers many opportunities for future research investigating the scope and structure of digital competencies at work. This dissertation addresses the need for more scientific research on the digital competencies of working adults and the aim to enhance the conceptualization of digital competencies through added knowledge.

The reliable and valid measurement tool of digital communication and collaboration competencies at work forms the basis to further explore the variance in individual digital competencies over time. The developed scale allows the exploration of the changeability of digital communication and collaboration competencies through systematic training. Generally, extending the knowledge of when which digital competencies at work are especially relevant for whom is essential to keep pace with the fast-growing demands of modern work environments (Trenerry et al., 2021). From a scientific perspective, it is important to gain a deeper understanding of which digital competencies are required in which work or team settings to build specific competency models that could be useful for research on personnel selection and training, or work design (Krumm et al., 2012). With the possibility to measure the digital communication and collaboration competencies at work, the short-scale developed in this dissertation can be used to assess relationships with possible antecedents and outcomes, adding empirical evidence to the theoretical knowledge. In particular, the refined short-scale offers the advantages of shorter completion time and less burden on participants due to the smaller number of items. These advantages can be exploited in large-scale data collections, diary formats with multiple measurement times, and to persuade participants who have little time or who are impatient. Since the scale was developed on base of digital communication and collaboration competencies, needed at most office workplaces currently and in the future, and since the scale was validated with workers from different occupations and branches, the items are unlikely to become obsolete and do not need to be attuned to certain jobs or settings.

The findings in this dissertation imply digital communication and collaboration competencies at work be stable over time, even in times of crisis. Moreover, this research showed that the self-assessment of those competencies was not easily influenced by varying instructions. The studies in this dissertation contribute evidence that those much-needed assets in the workforce remain high and cannot be reduced easily, not even during a crisis. Noteworthy, the results also imply a stable and positive motivation of

workers to train their digital competencies that was not easily influenced. Additionally, another implication concerning motivation is that office workers remained highly engaged at work even during the pandemic. These findings are crucial for research on training or personnel development and can contribute to future research inspecting training modalities, for example. High training motivation cannot be induced easily but is a prerequisite for training success as it enhances engagement with the training material, study time, and training transfer (Bell et al., 2017; Chung et al., 2021). In addition, this dissertation provides first empirical evidence of the association between digital communication and collaboration competencies at work and training motivation. Workers who indicated higher levels of digital competencies also showed higher motivation to train those. These findings provide new evidence that could advance theories on training motivation and its antecedents at work. In line with the model on training motivation proposed by Chung et al. (2021), workers' self-assessed digital competencies could be antecedents enhancing training motivation in digital work environments.

Moreover, the findings on digital competencies could enhance theories in other fields of research about the effects of digitalization at work. As most previous research focused on employees who volunteered to work remotely, the studies in this dissertation used mixed samples including voluntary and involuntary remote workers. Thereby, this research contributes to expanding knowledge in the field of remote work. Prior studies on technology adaption found that workers are more likely to use and accept new technologies when the use was voluntary (Lee et al., 2003). However, workers with high digital competencies might decide to try and use innovative technologies at work and might feel more confident to be able to handle those technologies than workers who rate their digital competencies to be rather low. This assumption is in line with recent research on digital workplace transformation stressing the importance of feeling digitally competent for workers to fully embrace opportunities offered by technology and to explore those (Meske & Junglas, 2020). Workers' responses to new technologies can shape important work outcomes and alter work design, when the use of those technologies is changed due to mistrust or lacking competencies, for example (Wang et al., 2021). Thus, exploring the self-assessed digital competencies of workers could open new perspectives to the research on technology adaptation and facilitate digital transformation at the workplace, too.

Another interesting field of research that could profit from the present findings on digital competencies is communication. Theories from the beginning of research on digital communication, for example on media richness postulate that media channels can be classified according to the number of social cues that can be conveyed in communication using this channel (Daft & Lengel, 1986). For instance, face-to-face conversations are richer than instant messaging as the latter channel lacks nonverbal cues such as gestures and contextual information such as the surrounding in which the message is received. However, more modern theories, like the social information processing theory (Walther, 2016), advanced this approach by including increasing skill levels over time as a relevant

factor to improve digital communication. The scale developed in this dissertation enables the exploration of various levels of digital communication and collaboration competencies and could be used to add knowledge in this field. While modern work settings, such as remote work practices, can deprive workers of the choice of the appropriate communication channels (L. Yang et al., 2022), it is even more relevant that they know what kind of media to use to converge on the meaning of information versus to communicate complex ideas. Fortunately, knowing what kind of media to use makes an integral part of being digitally competent according to the definition and scale provided in this dissertation. Consequently, even though more intuitive designs of technologies would facilitate (digital) communication for all workers, further expansions of theory in this field could profit from taking individual differences in digital communication competencies into account.

3.2 Practical Implications

Besides theoretical implications, the present research offers a range of opportunities for application, too. Overall, the present dissertation emphasizes the importance to give attention to digital competencies at work, especially in fast-changing digitalized workplaces. The framework of digital competencies at work can serve as a supporting tool for personnel selection processes as well as a guide for training initiatives. For example, managers could identify the needed digital competencies for a certain job position that are likely to play a role in mastering anticipated challenges in the future. Likewise, existing training programs to improve single skills or abilities may be optimized to train the competencies that future workers need to obtain to handle potential obstacles at their job positions competently. Similarly, training programs introducing specific software or hardware used at work can be adjusted to the level needed. In addition, prior research showed that a selection process that is based on the competencies of the applicants offers broader options for personnel development than a personality-based selection process (Hertel et al., 2006). The identification of digital competencies as potentially relevant variables in digital work environments in the present research implies that digital competencies should be taken into account in selection processes and recruiting strategies of organizations.

On an organizational level, digital competencies should be included in the specific competency models of organizations as key factors for the future development and innovative capabilities of employees and organizations (Campion et al., 2011). These competency models can be used as a guiding frame for decisions on selection, training, promotion, and compensation, for example (Krumm et al., 2012). In combination with the clear definitions proposed in this dissertation, the competency models can be used to establish general wording around digital competencies in the organization and to align the corporate strategy to relevant competencies in the future.

In human resource development, the developed measurement tool facilitates the identification of the developmental potential in the workforce. Knowing specifically which competencies individual workers lack, allows more specific conversations about developmental opportunities with those workers on the one hand and the development and implementation of more efficient and effective vocational training tools, on the other hand. Furthermore, adding training to develop these specific digital competencies could enhance talent management programs and facilitate succession planning. Additionally, identifying the digital competencies that job applicants need at work could improve the curricula of established vocational education or training programs. From the perspective of individual workers, the identification of fields with developmental potential, especially with self-assessment tools, can foster the motivation to educate themselves, trigger formal as well as informal learning, and increase training transfer (Bell et al., 2017; Tannenbaum & Wolfson, 2022). Furthermore, keeping track of the digital competencies of existing employees seems especially important amid the shortage of specialists (Kauffeld & Frerichs, 2018). On a strategic level, measuring digital competencies allows for adapting flexibly to new requirements and acting adequately, even in the face of uncertainty in dynamic work environments.

This research found a link between digital communication and collaboration competencies at work and training motivation. This is in line with prior research findings, showing that workers are more likely to partake in training when motivated to further develop at work (Mason & Brougham, 2020; Meske & Junglas, 2020). Taken together with the prior findings, this implies that office workers are likely to seek out opportunities to train their digital competencies and prepare for challenging demands posed by fast-changing work environments. Findings in this dissertation also show a positive correlative relationship between digital communication and collaboration competencies at work and work engagement. Overall, this indicates that office workers with high levels of digital competencies are likely to be engaged at work and motivated to learn and develop.

Digital communication competencies become vital for the future workforce that will be working remotely for essential parts of their work time. L. Yang and colleagues (2022) found in their recent analysis of communication in organizations, that especially informal communication networks are integral to the success of organizations and workers' careers. However, this setting is still less challenging as workers can leverage existing network connections that were built in person and take them online compared to workers starting their careers in remote settings, who have to build their professional networks from scratch. Yet, high levels of digital communication competencies could mitigate some negative effects on workers. As a practical implication, it can be concluded that office workers need to maintain a certain level of digital communication competencies to benefit from network support.

4. General Conclusion

As the work environments continue to change, the required competencies to succeed in these modern workplaces gain even more importance. In this dissertation, I provide a comprehensive framework and definition for digital competencies at work that is a solid base to foster more research, extend the scope of the construct, and incorporate it into broader areas of work and organizational science. Besides the opportunity to measure digital communication and collaboration competencies at work with a valid and reliable short-scale, the diverse methods applied in this dissertation add initial evidence on the nomological net of the construct and provide in-depth knowledge about workers' self-assessment of digital competencies. The results of this dissertation highlight the relevance of digital competencies in challenging modern work environments and offer fruitful research avenues to further increase our knowledge on this important topic in research and practice.

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Personal Contribution to the Publications of This Dissertation

Hereby, I declare that I have not submitted or had not submitted this dissertation in any form to another faculty.

Further, I certify that I have written this dissertation independently and without unauthorized assistance, that I have used only the sources indicated, and that I have indicated text passages taken verbatim or in spirit from the literature.

Moreover, I confirm that I have made the lead contribution to the papers produced under joint authorship included in this dissertation. For example, I wrote the first draft of every manuscript, did the formal data analysis, data curation, reviewing, and editing of the manuscript, and made the lead contribution to conceptualization and methodology. Therefore, I am the first author of all papers.

Heidelberg, 26.10.2022

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