Explaining Self-Regulated Learning in the Context of Work: The Role of Problem-Solving, Collaboration, Communication and Technology Use

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Abstract

Due to increasing digitalization, knowledge workers' job profiles and working activities are increasingly shaped by the three components of *complex problem-solving*, *collaboration and communication* as well as *technology (use)*. As a result, self-regulated learning (SRL), in the context of work-related formal as well as informal learning, is increasingly important in enabling knowledge workers to fulfill changing working tasks and requirements, to keep up with further changes, as well as to prepare young people for such work environments. These three major components and the resulting changes in working tasks and requirements not only necessitate learning but are also valuable sources for enhancing learning. Therefore, the aim of this thesis is to examine how employees' and tertiary education students' learning can be supported in settings with different combinations of these three major components.

Firstly, the influence of social interactions on vocational education and training (VET) students' self-perceived informal workplace learning is investigated, also taking personal antecedents, contextual antecedents, and emotional experiences into account. Moreover, problem-solving and learning in a technology context are addressed. This comprises, on the one hand, the influence of solving software-related problems on workplace learning, again considering potential personal antecedents, contextual antecedents as well as emotional experiences. On the other hand, ERP software users' availability and usage of different problem-solving activities is examined, with a special focus on so called Electronic Performance Support Systems (EPSS). Lastly, it is investigated which digital tools are used by higher education students for their Computer Supported Collaborative Learning (CSCL), how useful they are perceived to be, why the tools are used and for which activities within CSCL they are used.

The results of this thesis underpin the importance of social interactions, sometimes in collaborative contexts, as well as software-related problem-solving and tool use as activities that support informal workplace learning. Contextual and personal antecedents as well as emotional experiences also play a central role here. In addition, the research findings demonstrate the significance of technology and tools for remote CSCL, with a focus on learners' agency within tool selection and the need for tool combination in CSCL. These results point to many areas where organizations and tertiary education institutions, as well as individual learners themselves, can take action to enhance SRL to be successful in digitalized workplaces.

Dedication

For my grandmother Rosemarie Fischer
who always believed in me finishing this thesis

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List of Abbreviations

SRL	Self-regulated learning
VET	Vocational education and training
EPSS	Electronic Performance Support Systems
CSCL	Computer Supported Collaborative Learning
Cedefop	European Centre for the Development of Vocational Training
WEF	World Economic Forum
ESJS	European skills and jobs survey
AI	Artificial Intelligence
ML	Machine Learning
OECD	Organisation for Economic Co-operation and Development
CL	Collaborative learning
ESJ	European skills and jobs
ERP	Enterprise Resource Planning
HR	Human Resources
MSLQ	Motivated Strategies for Learning Questionnaire
CE	Concrete experience
AE	Active experience
RO	Reflective observation
AC	Abstract conceptualization
ICC	Intraclass correlation coefficient
JDCS	Job Demands Control Support
TAM	Technology Acceptance Model
AET	Affective Events Theory
AR / VR	Augmented Reality / Virtual Reality
ANOVA	Analyses of variance
MANOVA	Multivariate analyses of variance
LMS	Learning Management System
UI	User interface

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1 Introduction

1.1 Motivation and research goals

Due to various changes in knowledge workers' job profiles and activities, they are increasingly shaped by the three components of *complex problem-solving*, *collaboration and communication* as well as *technology (use).* As a result, self-regulated learning (SRL), in the context of work-related formal as well as informal learning, has become crucial since it empowers knowledge workers in meeting the evolving demands and tasks of their professions but also to keep up with further changes. Furthermore, it plays an important role in equipping young people with the necessary skills. These three major components and the resulting changes in working tasks and requirements not only necessitate learning but are also valuable sources for enhancing learning.

In general, more and more digital technologies are used in the modern workplace (Arntz et al., 2020; Bughin et al., 2018; European Centre for the Development of Vocational Training [Cedefop], 2018; Harteis et al., 2022; World Economic Forum [WEF], 2023b). By 2018 about half of the employees surveyed in the European skills and jobs survey (ESJS) stated that they experienced changes in the technologies they use in the workplace and over 70 percent of participants stated that they needed at least fundamental basic digital skills in their jobs to perform work tasks (Cedefop, 2018). In the last decades, technological innovations have led to ongoing automation by robots and computers of cognitive and manual routine tasks that used to be performed by humans (Arntz et al., 2020; Bughin et al., 2018; Cedefop, 2018). In this context, routine tasks are characterized as following well-defined rules which enables automatization by using rule-based algorithms (Arntz et al., 2020; Frey & Osborne, 2017). In recent years, Artificial Intelligence (AI) technologies, like Machine Learning (ML), have also found their way into the workplace (Arntz et al., 2020; Bughin et al., 2018; Organisation for Economic Co-operation and Development [OECD], 2023; WEF, 2023b) and will be used even more in the future (Bughin et al., 2018; OECD, 2023; WEF, 2023b), which will accelerate the automation pace (Brynjolfsson & Mitchell, 2017). These technologies enable the automation of cognitive non-routine tasks that previously could only be carried out by humans and were said to be irreplaceable by technology (Autor et al., 2003; Brynjolfsson & Mitchell, 2017; Cedefop, 2018; Frey & Osborne, 2017; Lane et al., 2023; OECD, 2023). Therefore non-routine tasks were previously defined as tasks "for which the rules are not sufficiently well understood to be specified in computer code" (Autor et al., 2003, p. 1283). Cognitive non-routine tasks that may be automated using recent technology include, for instance, truck driving, medical diagnoses or legal writing (Frey & Osborne, 2017). Although, there are contradictory

study results and predications regarding the potential danger of job loss due to increasing AI penetration and the resulting automatization (Arntz et al., 2020; Bughin et al., 2018; Cedefop, 2018; Frey & Osborne, 2017; OECD, 2023), some authors convincingly present that for most jobs this fear is unfounded and that it is unlikely that workplaces or occupations will become fully automated (Arntz et al., 2020; Bughin et al., 2018; Cedefop, 2018; Lane & Williams, 2023; Lane et al., 2023; Smit et al., 2020; WEF, 2023b)[1]. Instead, with the current knowledge, it is expected in many cases that, in particular for knowledge workers, the increasing automatization leads to task reorganization and the creation of completely new (complex) rather than to widespread job loss (Lane et al., 2023; OECD, 2021, 2023; Smit et al., 2020). As a result, employees are able to spend more time on higher productivity and complex tasks and adjust towards non-automatable tasks like, for instance, tasks that require creative or critical thinking, social intelligence, reasoning or problem-solving, which AI is still not able to perform and which will be difficult to automate, at least in the near future (Cedefop, 2018; Frey & Osborne, 2017; Lane & Williams, 2023; Malhotra, 2021; OECD, 2021; Smit et al., 2020). In addition, these tasks can be complemented by technology, supporting for instance predicting tasks or decision-making (Arntz et al., 2020; Frey & Osborne, 2017; Lane & Williams, 2023; Lane et al., 2023; OECD, 2023; Smit et al., 2020). Furthermore, a stronger focus on complex tasks and problem-solving will lead to increasing collaboration, as tackling these tasks and problems often requires specialist knowledge from different specialisms and collaboration between specialists (Littlejohn & Margaryan, 2014; Littlejohn & Pammer-Schindler, 2022; Malhotra, 2021). This will also result in more teamwork and agile ways of working (Bughin et al., 2018; Littlejohn & Pammer-Schindler, 2022). Thus, task and job profiles change significantly (Bughin et al., 2018; Harteis et al., 2022; OECD, 2021), resulting in a shift towards activities that comprise complex problem-solving, collaboration and communication as well as technology (use) and this shift is likely to continue in the future (Bughin et al., 2018; OECD, 2021; WEF, 2023b).

This shift in working activities is also reflected in the necessary skillset for todays and future workplaces identified in several studies and reports by international organizations and companies. In this vein, skills like *analytical thinking (and decision making)* (Bughin et al., 2018; WEF, 2023b), *creative thinking and problem-solving* (Bughin et al., 2018; Lane et al., 2023; OECD, 2023; WEF, 2023b), as well as *complex information processing and interpretation* (Bughin et al., 2018) referring to aspects relevant for complex problem-solving are

[1] However, it has to be mentioned that these studies and assumptions did not consider recent advances in generative AI applications like ChatGPT, whose effects on jobs and the workplace are currently still difficult to assess in full (Organisation for Economic Co-operation and Development [OECD], 2023).

mentioned. Skills relevant for collaboration and communication are, for instance, *empathy and active listening* (WEF, 2023b), *interpersonal skills and empathy* (Bughin et al., 2018), *advanced communication (and negotiation) skills* (Bughin et al., 2018; Lane et al., 2023; OECD, 2023) or *teamwork skills* (OECD, 2023). Skills related to technology (use) include, for example, *technological literacy* (WEF, 2023b)*, AI and big data skills* (Lane et al., 2023; OECD, 2023; WEF, 2023b), *technology design, engineering, and maintenance skills* (Bughin et al., 2018) or *advanced IT skills and programming skills* (Bughin et al., 2018; OECD, 2023). In addition, all studies and reports on current and future skills attributed crucial importance to employees' learning and, in particular, lifelong learning and the corresponding skills (Bughin et al., 2018; Lane et al., 2023; OECD, 2023; WEF, 2023b). This finding is in line with the increasing importance of lifelong learning and SRL postulated in the scientific literature (Bell, 2017; Fontana et al., 2015; Littlejohn & Pammer-Schindler, 2022; Milligan, Littlejohn, & Margaryan, 2015). SRL refers to "the degree to which students are metacognitively, motivationally, and behaviorally active participants in their own learning process" (Zimmerman, 2013, p. 137). It can occur in both, formal and informal learning contexts (Noe et al., 2014; Nokelainen et al., 2017).

When employees are confronted with increasingly complex tasks and problems, eventually complemented by technology like AI and in new collaborative formats, this requires the acquisition of new and up-to-date knowledge and skills (Arntz et al., 2020; Cedefop, 2018; Harteis et al., 2022; Lane & Williams, 2023; Lane et al., 2023; Littlejohn & Pammer-Schindler, 2022; Malhotra, 2021; OECD, 2021; Smit et al., 2020). These are also necessary for technology introduction in the first place (Arntz et al., 2020; OECD, 2021). The need for up-to-date knowledge applies especially for technology-related knowledge as innovation cycles will become shorter (Cedefop, 2018) and knowledge is expected to become obsolete quite quickly (Cedefop, 2018; OECD, 2021). Most of the necessary learning for digitalized workplaces will be informal in nature, because the need for skills will develop quickly (Smit et al., 2020) and formal learning can neither provide the variety of necessary learning (Kyndt et al., 2018; Littlejohn & Pammer-Schindler, 2022) nor map changes in an agile way into curricula (Littlejohn & Margaryan, 2014). Furthermore, predicting future requirements can be difficult for formal learning offerings (Harteis et al., 2022). Because of these reasons there is a gap between knowledge needs in the workplace and the curricula of formal education (Tynjälä, 2008), which can be addressed by informal workplace learning. In informal workplace learning SRL is potentially especially important (Cuyvers et al., 2020; Hökkä et al., 2020; Milligan, Fontana, et al., 2015; Sitzmann & Ely, 2011).

The three identified central components of digitalized workplaces and the resulting working tasks and requirements, however, necessitate not only learning, but are also fruitful sources for employees' informal learning. Hence, complex problem-solving, collaboration and communication as well as technology (use) can support informal workplace learning, especially against the background that these make up an increasingly large part of work activities. In this vein, (increasing) job and task complexity (Ferreira et al., 2017; Russo, 2017; van der Velden & Verhaest, 2017), problem-solving in general (Eraut, 2004; S. Jeong et al., 2018; Kyndt et al., 2018; Rausch, 2013; Rintala et al., 2019; Tynjälä, 2013; Tynjälä & Häkkinen, 2005) as well as technology use (Kiani et al., 2020; Kiani et al., 2019; OECD, 2021) and the social aspect of learning (Carmeli et al., 2009; Ellinger & Cseh, 2007; Grohnert et al., 2019; Janssens et al., 2017; Kyndt et al., 2009; Melo & Beck, 2015; Raes et al., 2015; Rausch, 2013; Tews et al., 2017; Watzek et al., 2019) can enhance informal workplace learning.

Complex problem-solving, collaboration and communication as well as technology (use) are often not separate areas where isolated tasks are performed, but instead many working tasks combine aspects from these areas. Computer Supported Collaborative Learning (CSCL) represents a combination of all components. In this context collaborative learning (CL) is defined as "a situation in which two or more people learn or attempt to learn something together" (Dillenbourg, 1999, p. 2), in which each learners' individual self-regulation but also regulation within the group members is central (Hadwin et al., 2011, 2018; Järvelä & Hadwin, 2013; Panadero & Järvelä, 2015). CSCL is then CL that is facilitated or mediated by digital technology and digital tools (Chen et al., 2018; Kirschner & Erkens, 2013; Ludvigsen & Arnseth, 2017; Ludvigsen et al., 2021; Ludvigsen & Mørch, 2010; Stahl & Hakkarainen, 2021; Stahl et al., 2006). In CSCL, as it is important for both employers and employees that employees possess the necessary skillset for jobs in a digitalized workplace, training institutions and tertiary education institutions should promote these skills and allow students to practice working and learning that is close to real working conditions (Arntz et al., 2020; OECD, 2021; WEF, 2022, 2023a). This can be achieved by using CSCL to jointly solve problems related to the seminar topic, for example, that also meets the demands that educational programs at all levels should incorporate CL (OECD, 2021) and that skills such as problem-solving or collaboration should be taught in a more authentic way (OECD, 2021). Additionally, the European skills and jobs (ESJ) survey (Cedefop, 2015) showed that 31 percent of the participants who entered their first job and 27 percent of the participants who entered their first job and were in education or training before, stated that they had lower skills than needed for the job. The participants indicated especially a lack of technical skills and skills like

problem-solving, communication and teamwork (Cedefop, 2015). Although the incidences varied between countries and companies, the results and their potential effects in the workplace may be problematic. Here the integration of CSCL into tertiary education could address this problem too.

In summary, the three major components of complex problem-solving, collaboration and communication as well as technology (use) shape workplaces, tasks, and skills today, and will continue to do so in the future. While the resulting changing work activities and requirements make learning necessary, they are also themselves valuable sources of employees' learning and, when integrated into tertiary education, can prepare young people for the demands of modern workplaces. Therefore, the aim of this thesis is to examine how employees' and tertiary education students' learning can be supported in settings with different combinations of these three major components. This thesis contains four research papers for this purpose, whose respective contents, addressed research gaps and research objectives are examined in more detail in the following subchapter.

1.2 Research gaps, research questions and structure of the thesis

Due to the significance of collaboration and communication in the workplace and its potential to support informal workplace learning, there is a need for empirical evidence on how social interactions and what aspects of it promote learning. Although workplace learning is inherently social (Billett, 2001, 2004; Ellinger & Cseh, 2007; Eraut, 2000, 2004; Lave & Wenger, 1991; Marsick et al., 2017; Poell & van Woerkom, 2011; Rausch, 2013; Tynjälä, 2008), to date there are only a few empirical studies that have investigated the relationship between social interactions and informal learning in the workplace more deeply (Bono et al., 2007; Collin & Valleala, 2005; Daniels et al., 2009; R. H. Mulder, 2013; Rozkwitalska, 2019; Rozkwitalska et al., 2017; Schürmann & Beausaert, 2016). In addition, most of these studies were qualitative studies or questionnaire studies with only a few items on social interactions. An in-depth investigation can incorporate social interactions' characteristics as well as the potential influence of emotions and personality traits on informal learning, as emotions (Benozzo & Colley, 2012; Hökkä et al., 2020) and personality traits (Cerasoli et al., 2018; Kyndt et al., 2013; Noe et al., 2014; Rintala et al., 2019) were found to affect workplace learning positively in previous empirical studies. Despite social interactions' significance in the workplace and the above-mentioned empirical evidence, to my knowledge, there is no study that takes social interactions' situational characteristics, emotions and personality into account when investigating workplace learning. In addition, no study in the context of vocational education and training (VET) exists that investigates social interactions' impact on workplace

learning considering these in-depth aspects, although social interactions are especially important for the early career learning of novices like VET trainees (Eraut, 2007). Thus, based on diary data of VET trainees, the first research paper included in this thesis addresses the following research questions:

- RQ1: How do social interactions' situational characteristics affect self-perceived learning from these interactions?
- RQ2: How do emotional experiences affect self-perceived learning from social interactions in the workplace?
- RQ3: How do personality traits affect self-perceived learning from social interactions in the workplace?

Due to the changing work tasks and job profiles of knowledge workers already discussed, problem-solving in the context of technology (use) as well as its potential to enhance employee learning have become increasingly relevant. For solving work-related problems, knowledge workers usually have access to various resources (Cuyvers et al., 2016; Kiani et al., 2020; Kiani et al., 2019; Rausch et al., 2015). Based on Rausch's (2011; Rausch et al., 2015) approaches to problem solving in the workplace, Leiß et al. (2022) extend and classify them as personal, social and technological resources that enable users to perform work-related problem-solving activities. Although there is some empirical work on employees' use of resources, problem-solving activities and learning (Cuyvers et al., 2016; Haemer et al., 2017; Kooken et al., 2007; Rausch et al., 2015), with some focusing specifically on the software context (Andrade et al., 2009; Kiani et al., 2020; Kiani et al., 2019; Novick et al., 2009), empirical evidence is scarce. In addition, previous research has mostly relied on interviews, in-lab observations and, occasionally, surveys. Moreover, learning and problem-solving are complex phenomena that are influenced by various personal and contextual antecedents (Cerasoli et al., 2018; S. Jeong et al., 2018; Littlejohn & Pammer-Schindler, 2022; Noe et al., 2014; Rintala et al., 2019; Tynjälä, 2008; Vu et al., 2022). To the best of my knowledge, there is no empirical study so far that examines employees' use of resources as well as the resulting learning in software-related problem-solving by using a research diary, also including different personal and contextual antecedents. Against this background, the second research paper included in this thesis uses diary data to investigate how

- (RQ1) problem-solving activities;
- (RQ2) emotional experiences;
- (RQ3) contextual factors; and

- (RQ4) personal factors
  influence learning from solving software-related problems?

For solving software-related problems so called Electronic Performance Support Systems (EPSS) are especially promising. EPSS are supposed to enhance employees' performance and learning through task-specific and granular help in task performance and problem-solving (Mao & Brown, 2005). Although companies have applied EPSS - with varying success - since the 1990s, empirical research on their effectiveness is scarce (Chang, 2004; Gal et al., 2017; Gal & Nachmias, 2012; Mao, 2004; Mao & Brown, 2005; Nguyen & Klein, 2008). This is especially true for recent studies that have included new technological capabilities in their definition and design of EPSS. In addition, some of the results of older studies can now be considered obsolete, because technologies available in the past are very different from those available today (Ley, 2020). Moreover, literature on EPSS has been criticized for not being empirical (Gal & van Schaik, 2010; Mao, 2004; Nguyen, 2005) but based instead on anecdotal evidence (Gal & van Schaik, 2010; Mao, 2004). Furthermore, although Enterprise Resource Planning (ERP) systems are an important category of software applications in office work for knowledge workers, no empirical study on EPSS has yet been carried out, focusing in particular on the potential of recent EPSS in relation to ERP systems. These research gaps are addressed by the third research paper included in this thesis. In two questionnaire studies, data of people working in Human Resources (HR)-related positions and functions (sub study 1) and data of users of ERP software (sub study 2) were collected to answer the following research questions:

- RQ1: How significant are EPSS considered as a learning resource at present and in future by HR employees?
- RQ2: What potential advantages and obstacles concerning the implementation and use of EPSS are seen by HR employees?
- RQ3: What activities are available to ERP users when they need to solve an ERP-related problem in the workplace and how frequently are these activities used when available?
- RQ4: Do the ERP user types differ in terms of availability and frequency of EPSS use when dealing with an ERP-related problem in the workplace?
- RQ5: What factors (contextual and individual/personal factors) influence the frequency of EPSS use when dealing with an ERP-related problem in the workplace?

- RQ6: Which EPSS characteristics are considered the most useful by ERP users and do ERP user types differ in their assessment of usefulness?

It is the responsibility of post-secondary education to prepare young people for the requirements of modern workplaces (Miller & Hadwin, 2015). To prepare students for working and learning in workplaces that are shaped by problem-solving, collaboration and communication and technology (use) as central components higher education institutions can incorporate CSCL into their teaching. In general, there is a variety of technology and tools that can be used and that support CSCL (Al-Samarraie & Saeed, 2018; Chen et al., 2018; H. Jeong et al., 2019). They afford learners opportunities to "(1) engage in a joint task, (2) communicate, (3) share resources, (4) engage in productive collaborative learning processes, (5) engage in co-construction, (6) monitor and regulate collaborative learning, as well as (7) find and build groups and communities" (H. Jeong & Hmelo-Silver, 2016, p. 249). Existing research on tool use in CSCL has major shortcomings. Previous studies have typically only investigated the effects of one or two selected and prescribed tools (H. Jeong et al., 2019), although students' agency regarding what tools are used and how they are used is important within CSCL (Tchounikine, 2019). In addition, one tool is often not sufficient for successful CSCL and in realistic contexts several tools are usually combined and alternated for different situations (Chen et al., 2018; Ludvigsen & Steier, 2019). Moreover, empirical investigations should focus more on how commercial tools can support CSCL (Ludvigsen & Steier, 2019). As far as it is known, no previous empirical study has investigated which (very likely commercial) tools students use for CSCL when they have the freedom to decide. Accordingly, no study has investigated the reasons behind students' tool choices in CSCL and for which activities the tools were then used. These research gaps are addressed by the fourth research paper by answering the following research questions:

- RQ1: What tools were used for collaboration in CSCL?
- RQ2: How useful were these tools for collaboration?
- RQ3: Why were these tools used?
- RQ4: For which activities within CSCL were the tools used?

An overview of the research focus, research approach, measures, analysis, and sample of all four papers included in this thesis is provided in Table 1-1.

Table 1-1: Overview of the papers included in this thesis

Paper 1	
Reference	Leiß, T. V., & Rausch, A. (2023a). How personality, emotions and situational characteristics affect learning from social interactions in the workplace. *Vocations and Learning*, *16*(1), 73–97. https://doi.org/10.1007/s12186-022-09303-w
Research focus	Investigation of the influence of 1) social interactions' situational characteristics, 2) emotional experiences, and 3) personality traits on self-perceived learning from social interactions in the workplace.
Research approach	Quantitative research approach
Measures	Two semi-standardized self-report questionnaires and a semi-standardized research diary
Analysis	Secondary analysis using multilevel analysis
Sample	43 German VET trainees with 1,328 recorded diary entries
Paper 2	
Reference	Leiß, T. V., & Rausch, A.(2023b). Informal learning from dealing with software-related problems in the digital workplace. *Journal of Workplace Learning*, *35*(9), 291–310. https://doi.org/10.1108/JWL-03-2023-0042
Research focus	Investigation of the influence of 1) problem-solving activities, 2) emotional experiences, 3) contextual factors, and 4) personal factors on learning from solving software-related problems.
Research approach	Quantitative research approach
Measures	Standardized self-report questionnaire and semi-standardized research diary
Analysis	Multilevel analysis
Sample	48 German students working in a German software company with 240 recorded diary entries
Paper 3	
Reference	Leiß, T. V., Rausch, A., & Seifried, J. (2022). Problem-solving and tool use in office work: The potential of Electronic Performance Support Systems to promote employee performance and learning. *Frontiers in Psychology*, *13*, 869428. https://doi.org/10.3389/fpsyg.2022.869428
Sub study 1	
Research focus	Investigation of 1) the significance of EPSS as a learning resource considered by HR employees at present and in future, and 2) the potential advantages and obstacles concerning the implementation and use of EPSS as seen by HR employees.
Research approach	Quantitative research approach
Measures	Standardized self-report questionnaire
Analysis	Descriptive and multivariate methods of analysis
Sample	301 people working in HR-related positions and functions
Sub study 2	
Research focus	Investigation of 1) available activities for ERP users to solve an ERP-related problem in the workplace and the frequency of use of these activities, 2) potential differences between the ERP user types in terms of availability and frequency of EPSS use when dealing with an ERP-related problem in the workplace, 3) the factors (contextual and individual/personal factors) influencing the frequency of EPSS use when dealing with an ERP-related problem in the workplace, 4) the EPSS characteristics considered the most useful by ERP users and potential differences between ERP user types in their assessment of usefulness.
Research approach	Quantitative research approach
Measures	Standardized self-report questionnaire
Analysis	Descriptive and multivariate methods of analysis
Sample	652 users of ERP software

Table 1 1: Overview of the papers included in this thesis (continued)

Paper 4	
Reference	Leiß, T. V. (2023). Students' tool use in Computer Supported Collaborative Learning in higher education [Manuscript submitted for publication]. Chair of Economic and Business Education, University of Mannheim.
Research focus	Investigation of 1) the tools used for collaboration in CSCL, 2) the usefulness of these tools for collaboration, 3) why these tools were used, and 4) the activities within CSCL for which the tools were used.
Research approach	Qualitative and quantitative research approach
Measures	One standardized and one semi-standardized self-report questionnaire and semi-structured interviews
Analysis	Descriptive and qualitative content analysis
Sample	110 German university students of which 12 were additionally interviewed

This thesis is structured into seven chapters. The first chapter sheds light on the changes within digitalized workplaces, the resulting necessary skill set, central components of knowledge workers' workplaces, and working tasks as well as the necessity of continuous learning. Furthermore, the chapter presents the research gaps and the derived research questions that are addressed by the four papers included in this thesis. The second chapter presents a theoretical framework for all papers, referring to SRL as an overarching concept. SRL is introduced with a focus on SRL strategies that can be applied to four SRL areas. In addition, the link of SRL with CL and workplace learning is drawn. Another focus lies in the introduction of a comprehensive and extended process model of workplace learning. Chapters three to six each comprise one of the four research papers included in this thesis. The last chapter summarizes the key findings of all four research papers and identifies several limitations of the paper. From the results and limitations several suggestions for future research are derived. The chapter and the thesis close with practical implications which emerge from the results and a global conclusion.

1.3 References

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2 Conceptual Foundation

2.1 Self-regulated learning

2.1.1 Foundations of self-regulated learning

Self-regulation is a central human quality (Hardy et al., 2019; Usher & Schunk, 2017; Zimmerman, 2000) and thus also a corner stone of every successful learning process (Boekaerts & Minnaert, 1999; Panadero, 2017; Puustinen & Pulkkinen, 2001). After several decades of research on SRL, it was considered in the light of various theories and a number of models were developed (Panadero, 2017; Sitzmann & Ely, 2011). One of the most influential SRL models is from Zimmerman (2000) (Panadero, 2017), which is why I start my explanations with Zimmerman's definitions and my further explanations will be based on his model. In this vein, self-regulation can be defined as "self-generated thoughts, feeling, and actions that are planned and cyclically adapted to the attainment of personal goals" (Zimmerman, 2000, p. 15) and thus refers to a person's modulation of his or her (meta)cognition, motivation and affect as well as behavior (Pintrich, 2000; Puustinen & Pulkkinen, 2001; Sitzmann & Ely, 2011). These SRL areas are also considered by most SRL models (Panadero, 2017). In this context, cyclically means that feedback from previous performance and learning efforts is used for adjustments during subsequent efforts (Zimmerman, 2000). Metacognition is "thinking about thinking" (Jacobs & Paris, 1987, p. 255) with the two basic components of 1) knowledge of cognition and 2) regulation of cognition (Jacobs & Paris, 1987; Schraw & Sperling Dennison, 1994). Affect, in turn, is an umbrella term that includes moods as well as emotions (Dasborough et al., 2008; Diener et al., 1999; Fiedler & Beier, 2014; Forgas, 1994; Weiss & Cropanzano, 1996) and motivation targets at the initiation and persistence of behavior (Bandura, 1977; Linnenbrink-Garcia & Patall, 2018; Pintrich & Schunk, 1996).

Based on the presented definition of self-regulation (Zimmerman, 2000), self-regulated learning (SRL) is then "the degree to which students are metacognitively, motivationally, and behaviorally active participants in their own learning process" (Zimmerman, 2013, p. 137). This includes "(a) setting specific proximal goals for oneself, (b) adopting powerful strategies for attaining the goals, (c) monitoring one's performance selectively for signs of progress, (d) restructuring one's physical and social context to make it compatible with one's goals, (e) managing one's time use efficiently, (f) self-evaluating one's methods, (g) attributing causation to results, and (h) adapting future methods" (Zimmerman, 2002, p. 66). Zimmerman's (2013) definition points to a strong proactive component of SRL, referring to the fact that learners initiate and direct their own learning efforts (Pintrich, 2000; Zimmerman, 1989, 2008) as well as the significance of learners' agency (Bandura, 1986, 1989). Moreover, this

definition reflects the constructivist view of learning on which it is based (Pintrich, 2000, 2004). Within the constructivist view of learning it is assumed that knowledge is constructed through a learner's active engagement and is dependent on the context, socio-cultural constraints as well as on a learner's own knowledge structures and previous experiences (Seel et al., 2017). Hence, every learner constructs his or her own knowledge based on his or her previous knowledge and this is independent of how the knowledge was taught. If a teaching person is involved, he or she mediates learning instead of taking an instructional role (Seel et al., 2017).

Zimmerman (2000) structures self-regulatory processes and thus SRL processes into three cyclical stages: *forethought*, *performance* and *self-reflection*. The forethought phase refers to all processes and activities that take place before the actual acting (Zimmerman, 2000). These processes are used to prepare the learning efforts and to support learning (Zimmerman, 2013) and include the subprocesses of task analysis and self-motivation resulting from self-motivation beliefs (Zimmerman, 2000, 2002). The performance phase refers to processes during learning efforts, comprising the subprocesses of self-control and self-monitoring of the performance (Zimmerman, 2000, 2013). The self-reflection phase encompasses all processes after the learning effort with the subprocesses of self-judgement and self-reaction (Zimmerman, 2000). These self-reflections, in turn, impact the next forethought phase, due to self-regulation's cyclical nature (Pintrich, 2000; Zimmerman, 2000, 2013).

Pintrich (2000) suggests a four-phase SRL process model that is conceptualized very similar to Zimmerman (2000). The four phases are 1) *forethought, planning and activation*; 2) *monitoring*; 3) *control* as well as 4) *reaction and reflection* (Pintrich, 2000). Pintrich (2000, 2004) explicitly states that distinguishing in phases does not definitively imply that the phases are linearly structured, that every phase has to be passed through or that it is always possible to separate them reliably. Instead, processes within the phases can take place dynamically and simultaneously or learning takes place more implicitly or unintentionally (Pintrich, 2000, 2004). In all four SRL process phases the four areas of cognition, motivation and affect, behavior or contextual features are relevant and can be planned, monitored, controlled and regulated by the learners (Pintrich, 2000). While the first three areas are aspects of the learner, the context area refers to other people like peers or teachers as well as task and contextual conditions such as task characteristics, the classroom or the cultural context. They enhance or constrain learners' attempts to self-regulate their learning process (Pintrich, 2000). The impact of social and environmental influences, like the social milieu, social assistance, academic tasks or the physical surroundings, on SRL processes was also pointed out by Zimmerman (1989,

2000). He assumed that social and environmental aspects and processes as well as those related to a learner's self impact each other reciprocally (Zimmerman, 1989, 2000). In this vein, learners' self-initiated regulatory processes can adjust and regulate the physical or social environment (Zimmerman, 2000). The physical and social environment, in turn, can influence learners' SRL processes or can be used by the learners as resources to enhance their SRL (Zimmerman, 2000).

2.1.2 Learning strategies and motivational beliefs within self-regulated learning

Within SRL learners use various self-regulated learning strategies (Pintrich, 2004; Puustinen & Pulkkinen, 2001; Sitzmann & Ely, 2011; Zimmerman, 1989; Zimmerman & Martinz-Pons, 1986; Zimmerman & Moylan, 2009). Based on Pintrich et al. (1992, 1993), I classify them into cognitive, metacognitive and resource management strategies and also add motivation regulation and emotion regulation strategies. Cognitive strategies include, for instance, *rehearsal and memorizing* (e.g., repeating words to support recall) (Pintrich et al., 1992; Zimmerman & Martinz-Pons, 1986), *elaboration* (e.g., summarizing, paraphrasing) (Pintrich et al., 1992; Weinstein et al., 2016), *organization* (e.g., clustering, outlining) (Pintrich et al., 1992; Weinstein et al., 2016; Zimmerman & Martinz-Pons, 1986) and *critical thinking* (i.e., applying previous knowledge to new situations, making critical evaluations to ideas) (Pintrich et al., 1992). Metacognitive strategies refer to *planning* (i.e., task analysis, goal setting) (Pintrich et al., 1992; Zimmerman & Martinz-Pons, 1986; Zimmerman & Moylan, 2009), *monitoring* (e.g., of one's own comprehension) (Pintrich et al., 1992; Zimmerman & Martinz-Pons, 1986; Zimmerman & Moylan, 2009) and *regulation* (e.g., adjusting the reading speed) (Pintrich et al., 1992). Resource management strategies are, for example, *managing time and study environment* (e.g., choosing the appropriate place for studying; scheduling, planning and managing the study time) (Pintrich et al., 1992; Weinstein et al., 2016; Wolters, 1999, 2003; Zimmerman & Martinz-Pons, 1986; Zimmerman & Moylan, 2009), *regulating one's own effort* (e.g., persisting despite of difficulties or boredom) (Pintrich et al., 1992; Weinstein et al., 2016), *seeking assistance or help* (e.g., seeking help from peers or a teaching person when needed) (Pintrich et al., 1992; Weinstein et al., 2016; Zimmerman & Martinz-Pons, 1986; Zimmerman & Moylan, 2009), *peer learning* (e.g., studying in a group or with friends to enhance learning) (Pintrich et al., 1992) and *information seeking* (e.g., searching for information in nonsocial sources) (Zimmerman & Martinz-Pons, 1986). In order to regulate affect, learners can use different coping strategies (Wolters, 1999, 2003) that are in general more emotion-focused or more problem-focused (see also *emotion-focused* and *problem-focused coping* (Folkman & Lazarus, 1980; Lazarus & Folkman, 1987)) (Wolters, 1999, 2003).

Strategies for motivation regulation include, for instance, *self-consequating or self-rewarding* (i.e., learners provide themselves with rewards or punishments for their learning activities) (Bandura, 1977; Corno, 1993; Wolters, 1999, 2003; Zimmerman & Martinz-Pons, 1986; Zimmerman & Moylan, 2009), *performance and mastery self-talk* (e.g., emphasizing reasons why one wants to complete a task or stressing that one wants to become more competent) (Wolters, 1999, 2003), *interest enhancement* (e.g., making a tasks less boring by competing with other learners) (Corno, 1993; Wolters, 1999, 2003; Zimmerman & Moylan, 2009) as well as *proximal goal setting* (i.e., breaking down complex tasks into smaller and less complex subtasks) (Wolters, 2003).

Motivation regulation is used to regulate different motivational beliefs during SRL processes (Pintrich, 2004). In this context, relevant motivational beliefs for SRL are in particular *self-efficacy*, *outcome expectancies*, *goal orientation, interest or value* and *attributions* (Pintrich, 2000; Pintrich et al., 1992; Weinstein et al., 2016; Zimmerman, 2000; Zimmerman & Moylan, 2009; Zimmerman & Schunk, 2009). Self-efficacy refers to "people's judgements of their capabilities to organize and execute courses of action required to attain designated types of performances" (Bandura, 1986, p. 391) and therefore to master a task at hand (Pintrich et al., 1992). Outcome expectancies are a person's assessment that a certain behavior leads to certain outcomes and that he or she is able to successfully perform the necessary behaviors to produce the outcomes (Bandura, 1977). Goal orientation comprises learning goal orientation (i.e., focus on mastery and learning) and performance goal orientation (i.e., focus on approval from others) (Dweck & Leggett, 1988). In this context Pintrich et al. (1992) refer to intrinsic and extrinsic goal orientation, also reflecting intrinsic and extrinsic motivation within Self-Determination Theory (Deci & Ryan, 1985; Ryan & Deci, 2000). Interest or value comprise judgements on how important, useful, or interesting a task or learning content is (Pintrich et al., 1992, 1993; Zimmerman & Schunk, 2009). Attributions refer to perceptions of causes for success and failure of different outcomes like, for instance, learning outcomes (Weiner, 1986).

Pintrich (2004) assigned several SRL strategies that are measured in the Motivated Strategies for Learning Questionnaire (MSLQ) to the regulation areas of cognition, motivation and affect, behavior as well as context within his SRL phase model (Pintrich, 2000). I adapted this categorization and matching table by incorporating all the presented SRL strategies (see Table 2-1). The SRL strategies relevant to SRL processes listed in this table are of course not exhaustive.

Table 2-1: SRL areas and respective relevant SRL strategies

Cognition	Motivation / Affect	Behavior	Context
• Rehearsal and memorizing (C) • Elaboration (C) • Organization (C) • Critical thinking (C) • Planning (M) • Monitoring (M) • Regulation (M)	• Self-consequating or self-rewarding (MO) • Performance and mastery self-talk (MO) • Interest enhancement (MO) • Proximal goal setting (MO) • Emotion-focused coping (E) • Problem-focused coping (E)	• Effort regulation (R) • Seeking assistance or help (R) • Information seeking (R) • Peer learning (R) • Managing time / study environment (R)	• Managing time / study environment (R) • Peer learning (R)

Note. C = cognitive strategies, M = metacognitive strategies, MO = motivation regulation strategies, E= emotion regulation strategies, R = resource management strategies. Source: adapted from Pintrich, 2004, p. 390.

2.2 Collaborative learning

While I stressed until now only self-regulation in individual processes, it is also a "quintessential skill" (Järvelä & Hadwin, 2013, p. 26) in collaborative learning (Järvelä & Hadwin, 2013), focusing on the very strong social aspect within SRL (Pintrich, 2000; Zimmerman, 1989, 2000) which has taken center stage in recent research on SRL (Hadwin et al., 2011; Hadwin et al., 2010; Järvelä & Hadwin, 2013). Collaborative learning (CL) is defined as "a situation in which two or more people learn or attempt to learn something together" (Dillenbourg, 1999, p. 2). Collaborative learning includes every collaborative activity that takes place in an educational context but also in work practices and professional communities and contains, in many cases, joint problem-solving, and learning is more of a by-product (Dillenbourg, 1999). The term collaboration means "a coordinated, synchronous activity that is the result of a continued attempt to construct and maintain a shared conception of a problem" (Roschelle & Teasley, 1995, p. 70). A situation can be characterized as collaborative by three characteristics (Dillenbourg, 1999). The first one is symmetry, which means that the group members have the same knowledge level, are allowed to perform the same tasks, and have a similar status in their group and community. The second characteristic includes common goals of the group members and the group members' mutual awareness of these goals. The last characteristic, working together, refers to the degree of the division of labor amongst the group members. This characterization leads to the distinction that can be made between cooperative learning and collaborative learning (Dillenbourg, 1999). Cooperative learning is characterized by

the division of labor among the participants, resulting in a relatively independent completion of assigned subtask by single group members and the consolidation of these subtasks into the final joint group output. In collaborative work, however, group members work together to solve the problem at hand in a coordinated effort (Dillenbourg, 1999; Roschelle & Teasley, 1995). In collaborative learning and collaborative problem-solving a spontaneous division of labor may be possible, but the resulting "reasoning layers" (Dillenbourg, 1999, p. 11) are interwoven, unstable and the roles shift frequently (Dillenbourg, 1999).

In CL "working together means co-constructing shared task representations and shared goals, but also regulating learning through metacognitive monitoring and control of motivation, cognition, and behavior" (Hadwin et al., 2011, p. 77). Thus, within CL there is not only SRL of every single group member relevant, but also co-regulation and socially shared regulation of learning (Hadwin et al., 2011, 2018; Järvelä & Hadwin, 2013; Panadero & Järvelä, 2015). Co-regulation refers to a group member's regulation of other group members' learning, while socially shared regulation is group members collective, synchronized and productive regulation of the learning process (Hadwin et al., 2011; Järvelä & Hadwin, 2013). Socially shared regulation differs from co-regulation in "the extent to which joint regulation emerges though a series of transactive exchanges amongst group members" (Hadwin et al., 2018, p. 86). Co-regulation and socially shared regulation can take place in all SRL regulation areas (i.e., cognition, motivation/affect, behavior and context) (Hadwin et al., 2011, 2018; Panadero, 2017).

Individual self-regulation, co-regulation and socially shared regulation can be supported by technology and digital tools (Hadwin et al., 2018; Järvelä & Hadwin, 2013; Järvelä et al., 2016). Collaborative learning activities that are facilitated or mediated by digital technology and digital tools are called CSCL (Chen et al., 2018; Kirschner & Erkens, 2013; Ludvigsen & Arnseth, 2017; Ludvigsen et al., 2021; Ludvigsen & Mørch, 2010; Stahl & Hakkarainen, 2021; Stahl et al., 2006). Thus, CSCL can be seen as an extension of CL, based on the assumption that problem-solving and learning can be effectively supported by technology (H. Jeong et al., 2019). In this context technology is not only a medium but also a context enabling the construction and practice of new knowledge and skills (H. Jeong & Hmelo-Silver, 2016). Learning then occurs when the group members build and share knowledge and interact with the CSLC environment (Stahl & Hakkarainen, 2021). In general, a variety of technology and tools can be used for CSCL (Al-Samarraie & Saeed, 2018; Chen et al., 2018; H. Jeong et al., 2019). They afford learners opportunities to "(1) engage in a joint task, (2) communicate, (3) share resources, (4) engage in productive collaborative learning processes, (5) engage in co-

construction, (6) monitor and regulate collaborative learning, as well as (7) find and build groups and communities" (H. Jeong & Hmelo-Silver, 2016, p. 249).

2.3 Workplace learning

2.3.1 Self-regulated learning and informal (workplace) learning

Self-regulated learning can occur in formal as well as in informal learning contexts (Noe et al., 2014; Nokelainen et al., 2017). Oftentimes, informal learning is defined in contrast to formal learning (Eraut, 2000). Formal learning is described by the characteristics of a prescribed learning framework, the organization of the learning scenario, the involvement of a teaching person, the fact that gained qualifications are awarded and the definition of desired outcomes (Eraut, 2000). As a sort of a "residual category" (Eraut, 2000, p. 114) non-formal or informal learning summarizes learning that does not fall under the definition for formal learning. Thus, informal learning is described by an absence of the previously mentioned formal learning characteristics (Eraut, 2000, 2004). This definition is similar to another popular definition of informal learning proposed by Marsick and Watkins (1990). Eraut (2000, 2004) further distinguishes three types of informal learning that differ in terms of learners' level of intention to learn. These types are implicit learning, reactive learning, and deliberative learning. Within deliberative learning, a learner sets time aside explicitly for learning, which includes goal setting and may comprise planning and problem-solving (Eraut, 2004). Reactive learning occurs unplanned and almost spontaneously when performing a task and when there is not much time to think (Eraut, 2000, 2004). As a result, the learner is aware of his or her learning, however, the intentionality varies (Eraut, 2000). Within implicit learning, learning and the acquisition of knowledge are not based on conscious attempts, are not intended and therefore at the moment it takes place people are often not aware of their learning (Eraut, 2000). Thus, implicit learning always occurs while some other activity is carried out (Marsick & Watkins, 1990).

SRL is also relevant for workplace learning (Boekaerts & Minnaert, 1999; Cuyvers et al., 2020; Fontana et al., 2015; Littlejohn et al., 2016; Margaryan et al., 2013; Milligan, Fontana, et al., 2015; Milligan, Littlejohn, & Margaryan, 2015; Nokelainen et al., 2017; Vancouver et al., 2017), which occurs mainly and increasingly informally (Eraut, 2004, 2010; Fontana et al., 2015; Vancouver et al., 2017). SRL is potentially especially significant for informal workplace learning as informal settings require employees to independently monitor and recognize learning opportunities as well as knowledge gaps, structure learning, identify accurate and relevant information, monitor information's relevance for the respective learning goal and simultaneously control their emotions (Cuyvers et al., 2020; Hökkä et al., 2020; Milligan,

Fontana, et al., 2015; Sitzmann & Ely, 2011). Hence, SRL in the workplace is integrated with and structured by work tasks (Littlejohn et al., 2016; Margaryan et al., 2013; Margaryan et al., 2009). However, in informal workplace learning the previously presented SRL phases are usually not distinguishable and the related processes take place iteratively, simultaneously and continuously (Littlejohn et al., 2012; Margaryan et al., 2013; Margaryan et al., 2009).

The integration with and structuring of SRL by work tasks also illustrates that workplace learning is deeply integrated into work activities (Billett, 2004; Cuyvers et al., 2020; Gruber & Harteis, 2018; S. Jeong et al., 2018; Marsick & Watkins, 1990; Marsick et al., 2017; Tynjälä, 2008) and that participation in working activities and learning cannot be separated (Billett, 2004; Gruber & Harteis, 2018; Manuti et al., 2015). In that sense, the workplace can be seen as an environment that provides affordances for employees' learning (Billett, 2004) and workplace learning is highly contextual (e.g., Ellinger & Cseh, 2007; Eraut, 2000; Fuller & Unwin, 2011; S. Jeong et al., 2018; Marsick, 2009; Marsick & Watkins, 1990; Marsick et al., 2017). This refers on the one hand to the strong social component within informal workplace learning (e.g., Billett, 2004; Ellinger & Cseh, 2007; Eraut, 2000; S. Jeong et al., 2018; Marsick et al., 2017; Tynjälä, 2008), which is in line with the core assumptions of Social Learning Theory (Bandura, 1971), Situated Learning Theory (Lave & Wenger, 1991) as well as cultural-historical activity theory (Engeström, 1993; Vygotsky, 1978). On the other hand, context refers to, for instance, the organizational characteristics or the broader environment (e.g., Fuller & Unwin, 2011; S. Jeong et al., 2018; Kyndt & Baert, 2013; Marsick, 2009; Noe et al., 2014; Rintala et al., 2019; Tynjälä, 2008). Working and learning as well as various antecedents are integrated in the 3-P model of workplace (Tynjälä, 2013) that is presented in the next subchapter.

2.3.2 A Model of Workplace Learning

One of the most influential models for workplace learning is the 3-P model of workplace learning from Tynjälä (2013) that is based on Biggs' (1999) 3-P model of school learning. Tynjälä's (2013) 3-P model comprises three main components of workplace learning that influence each other: presage, process, and product. The presage component incorporates learner factors (i.e., individual person-related aspects) as well as learning context factors (i.e., the organization and its features). Within the model, presage factors are assumed to influence the learning process component through the learner's interpretation of the presage factors. This means that all the presage factors influence the learning process not directly but indirectly depending on how they are perceived by the learner (Tynjälä, 2013), reflecting the constructivist view on learning (Seel et al., 2017; Tynjälä, 2013). The process component encompasses different work activities that support workplace learning that, in turn, result in different

individual as well as organizational learning outcomes, included in the product component (Tynjälä, 2013). All but the last listed work activity in Figure 2-1 can be carried out as informal learning activity in which learning is not the main goal of the activity (Manuti et al., 2015). Learning outcomes then, in turn, can enter the next learning process as antecedents (Tynjälä, 2013), indicating a cyclical assumption within the model. Factors and processes within these three P's (Presage, Process, Product) are enhanced and constrained by factors of the sociocultural environment (i.e., larger context in which working and learning occurs) (Tynjälä, 2013). Gruber and Harteis (2018) point to the fact that the distinction of these 3 P's are purely analytical. In reality every factor can be a presage but also a product of learning processes at the same time (Harteis, 2022).

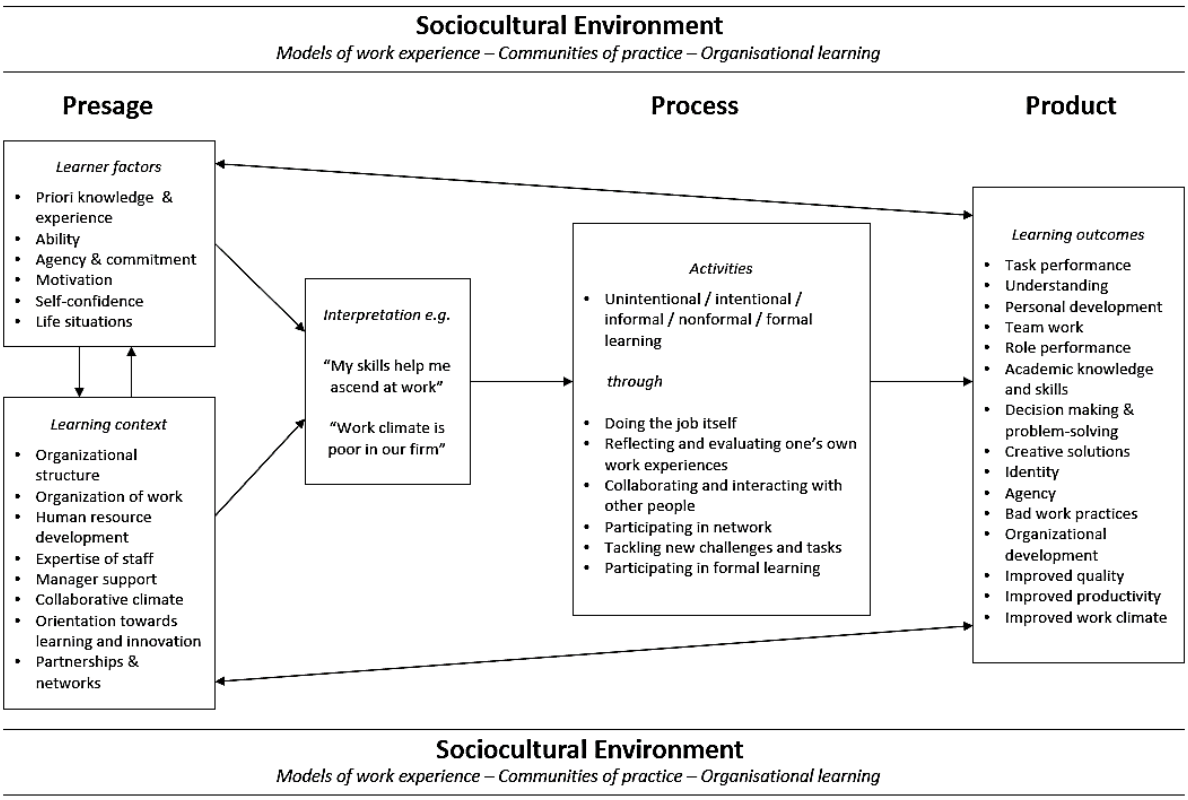

Figure 2-1: 3-P Model of Workplace Learning
Source: Tynjälä (2013, p. 14)

The learner and learning context factors, work activities and learning outcomes included in the 3-P model have many overlaps with other more recent reviews and meta-studies on workplace learning and studies categorizing and investigating different learning activities (Cerasoli et al., 2018; Cuyvers et al., 2016; Hökkä et al., 2020; S. Jeong et al., 2018; Kooken et al., 2007; Kyndt & Baert, 2013; Kyndt et al., 2018; Noe et al., 2014; Rausch et al., 2015; Rintala et al., 2019; Schürmann & Beausaert, 2016; Smet et al., 2022). As Tynjälä (2013)

points out, her model is more of a tentative holistic model which makes no claim to completeness, and so it can be expanded by further results of which I now mainly present aspects that relate to informal learning. In this vein, further learner factors like personality traits (e.g., the Big Five (McCrae & Costa, 1999), proactive personality (Bateman & Crant, 1993)) (Cerasoli et al., 2018; S. Jeong et al., 2018; Kyndt et al., 2018; Noe et al., 2014; Rintala et al., 2019; Schürmann & Beausaert, 2016), self-efficacy (S. Jeong et al., 2018; Kyndt & Baert, 2013; Kyndt et al., 2018; Rintala et al., 2019; Schürmann & Beausaert, 2016), learning goal orientation (Cerasoli et al., 2018; Kyndt & Baert, 2013; Noe et al., 2014), expectancy beliefs (Kyndt & Baert, 2013; Schürmann & Beausaert, 2016), attitude and epistemic beliefs (S. Jeong et al., 2018; Kyndt & Baert, 2013; Kyndt et al., 2018) as well as (socio)demographic variables (S. Jeong et al., 2018; Kyndt & Baert, 2013; Kyndt et al., 2018; Rintala et al., 2019) can be mentioned. Additional learning context factors are, for instance, workload and time (Cerasoli et al., 2018), various job and task characteristics (S. Jeong et al., 2018; Kyndt & Baert, 2013; Kyndt et al., 2018; Noe et al., 2014; Rintala et al., 2019; Schürmann & Beausaert, 2016), autonomy (Cerasoli et al., 2018; S. Jeong et al., 2018; Noe et al., 2014; Rintala et al., 2019; Schürmann & Beausaert, 2016), team characteristics and team structure (Noe et al., 2014; Schürmann & Beausaert, 2016), feedback (S. Jeong et al., 2018; Kyndt & Baert, 2013; Rintala et al., 2019; Schürmann & Beausaert, 2016), social integration with colleagues (Kyndt & Baert, 2013) as well as work tools and resources (S. Jeong et al., 2018; Kyndt et al., 2018; Rintala et al., 2019; Schürmann & Beausaert, 2016).

With regard to the process component, further work and learning activities are experimentation (S. Jeong et al., 2018; Kooken et al., 2007; Rausch, 2011; Rausch et al., 2015; Rintala et al., 2019; Schürmann & Beausaert, 2016), observation (Cuyvers et al., 2016; Rausch, 2011; Rausch et al., 2015; Rintala et al., 2019; Schürmann & Beausaert, 2016), searching and scanning for information (Rintala et al., 2019), problem-solving (S. Jeong et al., 2018; Rintala et al., 2019), learning from errors or conflicts (Rintala et al., 2019), retrieval from written material and online content (Cuyvers et al., 2016; Kooken et al., 2007; Rausch, 2011; Rausch et al., 2015; Schürmann & Beausaert, 2016) and information sharing (Schürmann & Beausaert, 2016). Another activity that is presumably performed upstream or is inherent to most of the other named activities and is mentioned for the sake of completeness is elaboration (Rausch et al., 2015).

Regarding the product component of the 3-P model, the learning outcomes could in general be more clearly categorized. Rintala et al. (2019), for instance, distinguish generic, job-specific and organizational-level outcomes and Cerasoli et al. (2018) divide them into

attitudes, knowledge / skill acquisition and performance. Within their review on workplace learning outcomes, Smet et al. (2022) distinguish between 1) changes in knowledge, skills or attitudes, 2) individuals' and organizations' processional achievement and 3) sustaining one's future development, each with several subcategories. They conducted a very detailed investigation of potential learning outcomes. The space available here does not permit a complete presentation and supplementation of the model. However, exemplary additional outcomes are, for example, daring to communicate, task-management skills, proactive attitudes, innovative work behavior, different forms of coping (physical, personal / psychological), improved self-confidence / efficacy, emotional well-being, job satisfaction, self-knowledge, improvement of learning attitude, anticipation, corporate sense or employability (Smet et al., 2022). Some of them may already fall under the product factor of personal development, however Tynjälä (2013) did not clearly elaborate what this label encompasses.

Affect and emotions are not included in the 3-P model (Tynjälä, 2013), but mentioned in several reviews on workplace learning (Hökkä et al., 2020; Kyndt & Baert, 2013; Rintala et al., 2019). Hökkä et al. (2020) performed an elaborated review on the role of emotional experiences within workplace learning and identified emotions and emotional experiences on the one side to influence workplace learning, and thus refer to the presage and process component. Within their reviews, Rintala et al. (2019) assigned emotions and Kyndt and Baert (2013) assigned anxiety to the learner factors in the presage component. On the other side, Hökkä et al. (2020) found emotions and emotional experiences to also be outcomes of workplace learning processes. Thus, emotions and emotional experiences could be included within all components in the 3-P model of workplace learning.

The 3-P models' components and factors as well as the presented possible augmentations show that in line with the described relevant areas of SRL, and also for informal workplace learning personal and contextual factors, informal work or learning activities, as well as motivation, affect and emotions are important. Moreover, there are several SRL aspects that are explicitly or implicitly included in the augmented 3-P model like the interpretation component (Cuyvers et al., 2020), the activities of reflecting on and evaluating one's own work experiences (Tynjälä, 2013) and elaboration (Rausch et al., 2015) as well as personal / psychological coping as workplace learning outcomes (Smet et al., 2022), which refers to a learner's regulation of motivation or affect and cognition (Berings et al., 2008). In addition, various presented work and learning activities are similar to previously mentioned resource management strategies (i.e., peer learning, help-seeking) for self-regulated learning (Pintrich, 2004). Further SRL strategies with similarities to presented work and learning activities that

are identified and examined in research are, for instance, searching for information (Littlejohn et al., 2016; Pylväs et al., 2022), eliciting feedback (Littlejohn et al., 2016; Pylväs et al., 2022), problem-solving (Littlejohn et al., 2016), trial and error or experimentation (Pylväs et al., 2022), learning by doing (Pylväs et al., 2022) or observing (Pylväs et al., 2022). Against this background Kittel and Seufert (2023) examined the relationship between five informal learning behaviors and SRL strategies (i.e., cognitive, metacognitive and resource related strategies). Their results indicate relationships between the informal learning behaviors and the SRL strategies, causing the authors doubting the separateness between the two concepts of informal learning and SRL strategies, in particular referring to metacognitive SRL strategies (Kittel & Seufert, 2023). However, overall research on SRL within (informal) workplace learning is scarce (Cuyvers et al., 2020; Kittel & Seufert, 2023; Littlejohn et al., 2016), especially considering the simultaneous integration of (informal) workplace learning and SRL characteristics (Cuyvers et al., 2020). Research on the relationship between SRL and informal workplace learning is still very much developing (Cuyvers et al., 2020).

2.4 Summary and link to the research papers

In summary, SRL is highly relevant for successful learning. On the one hand, this refers to a more formal learning process, which also includes CL processes that can be supported by technology and digital tools. Building on this, the last paper in this thesis examines which digital tools are used by higher education students for their digitally mediated CL, how useful these tools are perceived to be, why the tools are used and for which activities. SRL is also relevant for informal learning and potentially especially relevant for informal workplace learning due its strong emphasis on learners' initiative and active role. In general, workplace learning is deeply integrated with everyday working practices and is influenced by personal and contextual antecedents, learners' work as well as learning activities, and learners' emotions. Two significant work and learning activities are interacting with others and problem-solving. As already stated in the introduction, complex problem-solving, collaboration and communication as well as technology (use) are increasingly central aspects of digitalized workplaces that require continuous learning. Bringing together these key work and learning activities and central aspects of digitalized workplaces, the first paper included in this thesis examines how social interactions affect informal workplace learning, while also taking personal antecedents, contextual antecedents, and emotional experiences into account. The second and third paper address problem-solving and learning in a technology context. While the second paper focuses on the influence of solving software-related problems on workplace learning, again considering potential personal antecedents, contextual antecedents as well as

emotional experiences, the third paper mainly addresses ERP software users' availability and usage of different problem-solving activities, with a special focus on EPSS.

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3 How Personality, Emotions and Situational Characteristics Affect Learning from Social Interactions in the Workplace (Paper 1)

Paper 1 was published in October 2022 in the journal *Vocations and Learning* and is available at https://link.springer.com/article/10.1007/s12186-022-09303-w.[2]

3.1 Abstract

The present study examines the effects of social interactions' situational characteristics, emotions, and personality on self-perceived learning from social interactions at work based on diary and survey data. The sample comprises 43 German vocational education and training (VET) trainees in various apprenticeship programs. During the diary period of ten working days, the participants were instructed to record five typical social interactions at work every day. Quantitative data of 1,328 social interactions were analyzed by means of multilevel analysis. Regarding social interactions' characteristics, the analysis revealed the baseline level of instrumentality, an interruption of the social interaction, its instrumentality and questions asked by the trainee during the interaction as positive predictors of self-perceived learning. A trainee's higher speech proportion, however, was a negative predictor. Regarding state emotions, the emotional experiences of bored and motivated were identified as significant positive predictors of learning from social interactions at work. Emotions' baseline level as well as personality traits had no significant influence. The results indicate that social interactions' situational characteristics have the biggest influence on self-perceived learning from social interactions.

3.2 Introduction

In this paper, we investigate how social interactions at work contribute to workplace learning and how situational characteristics of these interactions, emotions during these interactions, and personality traits are related to self-perceived learning from the interactions. The interest in workplace learning has been growing since the 1990s (Ellström, 2011; Kyndt et al., 2013; Poell & van Woerkom, 2011). This growing interest is centered in particular on the necessity of continuous learning (Billett, 2008; Gijbels et al., 2010; Molloy & Noe, 2010; Tynjälä, 2008) and subsequently also lifelong employability (Manuti et al., 2015). Prevailing theories of work-related learning emphasize the social dimension (Billett, 2002; Engeström, 2001; Eraut, 2000; Lave & Wenger, 1991).

Any kind of learning in the workplace implies an actual or hypothetical interaction with the work environment. Thus, learning does not occur isolated from others, but instead is a social process, which ─ in the sense intended by Vygotsky (1978) ─ is mediated by the environment.

[2] For reasons of standardization within this thesis, table labels, notes, and formatting were adapted.

Workplace learning is inherently social (Billett, 2001a, 2004; Ellinger & Cseh, 2007; Eraut, 2000, 2004; Lave & Wenger, 1991; Marsick et al., 2017; Poell & van Woerkom, 2011; Rausch, 2013; Tynjälä, 2008) and one central aspect are social interactions (Collin & Valleala, 2005; Marsick et al., 2017; Rozkwitalska, 2019; Warhust & Black, 2015). By social interactions we refer to meaningful processes of verbal exchange between at least two people. Social interactions are particularly important for workplace learning within VET, in which social interactions with other people are core elements (Billett, 2010; Mikkonen et al., 2017). In addition, many social interactions of VET students are characterized by knowledge asymmetries, as they take place, for example, with colleagues or superiors. Moreover, in his typology of early career learning processes and activities, Eraut (2007) also emphasizes the importance of social interactions for workplace learning, especially for novices.

Although plenty of studies addressing workplace learning have focused on the social context of workplace learning, like for example communities of practice (Kirkman et al., 2013), learning networks (Melo & Beck, 2015), interpersonal relationships (Carmeli et al., 2009), leaderships styles (Froehlich et al., 2014), group learning and team learning (Gil & Mataveli, 2017; Raes et al., 2015; Watzek et al., 2019), help-seeking behavior after making an error (Grohnert et al., 2019) or social fun activities (Tews et al., 2017), to date, only a few studies have investigated the relationship between social interactions and informal learning in the workplace more deeply. In addition, most of the conducted studies were global qualitative studies or questionnaire studies with only a few items on social interactions, although micro-analyses of social interactions near the process are especially promising (Tschan et al., 2004). The limited number of studies that do exist identified, for example, interaction processes that supported workplace learning (Collin & Valleala, 2005) or learning experiences from mono- and intercultural interactions in the workplace (Rozkwitalska, 2019). In the VET context, social interactions were also addressed in broader studies that examined general facilitating factors for trainees' workplace learning (Virtanen & Tynjälä, 2008; Virtanen et al., 2014). To our knowledge, there is neither a study that takes social interactions' situational characteristics into account when investigating workplace learning nor a study that explicitly examines social interactions' learning potential in the context of VET.

Furthermore, emotions (Benozzo & Colley, 2012; Hökkä et al., 2020) and personality traits (Cerasoli et al., 2018; Kyndt et al., 2013; Noe et al., 2014; Rintala et al., 2019) were identified as affecting learning in the workplace as well. Emotions are "an inevitable part of all workplace learning" (Beatty, 2011, p. 341) and "always colour learning" (Benozzo & Colley, 2012, p. 307). Personality traits are basic tendencies that impact a person's thoughts, feelings

and actions (McCrae & Costa, 1996). One of the most significant and widely used concepts in this field are the Big Five personality traits (Barrick & Mount, 1991; Li & Armstrong, 2015; Major et al., 2006), which include the five traits neuroticism, extraversion, openness to experience, agreeableness, and conscientiousness (McCrae & Costa, 1987, 1996, 1999). There is some empirical evidence that these traits can affect informal learning in the workplace (Li & Armstrong, 2015; Noe et al., 2013; Simmering et al., 2003; Takase et al., 2018). Although, as outlined, while there is some evidence on the influence of emotions as well as personality on workplace learning, only some of the studies were conducted in the context of social processes or contain social aspects. Moreover, the great majority of these studies was not conducted in the VET context.

Thus, based on data from a diary study, the present secondary analysis considers the hierarchical structure of the underlying data and addresses the influence of social interactions' situational characteristics, emotions, and personality traits on learning from VET trainees' social interactions in the workplace. First, we will provide an overview of the theoretical constructs and related empirical work. The method section comprises details on the participants, the study design, the measures, and the analytical approaches. In the result section, we will present the test statistics. Finally, the results and applied methods are discussed, and we will offer an outlook for future research in this field as well as practical implications.

3.3 Theoretical Framework and Related Research

3.3.1 Workplace Learning and Social Interactions at Work

There are a lot of different definitions for workplace learning (Manuti et al., 2015; Tannenbaum et al., 2010). A commonly used definition describes workplace learning as processes that lead to the construction of new skills and competencies through work (Billett, 2001b; Eraut, 2000; Harteis et al., 2008). In general, workplace learning includes both formal and informal learning activities (Eraut, 2000, 2004; Janssens et al., 2017; Rintala et al., 2019; Schürmann & Beausaert, 2016). Eraut (2000) lists several central characteristics of a formal learning situation. These are a predefined learning framework, that is some kind of organized, predescribed learning goals, the presence of a trainer or teacher, and the receipt of a credit or qualification. In contrast, informal learning can be categorized by the absence of these features. Informal learning is unintended, unstructured and opportunistic, implicit and takes place in the absence of a designated teacher or trainer (Eraut, 2004). Huge parts of workplace learning take place informally (Eraut, 2010), as only a certain amount of occupational action knowledge and competence can be learned through formal learning activities (Dehnbostel, 2009).

Social interactions play a significant role in informal workplace learning. By social interactions we refer to meaningful processes of verbal exchange between at least two people. In general, social interaction of any kind may contribute to satisfying the need for relatedness as introduced within the Self- Determination Theory of motivation (Deci & Ryan, 1985). In this vein, Tschan et al. (2004) found that the frequency and perceived quality of interactions predicted affective commitment and job satisfaction in a new job. This may be all the more important for trainees since the other basic needs postulated within the Self-Determination Theory (Deci & Ryan, 1985), the need for competence and the need for autonomy, are largely unmet for newcomers in the workplace. Beyond relatedness, work-related interaction may also be conducive to the acquisition of competence and, thus, satisfy the need for competence in the long run. Following on from this, Bandura (1971) already situated learning in a social context within his Social Learning Theory and Situated Learning Theory emphasizes it as well (Lave & Wenger, 1991).

Although only a few studies were conducted in this context, their results indicate that social interactions can in fact have a positive impact on workplace learning. For instance, different clinical social spaces were found to be relevant for nurses' workplace learning related to social interactions (Bono et al., 2007), and Rozkwitalska et al. (2017) and Rozkwitalska (2019) identified workplace learning as a frequent outcome of both, mono- and intercultural workplace interactions. Mulder (2013) revealed several significant correlations between feedback content characteristics and informal learning activities. Moreover, some significant relationships with informal learning activities were found for characteristics of the feedback delivery as well as for the perceived support for using the feedback. Daniels et al. (2009) identified as part of their experience sampling study that discussing problems with others to solve problems is a significant positive predictor of hourly learning assessed at the same time. Furthermore, it was shown that some of the most frequent informal workplace learning activities employees engage in are talking and collaborating with others as well as asking for and receiving feedback. In line with these findings, feedback, support and interacting with colleagues and supervisors were identified as important drivers for informal learning activities (Schürmann & Beausaert, 2016). In addition, Collin and Valleala (2005) revealed three main social situations at work that include interactions and foster learning in the workplace. These were 1) constant efforts to guarantee interaction and maintaining a sociable atmosphere and equality, 2) the production of categories, for example regarding customers, colleagues or work tasks resulting in categories knowledge, and 3) networked and situationally driven problem-solving.

Further studies identified feedback (Ellinger & Cseh, 2007; Janssens et al., 2017; Koopmans et al., 2006; Kyndt et al., 2009; Rausch, 2013; Takase et al., 2018), assistance from others (Ellinger & Cseh, 2007; Rausch, 2013), communication (Ellinger & Cseh, 2007; Janssens et al., 2017; Koopmans et al., 2006; Moon & Na, 2009; Warhust & Black, 2015), cooperation (Janssens et al., 2017), access to knowledge acquisition and information (e.g., participating in work groups or in conferences or workshops) (Janssens et al., 2017; Raes et al., 2015), (informal) coaching (Janssens et al., 2017; Kyndt et al., 2009; Warhust & Black, 2015), reflection (e.g., being asked for feedback by colleagues) (Janssens et al., 2017), informal networking with colleagues (Warhust & Black, 2015), asking questions (Ellinger & Cseh, 2007; Koopmans et al., 2006; Raes et al., 2015), constructive conflict (Raes et al., 2015), role playing (Ellinger & Cseh, 2007) as well as talking things through (Ellinger & Cseh, 2007) as being positively related to informal workplace learning. In the context of VET, discussions with employees (Virtanen & Tynjälä, 2008) as well as the availability of individual guidance and guidance concerning trainees' development and assessment (Virtanen et al., 2014) were found to be related to trainees' workplace learning.

Moreover, some studies have taken social interactions' situational characteristics into account but only a few of them were conducted in the learning context. Previously addressed interaction characteristics were, for example, frequency and duration (Marlow et al., 2018; Matic et al., 2014; Noguchi-Watanabe et al., 2021; Tschan et al., 2004; Weijs-Perrée et al., 2020), regularity (Eddy et al., 2006), formality (Eddy et al., 2006; Matic et al., 2014), quality (Marlow et al., 2018), speech activity (Matic et al., 2014; Tschan et al., 2004), openness (Jeon & Kim, 2012), spatiality (Matic et al., 2014; Weijs-Perrée et al., 2020), initiation (Eddy et al., 2006; Kirmeyer, 1988; Tschan et al., 2004), participants (Eddy et al., 2006; Kirmeyer, 1988; Weijs-Perrée et al., 2020), aspects of the relationship between them (Eddy et al., 2006), face-to-face vs. at distance (Eddy et al., 2006) or interaction content and purpose (Eddy et al., 2006; Kirmeyer, 1988; Marlow et al., 2018; Tschan et al., 2004; Weijs-Perrée et al., 2020). Regarding the workplace learning context, it was shown, for example, that effective interactions were more likely mutually initiated and less likely initiated by a third party. In addition, the involvement of a direct supervisor and a more mandatory interaction more likely resulted in a lower effectiveness (Eddy et al., 2006). Furthermore, Jeon and Kim (2012) investigated open communication as a characteristic on the organizational and team level and found it to be significantly positively related to learning through interaction with peers.

3.3.2 Personality, Emotions and Learning from Social Interactions

In addition to social interaction characteristics, personality traits and emotional experience can influence informal learning as well. Several personality traits like the Big Five personality traits, self-efficacy and goal orientation were found to influence informal workplace learning significantly positively (Cerasoli et al., 2018; Jeong et al., 2018; Kyndt et al., 2013; Noe et al., 2014; Rintala et al., 2019). For our study, we expect the Big Five personality traits (McCrae & Costa, 1987, 1996, 1999) to be particularly relevant, as they are related to interactions with others in the workplace (Mount et al., 1998).

The Big Five personality traits are an "empirical generalization about the covariation of personality traits" (McCrae & Costa, 1999, p. 139) and relatively time-stable during adult life (McCrae & Costa, 1996, 1999). A person's specific trait profile influences his or her feelings, thoughts and actions (McCrae & Costa, 1996). The Big Five comprise the five traits of neuroticism, extraversion, openness to experience, agreeableness, and conscientiousness (McCrae & Costa, 1987, 1996, 1999). Persons high in neuroticism are characterized as being insecure, self-conscious, temperamental, and worrying. Furthermore, negative affect is central to neuroticism. This includes, for instance, feelings of depression, anger, anxiety and embarrassment (McCrae & Costa, 1987). Persons high in extraversion are described as being friendly, sociable, affectionate, and fun loving. The trait of openness to experience can be described with the adjectives imaginative, original, daring and broadly interested. It is further reflected in fantasy, feelings, ideas and aesthetics (McCrae & Costa, 1987). Agreeable people are sympathetic, helpful, cooperative and kind (McCrae & Costa, 1987; Saucier, 1994), while conscientious people are generally more scrupulous, dutiful, self-disciplined, ambitious and hardworking (McCrae & Costa, 1987). Tschan et al. (2004) found only very small effects of extraversion and social competences on the frequency and quality of interactions recorded in their diary study with 54 young professionals. Nevertheless, the expectation of an effect still appears plausible.

Concerning the Big Five personality traits and workplace learning, Noe et al. (2013) found significant positive correlations between all Big Five traits and informal learning, which included aspects of learning from oneself, learning from others and learning from non-interpersonal sources. However, when included in the regression analysis, they did not significantly predict informal learning. In their study on experiential learning styles according to Kolb (1984), Li and Armstrong (2015) identified extraversion as a significant positive predictor of learning from concrete experience (CE) and active experimentation (AE) and as a significant negative predictor of learning from reflective observation (RO) and abstract conceptualization (AC). Furthermore, agreeableness and conscientiousness predicted learning from CE

significantly negatively. In another study, conscientiousness was also significantly positively related with postfeedback development at the ten percent significance level (Simmering et al., 2003). Moreover, Takase et al. (2018) found extraversion, conscientiousness and openness to experience to be significantly positively related to overall workplace learning, composed of learning from practice, learning from feedback, learning from training, learning from others and learning from reflection. Extraversion was also significantly positively related to all facets of workplace learning, while conscientiousness was significantly positively related to all facets but learning from others. Openness to experience showed significant positive relationships with learning from practice and learning from reflection. In addition, in a subsequent regression analysis, results yielded that extraversion and conscientiousness were both positive predictors of overall workplace learning as well.

Three out of four presented studies to some degree include informal learning related to social interactions. However, Noe et al. (2013) include it as one of three learning aspects summarized in a general variable addressing informal workplace learning. Regarding the study by Simmering et al. (2003), it is not entirely clear whether the participants got their feedback in solely written form or with additional feedback discussions, for example, and the development activities again include various aspects and sources of informal learning. Based on the presented empirical results and theoretical considerations, we expect some relations of the Big Five and informal learning from social interactions. However, due to the explorative nature of the research we do not formulate concrete hypotheses.

In accordance with the theoretical considerations of Noe et al. (2013), it may be likely that more agreeable people are more inclined to ask other people for help and generally engage in more frequent conversations as they are friendlier and more cooperative (McCrae & Costa, 1987; Saucier, 1994). In addition, we can imagine that because of this trait, these people also have quite good relationships with their colleagues and superiors, which makes them easier to approach and other people more willing to help. Beyond the empirical findings already presented on the influence of extraversion on workplace learning, in our opinion it may be possible that more extraverted people being sociable (McCrae & Costa, 1987) are also more likely to initiate and participate in conversations and that they are more likely to ask questions. Because extraverts like to socialize, they may tend to ask a person rather than use another source of help when they have a problem or question. All of these aspects may promote learning from social interactions (see also Noe et al., 2013).

Conscientiousness may be related to learning from social interactions as well, as people with this trait are generally more ambitious and scrupulous (McCrae & Costa, 1987) which may

motivate them to seek help when faced with a problem or question (e.g., by asking other persons). Empirical evidence by Takase et al. (2018) may point to the expected relationship regarding extraversion and conscientiousness. Openness to experience is related to a broad interest in different things (McCrae & Costa, 1987). This may lead to people being very open-minded and interested in social interactions (McCrae & Costa, 1987), which could also have a positive effect on learning from them. People high in neuroticism are generally more insecure, affecting social interactions and subsequent learning outcomes as well (McCrae & Costa, 1987). For example, individuals with high neuroticism scores might be less confident to initiate and participate in social interactions. In addition, they might avoid asking questions and the associated acknowledgement of a lack of knowledge due to their uncertainty. As high neuroticism goes along with negative emotions (McCrae & Costa, 1987), these could also impact learning in different directions, something which will be discussed in more detail in the next section. Thus, we can imagine that all Big Five traits have an impact on learning from social interactions, which would at least be consistent with the correlational results of Noe et al. (2013).

Kleinginna and Kleinginna (1981) list 92 different definitions of emotions in the psychological literature and derive a comprehensive definition from them. According to them, emotion "is a complex set of interactions among subjective and objective factors, mediated by neural/hormonal systems, which can (a) give rise to affective experiences such as feelings of arousal, pleasure/displeasure; (b) generate cognitive processes such as emotionally relevant perceptual effects, appraisals, labeling processes; (c) activate widespread physiological adjustments to the arousing conditions; and (d) lead to behavior that is often, but not always, expressive, goal-directed, and adaptive" (Kleinginna & Kleinginna, 1981, p. 355). Research on emotions usually focuses on the subjective experience component. Furthermore, emotions are often considered to have a state and a trait component. While the trait component comprises stable individual differences in emotional experiences, the state component refers to transient episodes of emotional experiences or deviations in emotional responsiveness from the baseline (Nett et al., 2017; Watson & Clark, 1994).

Focusing on the subjective and the state component, Russell (1980) assumes in his circumplex model that emotions can be represented in one plane from a combination of the horizontal dimension *pleasure – displeasure* and the vertical dimension *arousal – sleep*. The first dimension is also referred to as valence, the latter as arousal (Feldman Barrett & Barrett, 1998; Russell, 1980). A classification of emotions based on these two dimensions leads to a circular arrangement of them in one plane within the circumplex model (Russell, 1980). Within the scope of the Affective Events Theory (Weiss & Cropanzano, 1996) work related events are

regarded in particular as the cause of emotional experiences in the workplace that again influence behavior and work attitudes. Furthermore, the Control-Value Theory (Pekrun, 2006) emphasizes the importance of achievement emotions on learning through motivational and cognitive mechanisms (Pekrun & Perry, 2014). Any emotion can be more or less useful for learning. Therefore, it would be inadequate to expect positive emotions to provoke learning and negative emotions to prevent learning (Pekrun & Perry, 2014). Although the Control-Value Theory refers primarily to the school context, its outlined general assumptions also hold for learning processes within the work context.

Several studies found emotions to influence informal workplace learning (Benozzo & Colley, 2012; Hökkä et al., 2020), but only some were conducted in the context of social processes. Daniels et al. (2009), for example, identified in their experience sampling study significant positive correlations of hourly learning with momentary activated pleasant affect and discussing problems to solve problems as well as momentary anxious affect with discussing problems to solve problems. Reio and Callahan (2004) found significant positive correlations of a modified version of the Workplace Adaptation Questionnaire, representing socialization-related learning in the workplace, with state anger, state curiosity and trait curiosity. In addition, the results of two subsequent path models yielded that state curiosity and trait curiosity affected socialization-related learning significantly positively. Moreover, Sebrant (2008) investigated nurses' workplace learning in a qualitative study and the results showed that envy between two groups of nurses led to less cooperation and learning from each other.

Altogether, there is a deep theoretical foundation and rich empirical evidence for the significance of social interactions for workplace learning as well as the influence of personality traits and emotions. However, only a few studies address the influence of personality traits and emotions on workplace learning in a social context and none of them were conducted within VET. Based on the theoretical considerations and empirical evidence as well as the shortcomings of previous research, we address the following three research questions:

- RQ1: How do social interactions' situational characteristics affect self-perceived learning from these interactions?
- RQ2: How do emotional experiences affect self-perceived learning from social interactions in the workplace?
- RQ3: How do personality traits affect self-perceived learning from social interactions in the workplace?

3.4 Method

To investigate the above research questions, a diary study with a preceding questionnaire was conducted. Data was analyzed using multilevel analysis.

3.4.1 Participants

To address the research questions, we conducted a diary study with 50 trainees within the German "Dual System" of vocational education and training (VET). The trainees were employed at a medium-sized utility company in Germany with 2,500 employees, amongst them 175 trainees, of which 50 participated in our study. They were at different stages of their apprenticeship programs and assigned in different departments, which is typical for dual apprenticeship. The mean age was 18.2 (SD = 1.04; min = 16; max = 21), 29 participants were female and 21 were male. A total of 22 of them were trainees in commercial trades (e.g., industrial management assistant; German: "Industriekaufmann/-frau") and 28 were trainees in technical trades (e.g., industrial mechanic; German: "Industriemechaniker/in").

3.4.2 Procedure

A semi-standardized diary was applied to collect data in situ and to avoid the typical memory biases of retrospective measures such as questionnaires and interviews (Bolger et al., 2003; Ohly et al., 2010; Rausch, 2014). During the diary period, which comprised ten working days, the participants were instructed to record five typical social interactions at work every day. Considering school attendances (usually 1.5 days a week), holidays, illness or work-related hindrances, the diary period was set to four weeks. The participants were asked to record the interaction as soon as possible or only a few minutes after the interaction had occurred. In the context of this study, we were interested in interactions they had with trainers, supervisors, other trainees and so forth in their working day. Before the diary period, a workshop was conducted to clarify the term "social interaction" and to familiarize the participants with the diary. Before and after the diary period, the participants completed a self-report questionnaire, one of which included scales on the Big Five personality traits.

3.4.3 Measures

Semi-standardized diary Most of the items in the diary were standardized in that they offered a list of possible characteristics to choose from or a statement that had to be rated on a given scale. This was to ensure that an entry required only a minimum of effort. The diary was implemented as a paper-and-pencil version and was to be deposited in sealed boxes after the diary period.

To gain information on the interaction content, one item required the participants to choose from a list of possible contents for the social interaction (multiple selection): (a) an actual task demanded cooperation; (b) a concrete problem / an exception popped up, (c) instruction for new procedures that were unknown before; (d) planning / coordination upcoming workflows; (e) receiving feedback on past performance; (f) general issues concerning my apprenticeship program; (g) small talk / gossip; (h) other content. Thereafter, the participants gave a short complementary verbal description of the social interaction's context. Moreover, six situational characteristics had to be rated: (i) speech proportion (1 = *I hardly said anything* to 6 = I *talked all the time*); (ii) questions asked (1 = *I asked no questions at all* to 6 = *I asked a great many questions*); (iii) atmosphere (1 = *very tense* to 6 = *very open*); (iv) time pressure (1 = *very high* to 6 = *no pressure at all*); (v) instrumentality (1 = *not helpful at all* to 6 = *very helpful*); (vi) self-perceived learning (1 = *learned nothing at all* to 6 = *learned a great deal*). These characteristics were derived from the presented theory and empirical studies as well as own considerations.

In addition, the participants indicated their emotional states throughout the social interaction. Eight emotional states were arranged according to common circumplex models of emotion with valence on the x-axis and arousal on the y-axis (Russell, 1980). The participants were asked to choose up to three out of eight emotional states they experienced during the social interaction and rate how strongly they experienced them (1 = *a little* to 3 = *very*). Each emotional state was described using three adjectives. These were (a) *motivated / delighted / curious*, (b) *confident / happy / glad*, (c) *contented / accepted / proud*, (d) *calm / even-tempered / daydreaming*, (e) *bored / dull / uninterested*, (f) *unhappy / gloomy / sad*, (g) *irritated / annoyed / angry* and (h) *nervous / worried / afraid*. Emotional states that were not chosen were coded with zero.

On average, the trainees kept the diary on 9.7 days and recorded 41.5 interactions each, resulting in n = 2,077 recorded interactions. Participants that recorded less than 20 interactions were excluded from the analyses. After that, 43 participants who recorded n = 1,989 interactions were left. Of the 1,989 social interactions, 452 interactions occurred as (a) the actual task demanded cooperation; 259 interactions occurred due to (b) a concrete problem / exception; 307 social interactions were (c) instructions; 423 social interactions referred to (d) the planning or coordination of upcoming workflows; in 108 interactions the trainees (e) received feedback; 198 interactions included (f) general issues concerning the apprenticeship program; 269 social interactions contained (g) small talk or gossip and 349 interactions were classified as (h) other content. Multiple assignments were possible. A total of 16.2 percent of social interactions were

allocated to more than one content type. Table 3-1 provides some examples of the verbal description of social interactions out of the trainees' diaries that were allocated to the different content types from (a) to (h).

To investigate the research questions, only work-related interactions were included. These were the interaction categories (a) actual task demanded cooperation, (b) a concrete problem / an exception, (c) instruction, (d) planning / coordination upcoming workflows and (e) receiving feedback. 1,328 social interactions with these contents were reported by the participants. Little's MCAR-Test indicated that the missing values were not missing completely at random (Chi-square = 703.2782, df = 270, p = < 0.001). We assumed that the missing data mechanism is missing at random (MAR) (Newman, 2014) and imputed the missing data by using the R package mice (van Buuren & Groothuis-Oudshoorn, 2011). As recommended by Grund et al. (2018), we generated 20 imputations for the missing values.

Self-report questionnaire To measure the Big Five personality traits, we administered the German version of Saucier's (1994) "Big Five Mini-Markers" by Weller and Matiaske (2009). Sample adjectives for neuroticism are moody and jealous, for extraversion talkative and extraverted, for openness creative and intellectual, for agreeableness sympathetic and warm and for conscientiousness organized and practical. These mini markers consist of a list of 40 adjectives that are rated on a seven-point Likert-scale from 1 = *extremely inaccurate* to 7 = *extremely accurate*. The Cronbach's α were calculated for Extraversion (α = 0.80), Neuroticism (α = 0.80), Conscientiousness (α = 0.80), Agreeableness (α = 0.69) and Openness (α = 0.50). The first three values are satisfactory (Streiner, 2003).

Table 3-2 shows means, standard deviations and correlations between the main study variables for the n = 43 participants and the n = 1,328 social interactions included in the regression analysis.

3.4.4 Multilevel Analysis

As the diary data is nested within persons, the data are analyzed by means of multilevel analysis (Hox et al., 2018; Snijders & Bosker, 2012). Multilevel analysis is a statistical approach for datasets with nested sources of variability (Snijders & Bosker, 2012). It aims at explaining variance sources at different levels of analysis (Hoffman & Rovine, 2007). As a rule of thumb, to conduct a multilevel analysis, at least 30 groups on the highest level should be available to reliably estimate the coefficients and standard deviations (Maas & Hox, 2005). This precondition is fulfilled by the present dataset. Although the data of the present analyses are multiple observations nested in persons, it is not necessary to analyze the data as longitudinal data because the intra-individual variation in social interactions over four weeks is not considered a

Table 3-1: Examples of every content type for social interactions

Content type	n	Examples from diary entries
(a) Actual task demanded cooperation	452	- The installation of a streetcar front windscreen - Calling a supplier, because questions arose regarding the invoice sent to us. According to our records, the invoice was already paid
(b) concrete problem / exception	259	- Changing the drill head - I didn’ t know where to put the mail
(c) instruction	307	- Procedure for feeding electricity into the grid (photovoltaic systems) - Get circuit diagrams of the subway explained and asked appropriate questions about it
(d) planning / coordination upcoming workflows	423	- Planning of today’ s tasks - Changes in my activities - new task assigned, which was more urgent in the moment
(e) receiving feedback	108	- Appraisal session with Mr. XY about past training phase - Praise for task well done
(f) general issues concerning apprenticeship program	198	- It was discussed when I want to take leave in the department - Intermediate examination discussed
(g) small talk / gossip	269	- Work colleague getting married received a gift from the department with congratulations - It was about a television program that ran the night before
(h) other content	349	- We studied for the presentation at school and thought about the schedule - Showing the intern the location

Note. Multiple assignments were possible.

Table 3-2: Means, standard deviations and correlations between study variables

Variable	M	SD	M	SD	1	2	3	4	5	6	7	8
Big Five												
1. Extraversion	4.92	0.88	-	-	-	–.03	.04	.27	.33*	–.19	.05	–.05
2. Neuroticism	2.74	0.89	-	-	-	-	–.41**	–.06	–.00	.23	.04	.14
3. Conscientiousness	5.89	0.72	-	-	-	-	-	.20	.29	–.36*	–.28	–.14
4. Agreeableness	6.12	0.49	-	-	-	-	-	-	.16	–.02	–.02	.22
5. Openness	5.01	0.56	-	-		-	-	-	-	–.34*	–.46**	–.39**
Emotional experience												
6. nervous / worried / afraid	0.15	0.23	0.13	0.46	–.11***	.12***	–.14***	–.00	–.12***	-	.74***	.68***
7. unhappy / gloomy / sad	0.06	0.16	0.04	0.26	.00	0.03	.13***	–.02	–.19***	.29***	-	.80***
8. irritated / annoyed / angry	0.10	0.18	0.09	0.40	–.03	.09***	–.05	.07**	–.11***	.22***	.44***	-
9. bored / dull / uninterested	0.11	0.19	0.10	0.38	–.04	.12***	–.09**	.13***	–.19***	.08**	.18***	.40***
10. motivated / delighted / curious	1.74	0.54	1.71	1.16	.17***	–.03	.11***	.06*	.19***	–.10***	–.12***	–.21***
11. contented / accepted / proud	0.64	0.56	0.60	1.01	.12***	.02	0.05	.02	.05	–.08**	.01	–.04
12. confident / happy / glad	1.34	0.62	1.36	1.21	.25***	–.09**	.12***	.06*	.21***	–.17***	–.08**	–.16***
13. calm / even-tempered / daydreaming	0.53	0.42	0.48	0.82	–.03	.07**	–.11***	–.04	–.16***	–.05	.03	–.02
Characteristics of social interactions												
14. interruption	0.14	0.14	0.12	0.32	–.12***	.10***	–.03	.05	.01	.06*	–.03	–.01
15. instrumentality	3.53	0.76	3.55	1.58	–.02	–.01	–.12***	–.03	.07*	.05*	–.01	–.08**
16. time pressure	5.24	0.84	5.27	1.18	.10***	–.15***	.13***	.03	.19***	–.20***	–.05	–.10***
17. atmosphere	5.18	0.61	5.21	0.99	.21***	–.16***	.13***	.02	.24***	–.21***	–.07**	–.22***
18. questions asked	2.91	0.62	2.89	1.25	–.03	.06*	–.02	–.18***	.06*	.12***	.06*	.01
19. speech proportion	3.04	0.54	3.05	1.02	–0.05	–.07*	.09**	–.04	.03	.05	.01	.03
20. self-perceived learning	2.30	0.75	2.22	1.55	–.03	.08**	–.12***	.03	.09***	.05	.02	–.03

Notes. Means and standard deviations at the person level are displayed in column 1 and 2; means and standard deviations at the day level are displayed in columns 3 and 4; Correlations above the diagonal refer to person level data (level 2) ($N = 43$), with day level variables aggregated at the person level. Correlations below the diagonal refer to day level diary data (level 1) (n = 1,328). *$p < 0.05$, ** $p < 0.01$, ***$p < 0.001$.

Table 3-2: Means, standard deviations and correlations between study variables (continued)

Variable	9	10	11	12	13	14	15	16	17	18	19	20
Big Five												
1. Extraversion	–.03	.35*	.19	.45**	.05	–.23	.01	.14	.30	–.10	–.08	.11
2. Neuroticism	.23	–.04	.01	–.20	.16	.29	.02	–.20	–.29	.10	–.23	.16
3. Conscientiousness	–.26	.14	.04	.18	–.33*	–.17	–.26	.16	.21	–.10	.17	–.37*
4. Agreeableness	.32*	.16	–.03	.19	–.03	.22	–.08	.03	.04	–.40**	–.03	.06
5. Openness	–.51***	.28	.01	.30*	–.33*	.09	.19	.20	.28	.04	.04	.12
Emotional experience												
6. nervous / worried / afraid	.59***	.10	.12	–.03	.41**	.23	.15	–.20	–.21	.45**	–.02	.40**
7. unhappy / gloomy / sad	.69***	.14	.38*	.18	.62***	–.10	–.01	.02	.06	.22	–.00	.24
8. irritated / annoyed / angry	.84***	.06	.23	.05	.40**	.14	–.19	–.01	–.11	.13	–.03	.16
9. bored / dull / uninterested	-	.05	.23	.04	.47**	.26	–.20	–.09	–.12	–.01	–.08	.20
10. motivated / delighted / curious	–.21***	-	.47**	.61***	–.07	–.06	.15	.38*	.46**	.20	–.07	.25
11. contented / accepted / proud	–.05	.17***	-	.49***	.31*	–.00	–.08	.34*	.37*	.05	–.01	.20
12. confident / happy / glad	–.18***	.19***	.17***	-	.20	–.18	–.05	.43**	.70***	.07	.14	.10
13. calm / even-tempered / daydreaming	.05	–.16***	–.09***	–.13***	-	.11	–.08	.01	.08	.05	.05	.26
Characteristics of social interactions												
14. interruption	.09***	.02	–.02	–.02	.05	-	–.05	–.10	–.37*	.07	.14	.23
15. instrumentality	–.12***	.19***	.01	.04	–.06*	.05	-	–.03-	–.04	.32*	.07	.52***
16. time pressure	–.08**	.16***	.14***	.19***	.03	–.08**	.02	-	.63***	–.17	–.21	.13
17. atmosphere	–.17***	.23***	.15***	.33***	.04	–.12***	–.01	.36***	-	–.12	–.03	–.03
18. questions asked	–.05	.18***	–.02	.04	–.06*	.07*	.42***	–.09**	–.04	-	.40**	.33*
19. speech proportion	–.03	–.02	.11***	.10***	–.08**	.00	.04	–.11***	.02	.28***	-	–.04
20. self-perceived learning	.01	.25***	.04	.07*	–.02	.13***	.54***	.06*	–.01	.38***	–.07*	-

Notes. Means and standard deviations at the person level are displayed in column 1 and 2; means and standard deviations at the day level are displayed in columns 3 and 4; Correlations above the diagonal refer to person level data (level 2) ($N = 43$), with day level variable aggregated at the person level. Correlations below the diagonal refer to day level diary data (level 1) (n = 1,328). *$p < 0.05$, ** $p < 0.01$, ***$p < 0.001$.

function of time (Enders & Tofighi, 2007; Nezlek, 2001). Predictors on level 2 were centered at the grand mean, predictors on level 1 on the group mean (Enders & Tofighi, 2007). To control for the baseline level of emotional experience and the baseline level of interaction situational characteristics for every trainee, the group mean, and therefore the mean for each trainee is used as a supplementary control variable. These refer to the trait component of emotional experiences and interaction characteristics.

The presented research questions are tested in a series of multilevel models using the free software R. First the control variables are included (Model 1), then the characteristics of the social interaction (Model 2), after that the emotional experience (Model 3) and in Model 4 we included the Big Five personality traits. All models were calculated as means-as-outcomes models. To check for the improvement of model fit, the Δ-2*log statistics are calculated. The number of *dfs* resulted from the number of new predictors added. The Pseudo-R^2 value is calculated according to the formula proposed by Snijders and Bosker (2012).

3.5 Results

Before the investigation of the research questions, we calculated the intraclass correlation coefficient (ICC), using the intercept-only model. The ICC for self-perceived learning from social interactions is 0.186, indicating that 18.6 percent of the variance can be explained by differences in Level 2 and therefore by differences between the persons. Although the use of multilevel models is generally recommended for nested data, this ICC value clearly advocates multilevel modeling (Musca et al., 2011; Nezlek, 2008).

The analysis was started by computing the intercept-only model. In model 1, we included the control variables to control for the baseline level of emotional experiences and the general level of the social interactions' characteristics for the single participants. Table 3-3 shows the results of all models. Model 1 fits the data better than the intercept-only model. The *baseline level of instrumentality* of social interactions (= Ø instrumentality) was a significant predictor for the self-perceived learning from social interactions ($B = 0.473$, $SEB = 0.112$, $p < 0.001$).

In model 2, we added the situational characteristics of the social interactions as predictors. The model fit further increased. The characteristics *interruption* ($B = 0.311$, $SEB = 0.104$, $p < 0.01$), *instrumentality* ($B = 0.464$, $SEB = 0.025$, $p < 0.001$) and *questions asked* by the trainee ($B = 0.274$, $SEB = 0.032$, $p < 0.001$) were identified to be positive significant predictors of self-perceived learning from social interactions. The characteristic *speech proportion*, however, was a significant negative predictor ($B = -0.175$, $SEB = 0.036$, $p < 0.001$).

Table 3-3: Multilevel estimates for models predicting self-perceived learning from social interaction

	Null model			Model 1				Model 2				Model 3				Model 4			
	Estimate	**SE**	**t**	**Estimate**	**SE**	**Beta**	**t**	**Estimate**	**SE**	**Beta**	**t**	**Estimate**	**SE**	**Beta**	**t**	**Estimate**	**SE**	**Beta**	**t**
Intercept	2.2832	0.111	20.62***	-0.192	1.136		-0.169	-0.288	1.153		-0.250	-0.291	1.154		-0.252	-0.153	1.131		-0.135
Control variables																			
Ø nervous / worried / afraid				1.260	0.638	.427	1.976	1.065	0.645	.361	1.652	1.076	0.645	.365	1.677	1.168	0.656	.396	1.780
Ø unhappy / gloomy / sad				-2.089	1.129	-.490	-1.850	-1.709	1.142	-.401	-1.496	-1.739	1.143	-.408	-1.522	-1.569	1.271	-.368	-1.235
Ø irritated / annoyed / angry				-0.056	1.092	-.014	-0.051	-0.112	1.108	-.029	-0.101	-0.115	1.109	-.030	-0.103	-0.442	1.117	-.115	-0.395
Ø bored / dull / uninterested				0.846	0.831	.234	1.017	0.808	0.837	.224	0.965	0.823	0.838	.228	0.982	1.106	0.930	.307	1.189
Ø motivated / delighted / curious				0.062	0.214	.049	0.289	0.061	0.217	.049	0.283	0.062	0.217	.050	0.287	0.011	0.207	.009	0.052
Ø contented / accepted / proud				0.179	0.178	.146	1.009	0.163	0.180	.132	0.905	0.164	0.180	.134	0.913	0.216	0.170	.175	1.269
Ø confident / happy / glad				0.137	0.211	.123	0.650	0.127	0.214	.114	0.591	0.125	0.214	.112	0.584	-0.053	0.213	-.048	-0.248
Ø calm / even-tempered / daydreaming				0.468	0.270	.286	1.732	0.445	0.273	.272	1.632	0.449	0.273	.274	1.645	0.432	0.258	.264	1.671
Ø instrumentality				0.473	0.112	.527	4.216***	0.481	0.114	.536	4.204***	0.481	0.115	.536	4.199***	0.379	0.114	.422	3.322**
Ø time pressure				0.223	0.125	.273	1.781	0.212	0.128	.259	1.658	0.214	0.128	.262	1.673	0.240	0.120	.294	1.998
Ø atmosphere				-0.213	0.209	-.190	-1.019	-0.190	0.213	-.170	-0.889	-0.193	0.214	-.172	-0.904	-0.186	0.202	-.166	-0.922
Ø questions asked				0.151	0.178	.137	0.850	0.165	0.179	.149	0.922	0.164	0.179	.149	0.920	0.246	0.198	.222	1.241
Ø speech proportion				-0.170	0.171	-.134	-0.992	-0.174	0.173	-.137	-1.006	-0.170	0.173	-.135	-0.984	-0.141	0.173	-.112	-0.816
Characteristics of the social interaction																			
interruption								0.311	0.104	.220	2.982**	0.277	0.104	.196	2.667**	0.266	0.104	.188	2.562*
instrumentality								0.464	0.025	.451	18.248***	0.447	0.026	.435	17.512***	0.447	0.026	.435	17.516***
time pressure								0.040	0.038	.024	1.069	0.031	0.038	.018	0.812	0.030	0.038	.018	0.805
atmosphere								0.003	0.041	.002	0.084	-0.024	0.042	-.013	-0.561	-0.024	0.042	-.013	-0.563
questions asked								0.274	0.032	.215	8.516***	0.259	0.032	.204	8.078***	0.259	0.032	.204	8.079***

Table 3-3: Multilevel estimates for models predicting self-perceived learning from social interaction (continued)

	Null model			Model 1				Model 2				Model 3				Model 4			
	Estimate	**SE**	**t**	**Estimate**	**SE**	**Beta**	**t**	**Estimate**	**SE**	**Beta**	**t**	**Estimate**	**SE**	**Beta**	**t**	**Estimate**	**SE**	**Beta**	**t**
speech proportion								-0.175	0.036	-.109	-4.792***	-0.169	0.038	-.106	-4.605***	-0.170	0.037	-.106	-4.608***
Emotional experiences																			
nervous / worried / afraid												-0.109	0.081	-.032	-1.336	-0.108	0.081	-.032	-1.332
unhappy / gloomy / sad												0.008	0.149	.001	0.055	0.008	0.149	.001	0.056
irritated / annoyed / angry												-0.029	0.098	-.008	-0.296	-0.030	0.098	-.008	-0.301
bored / dull / uninterested												0.267	0.099	.066	2.708**	0.268	0.099	.066	2.717**
motivated / delighted / curious												0.167	0.034	.120	4.938***	0.167	0.034	.120	4.943***
contented / accepted / proud												-0.004	0.037	-.002	-0.095	-0.004	0.037	-.002	-0.096
confident / happy / glad												0.042	0.032	.031	1.321	0.042	0.032	.031	1.328
calm / even-tempered / daydreaming												-0.047	0.046	-.024	-1.021	-0.046	0.046	-.024	-1.014
Big Five																			
Extraversion																0.100	0.106	.128	0.943
Neuroticism																-0.090	0.101	-.118	-0.901
Conscientiousness																-0.205	0.131	-.216	-1.565
Agreeableness																0.134	0.229	.069	0.584
Openness																0.284	0.201	.234	1.409
-2 * log	4771.665			4736.931				4171.490				4132.701				4125.829			
Diff -2*log				34.724***				565.440***				38.789***				6.872			
Δ df				13				6				8				5			
$R2^2$Level 1				0.12				0.40				0.41				0.43			

Note. * $p < 0.05$ ** $p < 0.01$ ***$p < 0.001$

In model 3, the emotional experiences during the social interactions were included as predictors. Again, the model fit improved and the emotional experiences *bored / dull / uninterested* ($B = 0.267$, $SEB = 0.099$, $p < 0.01$) and *motivated / delighted / curious* ($B = 0.167$, $SEB = 0.034$, $p < 0.001$) were positive significant predictors of the self-perceived learning from social interactions. Emotions' baseline level did not have a significant influence. In model 4, the Big Five personality traits were included as predictors. However, the model fit did not improve significantly.

Regarding the standardized coefficients in model 3, the *baseline level of the instrumentality* of social interactions ($\beta = 0.536$) and the *instrumentality* of the current interaction ($\beta = 0.435$) were the strongest predictors of self-perceived learning from social interactions. Furthermore, there were moderate effects of *questions asked* ($\beta = 0.204$), the occurrence of an *interruption* ($\beta = 0.196$) and a low *speech proportion* ($\beta = -0.106$). Regarding emotional experiences, feeling *motivated / delighted / curious* was the strongest predictor ($\beta = 0.120$).

3.6 Discussion

In this study, we investigated the effects of situational characteristics of social interactions, emotional experiences and personality on learning from these social interactions at work. Data from 43 trainees within the German dual system of vocational education and training (VET) were analyzed. These trainees recorded 1,328 work-related social interactions. A multilevel analysis was conducted to address three research questions on the influences of the characteristics of social interactions (RQ1), of emotional experiences (RQ2), and of personality traits (RQ3) on self-perceived learning from social interactions. RQ1 and RQ2 are addressed based on model 3 of the multilevel analysis because the inclusion of the Big Five personality traits (RQ3) in model 4 did not further improve the model fit.

RQ1 addressed the influence of situational characteristics of social interactions on self-perceived learning from these interactions. The results reveal that the *baseline level of instrumentality* (= Ø instrumentality in Table 3-3) of the social interactions, an *interruption* of the social interaction, the *instrumentality* of social interactions and *questions asked* are significant positive predictors of self-perceived learning from social interactions. The trainees' *speech proportion*, however, is a significant negative predictor of learning. It seems plausible for novices that asking questions and listening to answers by more experienced co-workers is conducive to learning. In addition, this is in line with the findings of other studies that also identified asking questions as a behavior supporting learning (Koopmans et al., 2006; Raes et al., 2015).

Furthermore, not only does the perceived instrumentality of an interaction (i.e. the perception of how helpful the current interaction is) foster learning but also the baseline level of instrumentality (i.e. an individual's general tendency to perceive interactions as instrumental for their work activities) fosters learning. This general tendency can be due to individual dispositions such as interest or a general openness, but it can also be caused by contextual factors such as particularly supportive colleagues. The positive influence of an interruption of the social interactions on self-perceived learning is surprising. Unfortunately, we do not have information on the type of interruption. It might be that a more experienced colleague explained a current work task when the interruption occurred. During this pause the trainee might have reflected on his or her understanding and might have thought about clarifying questions. However, it could also be that the explaining person was forced to continue with a current work task and the trainee learned from observing. Finally, the longer an interaction takes, the higher the probability that an interruption occurs, while the probability that there are opportunities to learn is also higher. In line with this, the duration of a social interaction and an interruption of the interaction are significantly positively related in our data ($r = 0.26$, $p < 0.001$).

RQ2 addressed the influence of emotional experience during social interactions on self-perceived learning from social interactions. Results reveal that feeling *motivated / delighted / curious*, that is states of high arousal and medium pleasure, as well as feeling *bored / dull / uninterested*, that is states of moderate displeasure and high sleepiness, have a significant positive influence on self-perceived learning from social interactions. Thus, according to our results, high levels at both ends of the continuum *arousal – sleep* seem to promote learning. Regarding emotions with high arousal, a lot of other studies found a positive influence of motivation on workplace learning as well (Cerasoli et al., 2018; Rintala et al., 2019; Tynjälä, 2013). In addition, Reio and Callahan's (2004) results yielded a significant positive effect of state curiosity on socialization-related learning, which is in line with our results. The positive influence of states of moderate displeasure and high sleepiness is surprising. As such a state boredom usually has a negative impact on learning (Goetz & Hall, 2014). However, Nett et al. (2011) found that the "behavioral-approach" towards coping with boredom includes behaviors to change the situation, for instance, by asking for other tasks that are more interesting and challenging. That in turn could encourage learning. Another possible explanation is the assumption that boredom arises from being underchallenged (Csikszentmihalyi, 1988), which was found in first-year VET trainees by Nickolaus et al. (2009). Therefore, in our study, it could be that high-ability trainees who quickly understand what is discussed experience states of low arousal and lower pleasure rather than being challenged by possible further explanations and examples.

Hence, these emotional states during the interactions would point to trainees' already high competencies. We could not find a significant influence of emotions' baseline level. Thus, in contradiction to, for example, Reio and Callahan (2004), we did not find a significant impact of emotional experiences' trait component on learning.

RQ3 addressed the influence of the Big Five personality traits on self-perceived learning from social interactions. The inclusion of the Big Five in Model 4 did not improve the model fit. Therefore, it can be concluded that the Big Five have no significant influence on self-perceived learning from social interaction. However, they show several significant correlations with emotional experiences. It is possible that other personality traits that we did not include in our analysis are more important in this context. This could include, for example, zest (Noe et al., 2013). Looking at the standardized regression coefficients, results show that the strongest predictor is found in the situational characteristics of the interactions, that is the baseline level of instrumentality. Social interactions characteristics' inclusion in the regression analysis also led to the largest increase in explained variance in self-perceived learning from social interactions. Including emotional experiences hardly increased the explained variance.

In summary, our results confirm social interactions' potential to foster informal workplace learning as also found in a some prior studies (Bono et al., 2007; Daniels et al., 2009; Mulder, 2013; Rozkwitalska, 2019; Rozkwitalska et al., 2017; Schürmann & Beausaert, 2016). According to our results social interactions with a low speech proportion of trainees but in which they have the opportunity to ask questions, that include interruptions and that provoke emotional experiences of moderate displeasure and high sleepiness as well as states of high arousal and medium pleasure are conducive for self-perceived learning from social interactions. Furthermore, our research opens the avenue to explicitly include situational characteristics of social interactions into research. Regarding emotional experiences, there are very few studies on the effect of positive emotions on workplace learning (Hökkä et al., 2020). Together with these existing studies (Daniels et al., 2009; Owen, 2016; Rausch et al., 2015; Rausch et al., 2017; Watzek et al., 2019) our research helps address this gap. Moreover, applying the diary method provided valuable insights into the situational characteristics of trainees' everyday social interactions in the workplace. In addition, it meets Tschan et al.'s (2004) calls to study social interactions by means of microanalyses and in natural settings.

3.7 Limitations

Our study has several limitations. Firstly, reporting learning requires being aware of it. Implicit learning, however, often happens without one being aware of it (Eraut, 2000, 2004).

Furthermore, learning was addressed with only one item in the diary. Hence, some aspects of informal learning may therefore not be evident in the diaries. In addition, keeping the diary might have fostered learning because completing the diary form also triggers reflection, so some aspects of learning could also be overreported. Moreover, the causality on interaction-level can be questioned. For instance, having learned something could affect the perceived instrumentality of an interaction or could lead to feeling motivated. A further limitation is the fact that for reasons of completeness we included the Big Five personality trait of openness into the analysis despite it having a very poor Cronbach's alpha. However, it had no significant impact on learning from social interactions. Furthermore, we cannot be sure whether we included all relevant situational characteristics of social interactions in our research and we have not controlled for the personal relationship between the interaction partners, but this could certainly play a role in the perception of the interaction. Finally, the generalizability of the findings is limited as the sample is a nonprobability convenience sample and thus generally not representative.

3.8 Practical Implications and Future Research

Learning from social interactions in the workplace is considered a major source of informal workplace learning. Trainees' learning from social interaction increases if the interaction is perceived as instrumental for future work activities. Furthermore, self-perceived learning increases with the amount of questions asked and with a smaller share of their own speech. In a nutshell, skilled workers should focus on relevant content to foster trainees' learning, and trainees should ask questions and listen to their more experienced colleagues. Training companies should foster these kinds of interactions by acknowledging skilled workers' engagement in instructing and guiding trainees and by granting them extra time to do so. Trainees should be encouraged to ask questions whenever something is unclear to them.

As the data were collected in this study in only one company and only with trainees, future research should be conducted in other companies in different contexts and industries and also with more experienced employees. By doing so, it would then be possible to compare the findings. This would be interesting, especially because of the rather surprising positive influence of emotional states of low arousal and lower pleasure and of an interruption in social interactions. Further research should also focus on social interactions' situational characteristics to continue micro-analyses. In future investigations, data on the interaction content and the grade of trainees' school learning certificate could be collected as we expect them to be illuminating. In addition, the relation between learning from social interaction and other sources of learning could be a very informative focus of subsequent research. Finally, against the background of COVID-

19 and the increase in the amount of home office work, which will presumably remain in the future in at least a weakened form, it would be interesting to examine the influence of face-to-face social interactions versus digital interaction. Here, a focus could also be on whether the delivery mode serves as a moderator between the various potential influencing factors (e.g., characteristics of the social interaction, personality) and learning from social interactions.

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Data Availability

The dataset analyzed during the current study is available from the corresponding author on reasonable request.

Declarations

The authors have no relevant financial or non-financial interests to disclose. Furthermore, they have no competing interests to declare that are relevant to the content of this article. All authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest or nonfinancial interest in the subject matter or materials discussed in this manuscript.

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4 Informal Learning from Dealing with Software-Related Problems in the Digital Workplace (Paper 2)

Paper 2 was published in August 2023 in the *Journal of Workplace Learning* and is available at https://www.emerald.com/insight/content/doi/10.1108/JWL-03-2023-0042/full/html[3].

4.1 Abstract

Purpose - This paper aims to examine the impact of problem-solving activities, emotional experiences, and contextual and personal factors on learning from dealing with software-related problems in everyday office work.

Design/methodology/approach – To measure the use of problem-solving activities, emotional experiences and the contextual factors of problem characteristics and learning in situ, a research diary was used. To measure team psychological safety (contextual factor) and personal factors, including the Big Five personality traits, occupational self-efficacy and technology self-efficacy, the authors administered a self-report questionnaire. In sum, 48 students from a software company in Germany recorded 240 diary entries during five working days. The data was analyzed using multilevel analysis.

Findings – Results revealed that asking others and using information from the internet are positive predictors of self-perceived learning from a software-related problem, while experimenting, which was the most common activity, had a negative effect on learning. Guilt about the problem was positively related to learning while working in the office (as opposed to remote work) and feeling irritated/annoyed/angry showed a negative effect. Surprisingly, psychological safety had a negative effect on perceived learning.

Research limitations/implications – Major limitations of the study concern the convenience sample and the disregard for the sequence of the activities.

Originality/value – This study contributes to the limited empirical evidence on employees' problem-solving activities and informal workplace learning in the software context. To overcome the shortcomings of previous studies using retrospective assessments and in-lab observations, this study uses the diary method to investigate in situ.

4.2 Introduction

In the present study, we investigate the antecedents of informal workplace learning from dealing with software-related problems in the workplace. For several reasons, it is assumed that informal learning will become increasingly important compared to formal learning (Littlejohn

[3] For reasons of standardization within this thesis, the paper was inserted in American English, the citation style APA American Psychological Association 7th ed. was used, the appendix for this paper was included in a common appendix for the entire thesis and table labels, notes, and formatting were adapted. In addition, misspelling and typographical errors identified in the course of a further proofreading were corrected.

& Pammer-Schindler, 2022). First, software has become the most important tool for knowledge workers (Leiß et al., 2022; Littlejohn & Margaryan, 2014a, 2014b) and is subject to frequent updates and changes (Kiani et al., 2020). Oftentimes, users have to troubleshoot and learn software by themselves in the course of their regular working tasks (Kiani et al., 2020), as it is challenging to cover these rapid developments with formal training (Harteis, 2022; Kiani et al., 2020). Second, while standard curriculums have been successful in training employees in standard work practices, knowledge workers increasingly have to deal with "fuzzy tasks" (Harteis, 2022, p. 417), as well as complex and niche problems (Littlejohn & Pammer-Schindler, 2022). Thus, problem-solving is a central requirement for knowledge workers, especially when dealing with complex software tools, but, at the same time, problem-solving is also considered an important source of informal learning in the workplace (Kiani et al., 2020; Rausch, 2013; Tynjälä, 2013; Tynjälä & Häkkinen, 2005).

To solve work-related problems, knowledge workers usually have access to various resources (Cuyvers et al., 2016; Kiani et al., 2020; Kiani et al., 2019; Rausch et al., 2015). These can comprise personal, social and technological resources (Leiß et al., 2022). Although there is some empirical work on employees' use of resources and problem-solving activities and learning (Cuyvers et al., 2016; Haemer et al., 2017; Kooken et al., 2007; Rausch et al., 2015), with some focusing specifically on the software context (Andrade et al., 2009; Kiani et al., 2020; Kiani et al., 2019; Leiß et al., 2022; Novick et al., 2009), empirical evidence is scarce. Furthermore, previous research has mostly relied on interviews, in-lab observations and, occasionally, surveys. While interviews and surveys suffer from the disadvantage of being based on retrospective assessments, in-lab observations take place outside of real work activities, affecting their validity. The diary method as a research method enables retrospective memory bias to be reduced as well as an investigation in situ (Bolger et al., 2003; Ohly et al., 2010; Rausch et al., 2022). Thus, it is particularly appropriate for researching the handling of software (Benbasat et al., 2007; Littlejohn & Margaryan, 2014b). To the best of the authors' knowledge, no empirical study has examined software-related problem-solving and the resulting learning by applying intensive longitudinal methods such as diaries. To fill this research gap, the present study investigates employees' use of resources in solving software-related problems and the resulting learning by using a research diary.

Learning and problem-solving are complex phenomena that are influenced by various antecedents (Cerasoli et al., 2018; Jeong et al., 2018; Littlejohn & Pammer-Schindler, 2022; Noe et al., 2014; Rintala et al., 2019; Tynjälä, 2008; Vu et al., 2022). Thus, our study takes into account emotional experiences as well as the contextual factors of problem characteristics, team

psychological safety and the location of work, in addition to the personal factors of the Big Five personality traits and self-efficacy, as potential antecedents of learning from software-related problem-solving.

4.3 Informal learning through problem-solving

A large proportion of workplace learning takes place informally (Eraut, 2010; Tynjälä, 2013). Thus, it occurs apart from formally organized learning programs (Eraut, 2000; Marsick & Watkins, 2015), in the absence of a teacher and is oftentimes unstructured, unintended and implicit (Eraut, 2004; Marsick & Watkins, 2015). A central source of informal workplace learning is solving work-related problems (Eraut, 2000, 2004; Tynjälä, 2013; Tynjälä & Häkkinen, 2005). A problem can be defined as a situation in which an individual lacks knowledge on how to achieve a specific goal (Newell & Simon, 1972). Problem-solving usually comprises researching, acquiring and applying new knowledge and may therefore result in learning (Dörner & Wearing, 1995; Newell & Simon, 1972; Wüstenberg et al., 2012). Help-seeking behavior is conceptually closely related to problem-solving, as help-seeking is always associated with a specific problem that needs to be solved and may result in learning (F. Lee, 1997; van der Rijt et al., 2013). Characteristics of help-seeking include the involvement of more than one person and a certain proactivity within help-seeking (F. Lee, 1997; van der Rijt et al., 2013). Other studies explicitly further included non-personal interactions such as forums, text tutorials and videos as well as other resources on the web (Kiani et al., 2020; Kiani et al., 2019; Leiß et al., 2022).

In general, there are several information resources employees can refer to when they face work-related problems in the workplace. In the model of informal workplace learning through problem-solving, Leiß et al. (2022) classify them into personal resources, social resources and technological resources. These resources, in turn, offer several problem-solving activities that employees can use to solve problems at hand. Activities based on personal resources comprise reflecting and trying out. Activities based on social resources include observing competent others as well as asking competent others. Activities based on technological resources refer to consulting codified information, including physical and digital information and tools. Similar activities were reported by Cuyvers et al. (2016) and Haemer et al. (2017). Furthermore, the model highlights the role of personal and contextual factors as well as emotional experiences in problem-solving and learning.

Emotional experiences and workplace learning are strongly connected (Benozzo & Colley, 2012), and there is empirical evidence that emotional experiences impact workplace learning (Benozzo & Colley, 2012; Hökkä et al., 2020; Rausch et al., 2017; Zhao, 2011).

Furthermore, emotional experiences affect information-seeking in general, which may also influence learning. Different emotions influence the sources, the start, a potential limitation, the termination and the avoidance of information-seeking in different ways (Savolainen, 2014; Willson & Given, 2020). Feeling stressed, for instance, also causes early-career academics to ask colleagues instead of using codified information (Willson & Given, 2020). In addition, Zhang and Jansen (2009) found that happy people processed more general information, while sad people processed more specific information during an internet search. Within the context of problem-solving, Spering et al. (2005) found participants with negative induced emotions to be more thorough when searching for information during their problem-solving attempts and to be more likely to search for information before they started their problem-solving attempts. These findings show that emotional experiences influence not only whether and where people seek information but also how they use and process it.

4.3.1 Empirical research on solving software-related problems

There are a few empirical studies that investigated help resources and problem-solving activities and their influence on problem-solving in the context of workplace learning. In this vein, intrinsic and extrinsic reflection (Haemer et al., 2017), seeking help from others (Haemer et al., 2017; Kooken et al., 2007), interactions with others (Cuyvers et al., 2016), trial and-error (Cuyvers et al., 2016; Haemer et al., 2017; Kooken et al., 2007), observing (Cuyvers et al., 2016) and consulting (online) written material (Cuyvers et al., 2016; Kooken et al., 2007) were identified to support workplace learning.

Within the software context, in a previous study, Leiß et al. (2022) revealed consulting and observing colleagues as well as reflecting to be most often available and most often used to tackle enterprise resource planning (ERP) software-related problems. However, this was without clear reference to potential learning. Further studies found recalling (Andrade et al., 2009) and asking colleagues (Kiani et al., 2020; Novick & Ward, 2006) to enhance software use and learning. Regarding different online resources like videos or forums (Kiani et al., 2020; Kiani et al., 2019; Novick & Ward, 2006), built-in help (Andrade et al., 2009; Kiani et al., 2019; Novick et al., 2009) and trial-and-error (Andrade et al., 2009; Novick et al., 2009; Novick & Ward, 2006), empirical evidence on the frequency of use and usefulness for software use and learning is ambiguous. These few conducted studies share several limitations. Most studies only anticipated learning from task performance, were not field studies and were not conducted in situ.

4.3.2 Antecedents of learning from problem-solving

We distinguish contextual and personal factors as antecedents of learning from problem-solving (Cerasoli et al., 2018; Rintala et al., 2019; Tynjälä, 2013; Vu et al., 2022). As contextual factors, we assume that the location of work, team psychological safety and problem characteristics affect the use of problem-solving activities as well as the resulting learning.

Physical proximity can increase the likelihood that employees learn from each other (Škerlavaj & Dimovski, 2006), while geographical, temporal and perceived separation can negatively impact team communication and the synchronous availability of team members (Morrison-Smith & Ruiz, 2020). Thus, we suppose that with a person's greater separation from his or her team, it may be more difficult to ask other team members for help. Instead, other learning resources are used. This may impact learning outcomes.

Team psychological safety is "a shared belief that the team is safe for interpersonal risk taking" (Edmondson, 1999, p. 354), resulting, for example, in people daring to talk about problems and mistakes or ask for help without fear of losing face (Edmondson, 1999). Psychological safety is a positive antecedent of individual and team workplace learning (Edmondson & Lei, 2014; Frazier et al., 2017; Newman et al., 2017) and affects, for example, learning from failures (Carmeli & Gittell, 2009), proactive learning behaviors (Mornata & Cassar, 2018), cooperative learning (Post, 2012) and different forms of team learning behavior (Edmondson, 1999; Harvey, Jean-François, Johnson, Kevin J. et al., 2019). Hence, in teams with high team psychological safety, members may be more likely to dare to reveal their lack of knowledge and to ask other members for help, for instance. This assumption is in line with the results of van der Rijt et al. (2013), who found that trust, which is a concept that overlaps with psychological safety (Edmondson & Lei, 2014; Newman et al., 2017), is a significant positive predictor of asking for help (van der Rijt et al., 2013).

Generally, work-related problems can be shaped by different characteristics, like, for example, their structuredness (well-structured vs. ill-structured) (Jonassen, 1997), complexity (Smith, 1991), familiarity (Smith, 1991), difficulty (Smith, 1991), urgency (Rausch et al., 2015), severity (Feng & MacGeorge, 2006; Rausch et al., 2015) or responsibility (Feng & MacGeorge, 2006; Rausch et al., 2015). Three problem characteristics that we expect to be particularly relevant for the present study are urgency, potential negative consequences, and the extent to which a person feels guilty for the occurrence of the problem. The urgency of a problem, as well as its potentially negative consequences, can motivate people to solve it quickly and efficiently, which is likely to result in learning. Perceived responsibility can lead to employees not asking others for help so as not to reveal the problem to them, which can also impact learning.

Concerning personal factors, we expect the Big Five personality traits as well as self-efficacy to impact solving software-related problems and learning in the workplace. The Big Five personality traits refer to the five broad personality dimensions of extraversion, neuroticism, agreeableness, openness to experience and conscientiousness (McCrae & Costa, 1999). They influence informal learning in the workplace (Cerasoli et al., 2018; Noe et al., 2013; Rintala et al., 2019), as well as aspects related to technology acceptance and use (Barnett et al., 2015; Devaraj et al., 2008; Özbek et al., 2014). As, for example, people high in extraversion are sociable, talkative and friendly (McCrae & Costa, 1987), we expect them to be more likely to ask other people than use other (software-based) problem-solving activities when they face a software-related problem. This could also ultimately influence learning outcomes.

Furthermore, the Big Five personality traits influence an individual's information-seeking behavior in general, which could also impact learning. Al-Samarraie et al. (2017) investigated the influence of personality traits on information-seeking behavior. Results showed that when searching for a specific piece of information on the internet, people with high conscientiousness are quicker to retrieve information and decide than people with high agreeableness and extraversion. When searching for information on the internet, which requires evaluation in terms of quantity and quality, extraverts were the quickest to find it, followed by people high in agreeableness and people high in conscientiousness. When it comes to using facets and refining queries in an internet-based search process, that is, conducting complex information research, extraverts and people high in conscientiousness performed the best because of their information-processing strategies. In addition, Heinström (2005) found three different information-seeking patterns connected to the Big Five personality traits. The results yielded that the information-seeking behavior of fast surfing, characterized by effortless information seeking, using information confirming old views, problems with a critical analysis of detected information and a lack of time, was positively influenced by conservativeness (low openness to experience). Extraversion, openness to experience and low agreeableness were found to be positive predictors of broad scanning, which is a behavior comprising thorough and wide information seeking. The information-seeking behaviors of deep diving includes larger efforts to find information of only the highest quality. This behaviors was not significantly affected by any of the Big Five personality traits (Heinström, 2005).

Self-efficacy is a further predictor of informal workplace learning (Cerasoli et al., 2018; Choi & Jacobs, 2011; Jeong et al., 2018; Rintala et al., 2019) and can be defined as "people's judgement of their capabilities to organize and execute courses of action required to attain designated types of performances" (Bandura, 1986, p. 391). Self-efficiency can also be transferred

to computer and IT use. In some studies, computer self-efficacy was identified as a positive predictor of technology acceptance and use (Y. Lee et al., 2003; Venkatesh, 2000; Venkatesh & Bala, 2008). Self-efficacy may also impact the use of activities for solving software-related problems. For instance, it may have an influence on whether a user trusts himself or herself to independently solve such a problem. Then high self-efficacy might be related to being more likely to use problem-solving activities that do not involve other people, such as trying out or searching on the internet. Supporting this assumption, Cleavenger et al. (2007) also expect people with high self-efficacy to be less likely to ask other people about a problem at hand because of their belief in their own ability to handle the problem. Although Cleavenger et al. (2007) found no empirical evidence for this relationship, we nevertheless consider it plausible.

Altogether, given prior research's results and shortcomings discussed above, our study addresses the following research questions: How do (RQ1) problem-solving activities; (RQ2) emotional experiences; (RQ3) contextual factors; and (RQ4) personal factors influence learning from solving software-related problems?

4.4 Method

4.4.1 Participants

To address the above research questions, a diary study with 49 students from a software company in Germany was conducted. Participation was voluntary, and all participants provided written informed consent. As an incentive, the participants were offered a comprehensive workshop on the topics of scientific work and writing theses for the university. Twenty-one participants were female, 28 were male, and their mean age was 22.7 years. Of the 49 participants, 48 were students at various universities, and one was a vocational education and training (VET) student. Of the university students, 31 pursued their bachelor's degree and 17 pursued their master's degree. As the study was conducted during the COVID-19 pandemic, participants were also asked to indicate the percentage of their working time they usually spend at home and on site in the office each week. On average, the participants worked 82% of their weekly working time remotely.

4.4.2 Procedure

A semi-standardized diary was used to collect data in situ. The diary period comprised five working days, and the participants were asked to record about ten software-related problems during the diary period. Participants were asked to fill in the diary as soon as possible after the problem occurred or was solved. Depending on their working hours, participants could either keep the diary for five days within one working week or spread the five working days over several weeks (usually three weeks). Before the diary period, the participants completed an

additional self-report questionnaire that included demographics, personality traits, workplace characteristics and team characteristics.

4.4.3 Measures

Diary. Most diary items were standardized to reduce participant burden. The diary was provided digitally via the survey web app LimeSurvey and contained five content areas. First, the participants were asked to indicate if they worked remotely or on site in the office at the time the software-related problem occurred. Second, the participants rated three problem characteristics:

1) perceived guilt for the problem ("To what extent was I to blame for the problem?", from 1 = *not my fault at all* to 5 = *completely my fault*);
2) potential negative consequences resulting from the problem ("How negative could the potential consequences of the problem be?", from 1 = *no negative consequences* to 5 = *extremely negative consequences*); and
3) the problem's urgency ("Please assess the urgency of the problem", from 1 = *no time pressure at all* to 5 = *very high time pressure*).

For all items, the answer *not applicable* was also available. Third, participants selected the problem-solving activities that were used to deal with the software-related problem at hand. These were derived from the Model of Informal Workplace Learning Through Problem-Solving by Leiß et al. (2022). Available problem-solving activities were asking another person, using information from the internet, using internal information, using software-integrated information, using university course material, using one's own previous notes, experimenting (trying out) until the problem is solved and observing other people while they dealt with similar problems. Fourth, the participants indicated their emotional experience when dealing with the problem using the circumplex item of emotional experience (Rausch, 2014). Based on Russell (1980) and similar frameworks, eight emotional states were arranged with valence on the x-axis and arousal on the y-axis. The participants were asked to choose a maximum of three out of these eight emotional states they experienced when dealing with the software-related problem (1 = *a little* to 3 = *very*). Each emotional state was described using three adjectives. These were *motivated / delighted / curious*; *confident / happy / glad*; *contented / accepted / proud*; *calm / even-tempered / daydreaming*; *bored / dull / uninterested*; *unhappy / gloomy / sad*; *irritated / annoyed / angry*; and *nervous / worried / afraid*. Emotional states that were not chosen were coded as zero. Fifth, participants were asked to indicate how much they had learned from dealing with the software-related problem ("In what way did you learn something from working on

the problem?" rated on a five-point Likert scale from 1 = *learned nothing at all* to 5 = *learned a lot*).

In sum, the participants recorded 242 software-related problems, two of which were excluded from further analysis because of missing data. Descriptives for the activities used for solving software-related problems are displayed in Table 4-1.

Table 4-1: Descriptive statistics for problem-solving activities

Problem-solving activity	Usage absolute	Usage in % of all problems
Experimenting (trying out)	123	51.3
Using information from the internet	88	36.7
Asking another person	81	33.8
Using internal information	19	7.9
Using software-integrated information	16	6.7
Using one's own previous notes	11	4.6
Observing another person	9	3.8
Using university course material	4	1.7

Note. Multiple responses are allowed. Usage in % of all problems for n = 240 problems. Source: Authors' own work

Self-report questionnaire. Team psychological safety. Team psychological safety was measured using the four-item scale by Harvey, Jean-François, Johnson, Kevin J. et al. (2019) (e.g. "In this team, it is easy to speak up about what is on your mind"). A five-point Likert scale from 1 (*not agree at all*) to 5 (*strongly agree*) was used. The scale's consistency was good (Cronbach's alpha = 0.83).

Occupational self-efficacy. Occupational self-efficacy was measured using the scale by Abele et al. (2000) (e.g. "I know exactly that I can fulfil the requirements of my profession if I only want to"). The scale comprised six items that were rated on a five-point Likert scale from 1 (*not agree at all*) to 5 (*strongly agree*). The scale's consistency was rather low (Cronbach's alpha = 0.67).

Technology self-efficacy. Technology self-efficacy was measured using the scale by Laver et al. (2012), which comprises ten items and is based on the computer self-efficacy measure by Compeau and Higgins (1995). The items were rated on a five-point Likert scale from 1 (*not at all confident*) to 5 (*completely confident*). It shows good consistency (Cronbach's alpha = 0.80).

Big Five personality traits. The Big Five personality traits were measured by Saucier's (1994) Big Five Mini Markers and their German version by Weller and Matiaske (2009), which included four adjectives for each trait. The twenty adjectives were rated on a five-point Likert

scale from 1 (*not agree at all*) to 5 (*strongly agree*). Internal consistency was good for extraversion (Cronbach's alpha = 0.89), satisfactory for agreeableness (Cronbach's alpha = 0.71) and conscientiousness (Cronbach's alpha = 0.69), but unsatisfactory for openness to experience (Cronbach's alpha = 0.52) and neuroticism (Cronbach's alpha= 0.45).

4.4.4 Multilevel analysis

As the diary entries were nested in persons, we conducted a multilevel analysis (Hox et al., 2018; Snijders & Bosker, 2012). Two diary entries were excluded from the multilevel analysis as they contained too many missing values. This resulted in 240 diary entries from 48 participants that were included in the multilevel analysis. According to Enders and Tofighi (2007) and Nezlek (2001), we centered predictors on Level 2 at the grand mean and predictors on Level 1 at the group mean. Furthermore, we calculated the baseline level of problem characteristics and emotional experiences and included these variables in the analysis to investigate the influence of the Level 2 differences (Enders & Tofighi, 2007; Pond et al., 2021).

The research questions were tested by a series of multilevel models using the software R (Bates et al., 2015; Kuznetsova et al., 2017; R Core Team, 2022; Wickham et al., 2022). In Model 1, we added the problem-solving activities. We excluded activities that were used fewer than 15 times for solving software-related problems in the whole data set (observing colleagues, using one's own notes, and using university course material). In Model 2, we included the emotional experiences; in Model 3, the contextual factors; and in Model 4, the personal factors. Because the Big Five personality traits of openness to experience and neuroticism did not show satisfactory scale reliability, they were excluded from the analysis. The models were calculated as random intercept models. The pseudo-R^2 value was calculated based on Snijders and Bosker (2012). A table showing means, standard deviations, and correlations between all study variables for n = 48 participants and n = 240 diary entries included in the multilevel analysis is included in the Appendix A.

4.5 Results

First, the null model was calculated to get the intraclass correlation coefficient (ICC). The ICC for learning from dealing with software-related problems is 0.25, indicating that 25% of the variance can be explained by differences on Level 2, that is, between the participants. Then Model 1 was calculated by adding the activities for problem-solving (dummy coded with "0", indicating that an activity was not used). Model 1 fits the data better than the null model. Table 4-2 shows the results of all the calculated models. *Using information from the internet* was

Table 4-2: Multilevel estimates for multilevel modelling predicting self-perceived learning from dealing with software-related problems

	Null model			Model 1			Model 2			Model 3			Model 4		
	Estimate	**SE**	**t**	**Estimate**	**SE**	**t**	**Estimate**	**SE**	**t**	**Estimate**	**SE**	**t**	**Estimate**	**SE**	**t**
Intercept	2.99***	0.17	17.72	2.81***	0.26	10.654	2.30***	0.62	3.691	1.73*	0.71	2.423	1.94*	0.74	2.627
Problem-solving activities															
Asking others				0.40	0.25	1.608	0.48*	0.23	2.065	0.50*	0.22	2.236	0.50*	0.22	2.217
Using information from the internet				0.81***	0.23	3.457	0.75**	0.23	3.316	0.62**	0.22	2.810	0.54*	0.22	2.406
Using internal information				0.35	0.37	0.941	0.49	0.36	1.367	0.47	0.35	1.347	0.48	0.34	1.403
Using software-integrated information				0.24	0.40	0.600	0.44	0.38	1.171	0.40	0.37	1.094	0.52	0.37	1.422
Experimenting				–.0.59**	0.22	–.2.607	–0.43	0.22	–1.965	–0.38	0.21	–1.783	–0.43*	0.21	–2.035
Emotional experience															
Ø motivate / delighted / curious							0.41	0.30	1.387	0.21	0.27	0.803	–0.14	0.29	–0.492
Ø confident / happy / glad							0.06	0.40	0.141	–0.11	0.37	–0.305	–0.06	0.36	–0.152
Ø contented / accepted / proud							–0.32	0.34	–0.919	–0.29	0.31	–0.946	–0.36	0.30	–1.202
Ø calm / even-tempered / daydreaming							0.19	0.33	0.590	0.10	0.29	0.348	0.28	0.28	1.011
Ø nervous / worried / afraid							0.01	0.43	0.014	–0.47	0.44	–1.071	–0.51	0.43	–1.187
Ø bored / dull / uninterested							–0.03	0.43	–0.062	0.35	0.42	0.836	0.45	0.41	1.095
Ø unhappy / gloomy / sad							–0.04	0.58	–0.068	–0.07	0.49	–0.142	0.13	0.46	0.287
Ø irritated / annoyed / angry							0.05	0.33	0.146	–0.06	0.29	–0.210	–0.10	0.30	–0.350
Motivated / delighted / curious							0.10	0.11	0.855	0.14	0.11	1.279	0.15	0.11	1.357
Confident / happy / glad							0.21	0.13	1.659	0.18	0.13	1.418	0.18	0.13	1.421
Contented / accepted / proud							0.11	0.15	0.713	0.11	0.14	0.766	0.12	0.14	0.820
Calm / even-tempered/ daydreaming							–0.22	0.15	–1.490	–0.18	0.15	–1.226	–0.18	0.15	–1.223
Nervous / worried / afraid							–0.09	0.14	–0.645	–0.11	0.14	–0.794	–0.10	0.14	–0.727

Table 4-2: Multilevel estimates for multilevel modelling predicting self-perceived learning from dealing with software-related problems (continued)

	Null model			Model 1			Model 2			Model 3			Model 4		
	Estimate	**SE**	**t**	**Estimate**	**SE**	**t**	**Estimate**	**SE**	**t**	**Estimate**	**SE**	**t**	**Estimate**	**SE**	**t**
Bored/dull/uninterested							0.00	0.17	–0.020	0.02	0.17	0.111	0.03	0.17	0.179
Unhappy/gloomy/sad							–.0.14	0.19	–.0.726	–.0.14	0.18	–.0.770	–.0.15	0.18	–.0.825
Irritated/annoyed/angry							–.0.36**	0.13	–.2.871	–.0.35**	0.12	–.2.774	–.0.34**	0.12	–.2.750
Contextual factors															
Location of work (0 = remote work, 1 = work in the office)										–.0.74*	0.30	–.2.480	–.0.68*	0.29	–.2.291
Ø own guilt										0.33**	0.12	2.684	0.42**	0.13	3.113
Ø negative consequences										0.02	0.13	0.165	0.11	0.13	0.866
Ø urgency										0.08	0.14	0.588	–.0.08	0.17	–.0.477
Own guilt										0.13*	0.06	2.325	0.14*	0.06	2.413
Negative consequences										–.0.06	0.06	–.0.881	–.0.06	0.06	–.0.911
Urgency										0.10	0.08	1.261	0.11	0.08	1.346
Team psychological safety										–.0.45	0.24	–.1.838	–.0.67**	0.25	–.2.726
Personal factors															
Occupational self-efficacy													0.81*	0.35	2.315
Technology self-efficacy													0.16	0.30	0.523
Extraversion													–.0.13	0.16	–.0.839
Conscientiousness													0.63	0.36	1.726
Agreeableness													–.0.21	0.37	–.0.551
–.2 * log	917.63			887.75			850.84			823.11			814.55		
Diff –.2*log				29.88***			36.903**			27.729***			8.563		
Δdf				5			16			8			5		
R^2				0.14			0.24			0.36			0.40		

Note. *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$. Source: Authors' own work.

identified as a significant positive predictor of self-perceived learning, while *experimenting* was a significant negative predictor.

In Model 2, we added the emotional experiences to the analysis. Again, this model fits the data better than the previous one. Results show that a person's deviation from his or her baseline level of feeling *irritated / annoyed / angry* was a significant negative predictor of self-perceived learning. This means that higher feelings of being *irritated / annoyed / angry* are associated with less learning. Moreover, controlling for the emotional experiences resulted in *asking others* to become a further significant positive predictor of self-perceived learning from dealing with software-related problems, while *experimenting* was only significant at the ten percent level.

In Model 3, the contextual factors were included, which again resulted in a better model fit. The *location of work* (dummy coded with "0" indicating remote work and "1" indicating work in the office) was a significant negative predictor, indicating that participants learned less when they dealt with a software-related problem that occurred while they worked in the office. Moreover, the baseline level of the extent to which a person believes that he or she is to blame for the occurrence of software-related problems (Ø *own guilt*) as well as a person's deviation from this general tendency (*own guilt*) were significant positive predictors of self-perceived learning from software-related problems.

In the course of Model 4, we added the personal characteristics. This did not lead to a significant improvement in the model fit compared to Model 3. However, the results identified *occupational self-efficacy* as a significant positive predictor of self-perceived learning. Controlling for the personal factors also led to *team psychological safety* and, once more, *experimenting* to become significant negative predictors.

4.6 Discussion

In the present study, we investigated the influence of problem-solving activities, emotional experiences, contextual antecedents, and personal antecedents on learning from dealing with software-related problems in the workplace. In a diary study, 48 students from a German software company recorded 240 diary entries that were analyzed by multilevel modelling.

Regarding the effects of problem-solving activities on learning from solving software-related problems (RQ1), the results show that although experimenting on one's own is the most common problem-solving activity, it has a negative effect on self-perceived learning. There is conflicting evidence with respect to the frequency of using experimentation for problem-solving. While the high frequency we found is consistent with the findings of Andrade et al. (2009) and Novick et al. (2009), who found a high use of trial-and-error approaches in software-related

problem solving, (Rausch et al., 2015) found only little use of this strategy for general work-related problems in office work. In one of our previous studies, we also found rather lower usage for experimenting compared with other activities for solving ERP-related problems (Leiß et al., 2022). Thus, our results partly confirm and partly contradict previous research on the usage frequency of experimenting for solving (software-related) problems. What is surprising at first is the direction of the effect. The little evidence available so far tends to support the opposite effect. Novick et al. (2009), Haemer et al. (2017), Cuyvers et al. (2016) and Andrade et al. (2009), in their cases in combination with other problem-solving activities like recalling and helping, reported positive effects of experimenting on problem-solving success. However, only Haemer et al. (2017) and Cuyvers et al. (2016) referred to learning, but not in a software context. We assume that the effect of experimenting on learning may strongly depend on the complexity of the software and the problems encountered. Presumably, only simple problems can be efficiently solved with trial and error, but they offer little learning opportunity. As already stated in the introduction, knowledge workers are facing increasingly complex tasks and problems. Thus, experimenting may not be well suited for them and their problems and consequently has no positive impact on problem-solving performance or potential learning. An additional explanation would be that users need a certain amount of prior knowledge to learn effectively from experimenting (Haemer et al., 2017). Since our participants had rather less work experience, this could also explain the negative effect of experimenting on learning.

Moreover, Novick et al. (2009) identified three factors affecting experiment outcomes. First, these are evident, hidden, or false affordances. This includes cues and signposts in a software's user interface that make it appear that they lead to a certain function but in fact do not. A further factor affecting experiment outcomes was the match or mismatch of vocabulary. For example, a user often has a term in mind for a certain function and searches for it in the menu or on the user interface. If a different term is used there or a different path leads to the term, the problem solution may fail. The third factor affecting experiment outcomes is users' incomplete or wrong mental models. In this case, users have not fully understood how software works or how individual elements are interrelated, which also affects the problem-solving and learning negatively (Novick et al., 2009). We believe it is very likely that these factors also played a role among our participants and may explain the negative influence of experimenting on learning that we found.

Asking others and using information from the internet were the second and third most common activities for problem-solving and both were significant positive predictors of learning. This is in line with the results of other studies that found that asking colleagues (Cuyvers

et al., 2016; Haemer et al., 2017; Kiani et al., 2020; Kooken et al., 2007; Leiß et al., 2022; Novick & Ward, 2006; Rausch et al., 2015) and internet resources (Cuyvers et al., 2016; Kiani et al., 2020; Kiani et al., 2019; Kooken et al., 2007; Leiß et al., 2022) were rather frequently used and effective. As reasons for asking other people instead of using some sort of codified information, Kiani et al. (2020) found task-specific help needs; availability of company best-practices; and problems to find codified information and vocabulary problems when using other problem-solving activities (e.g. online research, manuals). Other authors reported similar problems when using problem-solving activities other than asking other people. These were problems related to the finding and identification of relevant information, as well as unsuitable levels of explanation, difficulty of navigation and vocabulary problems, especially for newcomers during help-seeing and learning (Andrade et al., 2009; Kiani et al., 2019; Kooken et al., 2007; Novick et al., 2009; Novick & Ward, 2006). We imagine that the above reasons were why our participants with rather limited work experience often relied on asking others, and that not having to face these difficulties when solving problems certainly supports learning.

Regarding the high usage of information from the internet, other studies found that online help is used because participants are familiar with it in another professional or personal context (Kiani et al., 2019), and often users do not want to use the printed manual because of navigation problems, outdated information, bulkiness and insufficient level of detail but instead use online help or online documentation (Novick & Ward, 2006). These could be reasons why the participants in our study used information from the internet frequently, and again, problem-solving activities and sources that do not present the aforementioned difficulties will certainly promote learning better.

Addressing the role of emotional experiences on learning from solving software-related problems (RQ2), an above-average experience of being irritated / annoyed / angry is negatively related to self-perceived learning. Our results support Savolainen's (2014) findings, which showed that negative emotions like anxiety, aversion, fear and irritation can limit and terminate people's information-seeking, and we expect this can impact learning. Moreover, within the control-value theory, anger is categorized as a negative activating emotion that can lead either to positive or negative learning outcomes, depending on the task and contextual conditions (Pekrun et al., 2011; Pekrun & Stephens, 2010). These ambivalent outcomes are also reflected in the empirical results (Callister et al., 2017; Loderer et al., 2020; Rausch et al., 2017; Reio & Callahan, 2004). The negative relationship we identified is in line with the results by Pekrun et al. (2011). However, the causality is unclear because irritation and anger towards the respective

software or problem at hand could also be the result of a lack of problem-solving and learning success.

Including contextual factors in the analysis (RQ3), working on site in the office (as opposed to working remotely) was a significant negative predictor of learning from software-related problems, indicating that participants learned less when they dealt with a software-related problem that occurred while they worked in the office. Furthermore, both the baseline level of guilt (Ø own guilt) as well as the situational above-average experience of guilt (own guilt) were both significant positive predictors of learning from software-related problems. Feng and MacGeorge (2006) assume that perceived responsibility for a problem may influence both receptivity to advice and the feeling that the problem is solvable, or fear of losing face and fear of negative evaluation by others, leading to resistance to advice. Feng and MacGeorge (2006) found no significant effect of responsibility on the receptiveness of advice. Perhaps, however, the direction of effect we found is also because of the former assumption, and therefore there is a positive effect on learning. Although there are studies that did not find a direct positive effect of guilt on learning (Rausch et al., 2017; Zhao, 2011), the direct positive effect we found is in line with the results of Liu and Xiang (2018).

The negative effect of working in the office is surprising, as we had expected that the opportunities to learn from the help of colleagues would be greater in the office (Škerlavaj & Dimovski, 2006). Besides, face-to-face interactions are often preferred and useful for problem-solving and learning (Kiani et al., 2020; Kooken et al., 2007) and, as already discussed, the results of the present study identified asking others to be a significant positive predictor of learning from solving software-related problems. It is possible that the positive impact of remote work on learning can be explained by the fact that remote workers rely more on using information from the internet, which also proved to be a significant positive predictor of self-perceived learning. However, there is no significant positive correlation between working remotely and using information from the internet. A further explanation for the unexpected results may be that working remotely allows employees to take more time to reflect and elaborate on a problem, which, in turn, fosters learning (Haemer et al., 2017).

Finally, including personal factors related to learning from solving software-related problems (RQ4) did not improve the model fit. Still, the significant positive influence of occupational self-efficacy is well in line with the existing research (Cerasoli et al., 2018; Jeong et al., 2018; Rintala et al., 2019). Most surprisingly, when controlling for personal factors, team psychological safety turned out to be a significant negative predictor of learning, which contradicts the findings of previous studies (Edmondson & Lei, 2014; Frazier et al., 2017; Newman et al.,

2017). One plausible explanation might be that high psychological safety may lead to turning to others too quickly without even trying to solve the problem by oneself, to delegating problems completely or to wasting time with unimportant things (Edmondson & Lei, 2014). This would mean losing learning opportunities, while lower psychological safety forces one to solve the problem on one's own, thus taking advantage of learning opportunities. However, this would question the positive effects of asking others as described above, and such a relationship cannot be found in the correlations. Team psychological safety is significantly positively correlated with working remotely and experimenting on Level 1. Because of the physical distance between colleagues, it may feel safer to just experiment when a person encounters a problem while working remotely. The obvious lack of knowledge cannot be observed directly by colleagues. Experimenting, however, is associated with less learning.

4.7 Limitations and further research

Our research is subject to several limitations. Some of the problem-solving activities were excluded from the analysis because they occurred too rarely, and for the activity of asking other people, we did not differentiate if the participants asked face-to-face or used communication tools. Furthermore, we did not consider the order in which the activities were performed, which would reveal more complex strategies. Moreover, we had a rather small convenience sample of rather young employees from only one company. Thus, the generalizability of our results is limited. Finally, learning was measured by only one diary item.

Altogether, using the diary method revealed deep insights into the complex processes of learning from software-related problem-solving in the workplace. The two strands of research on solving software-related problems and research on learning from problem-solving in the workplace – should be further integrated. Our study revealed several surprising results that should be investigated in replication studies and could be enhanced by qualitative data such as interviews or observational data. Considering the content, further research on possible mediators of the relationship between psychological safety and learning from problem-solving in the workplace would be interesting. Furthermore, the availability and use of software and tools for solving software-related problems (e.g., asking colleagues via communication platforms vs face-to-face) would be an exciting dimension. Finally, the content and extent of perceived learning could be captured in amore differentiated way.

4.8 References

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5 Problem-Solving and Tool Use in Office Work: The Potential of Electronic Performance Support Systems to Promote Employee Performance and Learning (Paper 3)

Paper 3 was published in April 2022 in the journal *Frontiers in Psychology* and is available at https://www.frontiersin.org/journals/psychology/articles/10.3389/fpsyg.2022.869428/full.[4]

5.1 Abstract

In the context of office work, learning to handle an Enterprise Resource Planning (ERP) system is important as implementation costs for such systems and associated expectations are high. However, these expectations are often not met because the users are not trained adequately. Electronic Performance Support Systems (EPSS) are designed to support employees' ERP-related problem-solving and informal learning. EPSS are supposed to enhance employees' performance and informal workplace learning through task-specific and granular help in task performance and problem-solving. However, there is little empirical research on EPSS. Two survey studies addressed this research gap. In the first study, 301 people working in Human Resource (HR)-related positions and functions evaluated the learning potential of EPSS as well as potential advantages and obstacles concerning the implementation and use of EPSS. Though other measures are currently assessed as more important for learning, HR employees expect a strong increase in the significance of EPSS for employee learning. In the second study, 652 users of ERP software completed a questionnaire on characteristics of their daily work tasks, team characteristics, individual dispositions, their coping with ERP-related problems, and characteristics of EPSS. Findings indicate that the most frequently available and used approach when dealing with an ERP-related problem is consulting colleagues. Three EPSS types can be distinguished by their increasing integration into the user interface and their context-sensitivity (external, extrinsic, and intrinsic EPSS). While external and extrinsic EPSS are available to many users, intrinsic EPSS are less common but are used intensively if available. EPSS availability is identified to be a strong positive predictor of frequency of EPSS use, while agreeableness as well as the task complexity and information-processing requirements show small negative effects. Moreover, more intensive ERP users use EPSS more frequently. In general, ERP users value, features such as context-sensitivity, an integration of the EPSS into the ERP system's user interface, the option to save one's own notes, and information displayed in an extra

[4] For reasons of standardization within this thesis, the citation style APA American Psychological Association 7th ed. was used, and table labels, notes and formatting were adapted. In addition, the correct publication year for Rausch et al. 2022 (mistakenly 2017) was used.

window. It is expected that EPSS will play an important role in workplace learning in the future, along with other measures.

5.2 Introduction

In this paper, we investigate the significance of Electronic Performance Support Systems (EPSS) for informal workplace learning, including their actual availability and frequency of use among different ERP user types. Office workplaces are shaped by two main developments. Firstly, knowledge workers in office workplaces are confronted with increasingly complex tasks because routine activities are automated or outsourced. Hence, more complex tasks remain for which routine solutions are not available (Bughin et al., 2018; Frey & Osborne, 2017; Littlejohn & Margaryan, 2014). Secondly, more and more software is used at office workplaces for organizational operations and decision-making (Billett, 2021; Eikhof, 2012; Venkatesh & Bala, 2008). Therefore, the skills needed in working life are increasingly linked to "electronically mediated tasks and work roles" (Billett, 2021, p. 1). Thus, an essential part of knowledge workers' competence is mastering the handling of software tools (Hämäläinen et al., 2018; Warren et al., 2009). Säljö (1999) argues that any learning means learning to use tools. His concept of cultural tools comprises not only physical tools but also intellectual concepts, such as technical language or specific calculation schemes and, of course, software tools. Similarly, Engeström (1993), based on Vygotsky's (1978) cultural-historical activity theory, emphasizes the significance of tools as mediating artifacts between the subject (i.e., the employee) and the object (i.e., the task at hand) and outlines that these tools can be physical or symbolic, internal or external. In case of office work, software applications are the most important tools. One important category of software applications in office work are Enterprise Resource Planning (ERP) systems. ERP systems usually comprise a variety of software modules that integrate data from several departments into one single system and support the management of all business processes (Kalling, 2003; Nwankpa, 2015). Learning in the context of an ERP system is especially of interest because of two reasons. First, as costs of implementing an ERP system are high, so are the expectations of the increase in the performance. However, these expectations are often not met because the users are not capable of handling these systems and not trained adequately (Jasperson et al., 2005; Rezvani et al., 2017). Second, the transfer of formally acquired knowledge to one's workplace often proves difficult for employees (Chang, 2004; Mao & Brown, 2005; Nguyen, 2009; Nguyen & Klein, 2008). This is also true for formal learning regarding ERP and sheds light on the importance of post-implementation learning, which means continuous on-the-job learning after an information technology has been implemented (Chou

et al., 2014; Deng, 2000). In this context, informal learning plays an important role, as most learning in the workplace occurs informally (Eraut, 2010). Informal learning in general can be defined as "any kind of learning which does not take place within, or follow from, a formally organised learning programme or event" (Eraut, 2000, p. 114). According to Eraut (2000; Eraut, 2004), informal learning can include different modes of learning, from unconscious learning (i.e., *implicit learning*) to conscious non-formal learning with clear learning objectives and time set aside to pursue it (i.e., *deliberative learning*). A typical working activity where learning is seen as a possible and welcome by-product is problem-solving (Eraut, 2000, 2004).

To support these different modes of informal workplace learning, contextual performance support, community or social technologies and adaptive learning technologies seem promising (Kravčík, 2019; Ley, 2020; Ley et al., 2014; Li & Herd, 2017; Lindstaedt et al., 2010). A solution that integrates these approaches and provides instant performance, and learning assistance when using software tools (e.g., ERP systems) and solving problems are EPSS (Chang, 2004). EPSS has the potential to "provide the right information to the right user at the right time" (Nguyen, 2009, p. 95). The concept of EPSS has its roots in the 1990s. Gery (1991) first mentioned EPSS and later identified 19 attributes of performance-centered EPSS (Gery, 1995). These included for example "establish and maintain a work context" or "contain embedded knowledge in the interface, support resources, and system logic" (Gery, 1995, p. 53). A more contemporary definition describes EPSS as "an electronic infrastructure that captures, stores, and distributes individual and corporate knowledge assets throughout an organization to enable individuals to achieve required levels of performance in the fastest possible time and with a minimum of support from other people" (Noe, 2017, p. 368). In a nutshell, granular task-specific information is presented to solve a problem at hand (Mao & Brown, 2005). Hence, performance is supported during work (Gery, 1995; Nguyen & Klein, 2008) at all career stages, ranging from "day-one performance" in rookies (Gery, 1995, p. 48) to the attainment of expert performance (Clem, 2007). EPSS reduce cognitive load (Tamez, 2012) and serve as an extension of the employees' long-term memory (Bastiaens et al., 1997; Mao, 2004). This means that the necessary knowledge may have been learned by an employee before but has not been memorized or has been forgotten in the meantime. However, several authors stress the potential of EPSS to not only enhance performance and remind users of what they have learned beforehand but also to support informal learning in the workplace (Gery, 1995; Raybould, 1995; van Schaik et al., 2002), for example by providing scaffolding (Cagiltay, 2006) or synthesizing and reflecting (Hung & Chao, 2007).

Although companies have been applying EPSS—with varying success—since the 1990s, empirical research on their effectiveness is scarce (Chang, 2004; Gal et al., 2017; Gal & Nachmias, 2012; Mao, 2004; Mao & Brown, 2005; Nguyen & Klein, 2008). This is especially true for recent studies that have included new technological capabilities in their definition and design of EPSS. In addition, some of the results of older studies can now be considered obsolete, because technologies available in the past are very different from those available today (Ley, 2020). Moreover, literature on EPSS is criticized for not being empirical (Gal & van Schaik, 2010; Mao, 2004; Nguyen et al., 2005) but based instead on anecdotal evidence (Gal & van Schaik, 2010; Mao, 2004). The present exploratory studies address this research gap from two perspectives. First, the potential of EPSS is assessed more generally by people working in Human Resource (HR)-related positions and functions (= HR employees) (RQ1 and RQ2). Second, the user perspective is taken into account (RQ3 to RQ6). In addition, EPSS can be viewed from two perspectives. First, EPSS can be viewed as a resource created to support employees' performance, problem-solving and learning. This is a more general view of EPSS, which can also address their availability as well as the design and different characteristics of a supplied EPSS. Second, the actual use of EPSS and its results can be examined. We considered these two perspectives in our studies. Altogether, we investigated six research questions, which are also illustrated in Figure 5-1.

- RQ1: How significant are EPSS considered as a learning resource at present and in future by HR employees?
- RQ2: What potential advantages and obstacles concerning the implementation and use of EPSS are seen by HR employees?
- RQ3: What activities are available to ERP users when they need to solve an ERP-related problem in the workplace and how frequently are these activities used when available?
- RQ4: Do the ERP user types differ in terms of availability and frequency of EPSS use when dealing with an ERP-related problem in the workplace?
- RQ5: What factors (contextual and individual/personal factors) influence the frequency of EPSS use when dealing with an ERP-related problem in the workplace?
- RQ6: Which EPSS characteristics are considered the most useful by ERP users and do ERP user types differ in their assessment of usefulness?

In order to systematize the hypothetical influencing factors, a comprehensive Model of Informal Workplace Learning Through Problem-Solving was developed in a first step. Based on that, two studies were conducted in order to answer the research questions. In study 1, 301

HR employees completed a questionnaire on the significance of EPSS for corporate learning as well as potential advantages and obstacles. In study 2, 652 users of ERP systems completed a questionnaire on their use of ERP systems, the availability, and their use of activities for solving ERP-related problems, their evaluation of EPSS characteristics as well as contextual and individual factors.

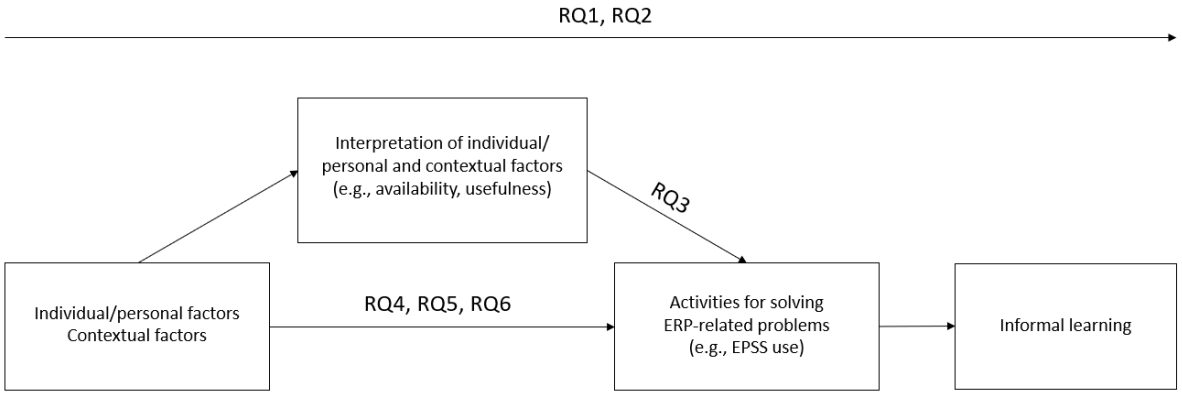

Figure 5-1: Conceptual model of the investigated research questions

5.3 Electronic Performance Support Systems and Informal Workplace Learning

5.3.1 Types, Effects, and Applications of EPSS

In general, three types of EPSS can be distinguished, which differ primarily in the degree of their integration into the target system (e.g., ERP systems) and their context-sensitivity (Gery, 1995). (1) External performance support is not integrated into the system or the work interface and can also be paper-based, for instance. As such, users have to turn away from the target system and to break the work context in order to use the external EPSS (Gery, 1995; Mao, 2004; Sumuer & Yildirim, 2015). Early examples of external performance support are help desks, questions and answers Q&A, job aids, manuals, knowledge databases, and search engines (Gal & Nachmias, 2012; Gery, 1995; Nguyen & Hanzel, 2007; Nguyen et al., 2005). More recent examples also include Web 2.0 technologies, such as online forums and communities and the content provided there. (2) Extrinsic performance support is integrated into the system, but not into its primary user interface (Gery, 1995). Instead, the presumably helpful information is displayed outside of the target system (Nguyen et al., 2005). This means that, for instance, a new window is opened. The system is often context-sensitive, which means that it can identify which task the user is working on. Based on this information, the extrinsic system can suggest appropriate information (Nguyen et al., 2005). Examples for extrinsic EPSS are advisors, wizards, and cue cards (Gery, 1995), but also often the conventional help function within a software. (3) Intrinsic EPSS integrate granular and context-sensitive information into the target system's user

interface (Gery, 1995). Hence, the information is provided directly in the flow of work (Gal & Nachmias, 2012; Gal & van Schaik, 2010; Nguyen et al., 2005). For users, it is often difficult to distinguish between the target system itself and the EPSS (Gery, 1995). An example more in line with older notions of an intrinsic EPSS is the integrated help that is displayed automatically when creating a new title within the reference management software Citavi® (Swiss Academic Software, Switzerland). More recent technical features that can be assigned to either extrinsic or intrinsic EPSS, depending on their design, include videos that colleagues have recorded about their own activities in the system as well as tutorials or guided tours, for example by the ERP vendor. In addition, the possibility to take notes in the system that are displayed to the documenting person or to groups of people, the next time this step in the system is entered, is conceivable. Other possible options may include social technologies, such as an integrated chat function for direct questions to experts or suggested experts with contact details. While Gery (1995) initially meant this distinction as a hierarchy with intrinsic EPSS as the superior type, in our opinion, today's technological developments question this general superiority. Newer EPSS and EPSS characteristics, such as video platforms for tutorials, can also be very effective, although they fall into the categories of external or extrinsic EPSS. The effectiveness depends more on the specific design of the EPSS and its characteristics than, for example, on the way they are integrated into the user interface alone. Therefore, we still find Gery's (1995) types useful to classify EPSS and EPSS characteristics, but we no longer assume a hierarchy in quality.

Overall, in our opinion, a contemporary definition of EPSS should be a much broader and more flexible one, that includes all technological devices and applications that enable users to solve problems in real time and thus enable learning in the flow of work. This is consistent with Hannafin et al.'s (2002) conclusion that EPSS do not have fixed features or components but can be seen more as "a perspective on designing systems that support learning and/or performing". Against this background, EPSS are still very relevant to address highly recent problems. They already contained the first approaches to adaptivity and context-sensitivity, that are still considered central in many current approaches, at an early stage. Today, thanks to new technological possibilities, they can be extended by numerous functionalities and realize the early goals much more effectively and successfully than in early implementations.

One of the most frequently mentioned benefits of EPSS is its potential to support employee performance (Barker & Banerji, 1995; Chang, 2004; Gery, 1995; Nguyen & Klein, 2008) and as a result different aspects of employee productivity (Altalib, 2002; Bastiaens, 1999). Several empirical studies have reported positive effects of EPSS on various measures of

performance (Bastiaens, 1999; Gal et al., 2017; Gal & Nachmias, 2011; Lanese & Nguyen, 2012; Mao & Brown, 2005; Nguyen et al., 2005; Nuss et al., 2014; Rios et al., 2013; Ugur-Erdogmus & Cagiltay, 2019; van Schaik et al., 2002; Yakin & Yildirim, 2016). These were, for instance, positive effects on expertise reports or speed of task completion of police officers in Turkey (Yakin & Yildirim, 2016) and positive effects on time used for and quality of maintenance procedures of the engine air bleed system on a Boeing 737 aircraft (Rios et al., 2013). Some studies compared the effect of EPSS with traditional training and found EPSS to be at least partly superior (Bastiaens et al., 1995; Gal et al., 2017; Mao & Brown, 2005). Moreover, a few studies have investigated the effects of different EPSS types (external, extrinsic, and intrinsic EPSS) on employee performance and productivity (Gal & Nachmias, 2011; Nguyen, 2005; Nguyen et al., 2005; Yakin & Yildirim, 2016). These were, for instance, employees' time on task and the service quality in a service call (Gal & Nachmias, 2011) and the performance in a task scenario within a company's learning management system (Nguyen et al., 2005). The results of these few studies are ambiguous and no general superiority of one EPSS type over other types can be inferred. As already mentioned, however, we believe that in studies that used more recent technological possibilities, such a general superiority of one type is not to be expected.

5.3.2 The Role of EPSS in Informal Workplace Learning

In addition to enhancing performance, EPSS are also supposed to foster (informal) workplace learning (Gal et al., 2017; Gery, 1995; Kalota et al., 2013; Kert & Kurt, 2012; Mao, 2004; Raybould, 1995; van Schaik, 2010; van Schaik et al., 2002). This is possible through different aspects and functionalities of EPSS. EPSS deliver just enough granular knowledge for the task at hand. Hence, compared to comprehensive formal training, the problems of inert knowledge and inhibited learning transfer are reduced since the newly acquired knowledge is immediately applied (Mao & Brown, 2005). In this context, EPSS can either replenish formal training or even substitute formal training in some cases (Mao, 2004; Mao & Brown, 2005; Nguyen & Klein, 2008; Noe, 2017). In particular, EPSS can support occasional users that would not benefit from extensive training in advance because most of the acquired knowledge would have faded before its application (Mao & Brown, 2005). Furthermore, EPSS can reduce cognitive load (Tamez, 2012) and provide scaffolding during complex tasks (Mao & Brown, 2005). Indeed, the few empirical studies on EPSS and workplace learning report positive effects (Gal & Nachmias, 2011; Kalota et al., 2013; Kert & Kurt, 2012; Mao & Brown, 2005; Nuss et al., 2014; van Schaik et al., 2002; Wild, 2000). Another research project in the context of computer-

mediated work included some adaptive and performance support functionalities, however, the authors did not call them an EPSS. Within the project, APOSDLE context-sensitive help and information as well as relevant experts regarding the working tasks at hand were suggested (Lindstaedt et al., 2010). The authors also reported a positive effect on the knowledge of knowledge workers in highly specialized domains, however not in broad customer-driven domains.

EPSS primarily support informal learning through solving task-related problems during the flow of work (Barker & Banerji, 1995; Mao, 2004). Since problems are defined as a situation in which an individual lacks the knowledge to achieve a current goal (Newell & Simon, 1972), problem-solving requires searching for information and hence, enables the acquisition of new knowledge. According to Rausch's (2011) and Rausch et al.'s (2015) classification of Approaches to Problem-Solving in the Workplace, solution approaches are based on either mental models or real-world experiences, and they are developed on either one's own or adopted from someone else (see Table 5-1; similar activities are reported by Cuyvers et al., 2016). This matrix is meant to be conceptually exhaustive but, of course, further examples could be listed. However, in most problem situations, people will not only use one approach but instead utilize combinations of different approaches that will usually start with reflection on the problematic situation.

Table 5-1: Approaches to problem-solving in the workplace

	Approaches based on mental models	Approaches based on real-world experience
Development of one's own approach	Reflecting (e.g., mental simulation, interpolation, analogy, abstraction, reduction)	Trying out (e.g., experimentation, hypothesis testing, trial and error learning)
Adoption of someone else's approach	Consulting competent others (e.g., assistance, guidance, instruction, EPSS) Consulting codified information (e.g., guidelines, manuals, EPSS)	Observing competent others (e.g., observing role models, watching video tutorials, EPSS)

Source: Rausch, 2011, p. 98; Rausch et al., 2015, p. 452

This classification of approaches again addresses the two perspectives in which EPSS can be viewed. On the one hand, EPSS' use for problem-solving and informal learning can be considered. In the case of a software-related problem, for instance a problem regarding an ERP system, different examples for the approaches can be mentioned. Typically, problem-solving

processes will start with a reflection on what is already known from prior experience and formal training. If combining this prior knowledge does not lead to a solution, one has to search for further information by using other approaches, for example by asking colleagues or reading the manual. In their diary study on everyday problem-solving in the domain of controlling, Rausch et al. (2015) found that asking colleagues was the most frequently applied strategy for novices but also for skilled employees. Consulting codified information, such as manuals, was used by novices but hardly used by skilled employees. It is a commonplace that people do not like to read manuals (Novick & Ward, 2006). On the other hand, EPSS can be seen as a resource that is designed and supplied to support employees. Thus, EPSS can be assigned to different approaches to problem-solving, depending on their design. For example, EPSS can enable employees to ask other people through a chat function integrated into the ERP system. EPSS can also provide codified information. For example, granular information that exactly matches the current task can be provided directly within the user interface. However, EPSS can also include multimedia content like short tutorials, again granular and matching to the problem at hand, or quick contact information about experts that can be approached. Moreover, they can provide videos of the current task that have been recorded by colleagues. In this way, others can be "observed" while performing the task. Thus, EPSS can support problem-solving processes and enable learning in a variety of ways.

5.4 Model of Informal Workplace Learning Through Problem-Solving

In order to investigate EPSS' role in technology-related problem-solving, we developed a holistic model, as problem-solving is dependent on the person of the problem-solver and embedded in the organizational and social context. Figure 5-2 shows our model of Informal Workplace Learning Through Problem-Solving as a synthesis of several already existing other models. It combines basic assumptions of Tynjälä's (2013) 3-P model, the Job Demand Control Support (JDCS) model (Johnson & Hall, 1988; Karasek, 1979; Karasek & Theorell, 1990), the Approaches to Problem-Solving in the Workplace (Rausch, 2011; Rausch et al., 2015), the Technology Acceptance Model (TAM 3; Davis et al., 1989; Venkatesh & Bala, 2008), and the Affective Events Theory (AET) by Weiss and Cropanzano (1996).

The basic structure of the model is based on Tynjälä's (2013) 3-P model. Individual factors—which we also refer to as personal resources—and contextual factors influence through the process of interpretation, problem-solving activities, and the use of resources in this context. These problem-solving activities then may result in problem-solving performance as well as competence development. Both interpretation and problem-solving activities can be influenced

by emotional experiences and can themselves influence emotional experiences. Relevant personal resources include user characteristics and personality traits. User characteristics can comprise for example the user role, experience in this role and prior knowledge or experience. There is empirical evidence that prior usage experience with a technology can influence technology use (Eckhardt et al., 2013; Lee et al., 2003) and that work experience can significantly negatively affect a technology's perceived usefulness (Laumer et al., 2016). Prior knowledge is also an important antecedent of informal learning processes in general (Cerasoli et al., 2018; Tynjälä, 2013). Regarding personality, the big five personality traits were found to influence or moderate technology acceptance (Devaraj et al., 2008). The big five personality traits (Cerasoli et al., 2018; Noe et al., 2014; Noe et al., 2013) and a proactive personality (Carmeli et al., 2009; Noe et al., 2014) are important antecedents of informal workplace learning as well. A proactive person can be described as someone "who is relatively unconstrained by situational forces, and who effects environmental change" (Bateman & Crant, 1993, p. 105). Thus, we assume that this disposition may also influence the choice of problem-solving activities (e.g., asking colleagues). Empirical studies have shown that proactive personality is positively related to information exchange with other people (Gong et al., 2012).

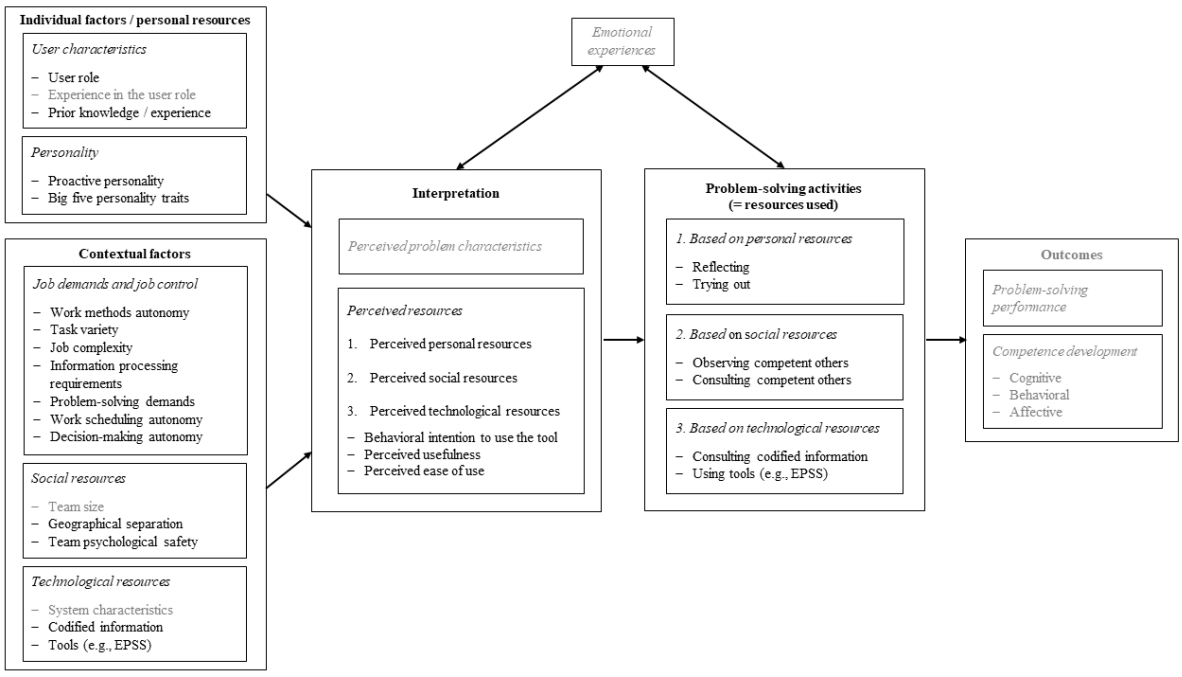

Figure 5-2: Model of Informal Workplace Learning Through Problem-Solving

Contextual factors include aspects of job demands and job control, aspects shaping social resources, and aspects shaping technological resources. There are several studies that found job characteristics, such as job demands and job control to be related to informal workplace learning

(Cerasoli et al., 2018; Noe et al., 2014; Rausch, 2013). In our model, we included work methods autonomy, task variety, job complexity, information-processing requirements, problem-solving demands, work-scheduling autonomy, and decision-making autonomy. These are work task characteristics that are conducive to emotion and learning (Rausch, 2012). Autonomy is also an antecedent of a technology's perceived usefulness and perceived ease of use (Arsal et al., 2009) as well as technology use (Ahuja & Thatcher, 2005). In our model, social resources include team size, a person's potential geographical separation from his or her team as well as the team psychological safety. Empirical evidence on the influence of team size in the context of technology use is, for instance, provided by Bradner et al. (2005). Their results show that interactions between team members, the willingness to communicate with others in the team, and the use of communication technology in the team differ significantly between distributed teams of different team sizes. Furthermore, geographical and possibly associated temporal and perceived distance in virtual teams can influence for example the communication within teams as well as the synchronous availability of colleagues (Morrison-Smith & Ruiz, 2020). A study by Liu et al. (2021) showed that the geographical separation in online professional networks can lead to information cocoons within geographic regions. Based on this empirical evidence, we suppose in our model that geographic distance could have an influence on the preferred problem-solving activity. Moreover, team psychological safety, defined as "a shared belief that the team is safe for interpersonal risk taking" (Edmondson, 1999, p. 354), affects learning in the workplace (Edmondson & Lei, 2014; Frazier et al., 2017; Newman et al., 2017). We expect team psychological safety to also influence the choice of problem-solving activities, since, for example, a low team psychological safety, in a problem situation, could lead to the fact that asking colleagues and superiors is rather avoided. The model part of technological resources comprises system characteristics, codified information, and tools (e.g., EPSS). We expect the presence of these aspects of technological resources as well as their interpretation to influence their actual use, as it is suggested by TAM (Davis et al., 1989; Venkatesh & Bala, 2008). TAM's assumed relationships were investigated many times empirically (Lee et al., 2003; Marangunić & Granić, 2015) and also in the context of learning technologies (Granić & Marangunić, 2019). This assumption already sheds light on another important aspect of our model. Contextual factors not only affect workplace learning directly (Cerasoli et al., 2018; Jeong et al., 2018; Rintala et al., 2019), but also indirectly through an individual's interpretation (Tynjälä, 2013). In case of a problem within a current work activity, the given individual factors/personal resources and contextual factors are subjectively and maybe unconsciously interpreted in terms of potential personal, social, and technological resources. Based on cognitive and non-cognitive processes, one or

more problem-solving activities can be applied. These problem-solving activities result from the given individual factors / personal resources and contextual factors and are conceptually based on the Approaches to Problem-Solving in the Workplace (Rausch, 2011; Rausch et al., 2015). In this vein, Carvalho (2019) found that the organizational environment, tool features, and task requirements were relevant factors for EPSS adoption and use. The use of one or more problem-solving activities ultimately results in outcomes, such as problem-solving performance and competence development (Rintala et al., 2019; Tynjälä, 2013), which can include cognitive as well as behavioral and affective aspects (Kraiger et al., 1993).

In the context of ERP-related problems, employees interpret their own user roles and competences, the characteristics of the present task, of their team, and their technological environment. One might, for instance, not trust his or her own competences and hence consult a colleague instead, while someone else might not consider his or her colleagues to be sufficiently competent or might not dare to bother them. Similarly, regarding technological resources, the availability, the perceived usefulness, and the perceived ease of use are important for the intent to utilize a software tool, such as an EPSS. Problem-solving is not a linear process. For instance, one might start reflecting on a problem confidently, but self-confidence decreases if no solution is in sight. This may lead to a re-interpretation of the technological resources or to overcoming the threshold to ask colleagues. Typically, more than one approach to problem-solving is applied. Once, a problem with the ERP system is resolved and given that the solution path is memorized, the same situation will not pose a problem in the future, hence, competence development has taken place.

Finally, we expect both, the interpretation and the problem-solving activities, to be influenced by emotional experiences. We base this assumption on empirical evidence on emotional experiences' effect on workplace learning (Hökkä et al., 2020) as well as on technology acceptance constructs (Lee et al., 2003; Venkatesh, 2000) and technology use (Beaudry & Pinsonneault, 2010; Lee et al., 2003). In addition, we assume that an influence in the other direction is also plausible, since learning activities (Hökkä et al., 2020)and technology use (Loderer et al., 2020) can also have an impact on emotions.

We conducted two survey studies which are the first step in a larger research project. The first study addresses HR employees' rating of EPSS as a learning opportunity. In this study, EPSS are viewed primarily as a technological resource designed to support employees. The second study focuses on ERP users' experiences of EPSS in solving software-related problems and is based on the developed model. Here, EPSS are seen primarily in light of their actual use for solving ERP-related problems. The second study comprises different activities for solving

ERP-related problems (e.g., EPSS use) that are based on the perception of the availability of the individual factors/personal resources and contextual factors. Therefore, not all aspects of the theoretical model are investigated empirically. Model components that are not part of the two questionnaire studies are grayed out in Figure 5-2.

5.5 Materials and Methods

5.5.1 Procedure and Sample

To address the research questions presented in the introduction, two questionnaire studies with different target groups were conducted. Thus, a cross-sectional research design was applied (Bickman & Rog, 2009). The first survey study addressed RQ1 and RQ2. A total of 301 HR employees participated, most of whom worked in Germany (n = 285). We drew a non-probability convenience sample, as we looked particularly for participants working in HR-related departments and functions (Henry, 2009). The majority of participants were recruited via mail and direct messages via LinkedIn. The participants worked in HR management (n = 104), HR development (n = 78), training and development (n = 77) and other areas.

The second survey study addressed RQ3 to RQ6. The questionnaire was completed by 652 ERP users, most of whom worked in Germany. Again, we drew a non-probability convenience sample, because we required participants with experience using an ERP system in different industries to take part in the study (Henry, 2009). The majority of participants were approached by a professional research institute. In addition, participants were recruited by open calls for participation via LinkedIn and other networks. In the sample, 284 persons were female and 365 persons were male. Participants were relatively evenly distributed across age intervals between 20–69 years and reported an average work experience of 17.5 years. A subsample of 28% of the participants reported that they were occasional ERP users who use the system, for example, to have their vacation approved, to submit a travel request, or for actions that only occur rarely. Half of the participants indicated that they were regular ERP end users who use the ERP system as part of their everyday work activities. Another 14% of the participants described themselves as experts, which means that they have the key user role and/or that they were the person in their team or department that is contacted for questions regarding the ERP system. The last user group comprised 9% who were administrators or SAP consultants. Administrators are responsible for the configuration and adaption of the ERP system. SAP consultants advise other companies regarding SAP software. We refer here to SAP because the company is the market leader for ERP systems and their systems are widely used in German-speaking countries. Table 5-2 provides an overview of all participants in both studies.

Table 5-2: Overview participants study 1 and study 2

	Study participants	
	Participants study 1	**Participants study 2**
HR employees		
HR management	104	
HR development	78	
Training and development	77	
Other areas	26	
ERP users		
Occasional users		182
End users		320
Experts		91
Administrators or SAP consultants		59
Σ	285	652

5.5.2 Measures

All questionnaires were distributed in German and in English. However, most participants answered the German version. All translations were checked by an English native speaker. The items used in the two questionnaires are included in the Appendix B.

5.5.2.1 Study 1: Questionnaire for HR Employees

Significance of Different Learning Measures for Employees. Participants rated the significance of six different measures (face-to-face training, coaching, e-learning, augmented reality / virtual reality (AR / VR), social software, EPSS) in their company at present and in the future (i.e., next 3–5 years) on a five-point Likert scale from 1 = *irrelevant* to 5 = *very relevant*.

Advantages and Obstacles Concerning the Implementation and Use of EPSS. Participants were requested to tick as many options as they wanted from a selection of eight potential advantages (e.g., "Reduction of search and problem-solving time") and seven obstacles concerning the implementation and use of EPSS (e.g., "A digital help system will find little or no acceptance among employees").

5.5.2.2 Study 2: Questionnaire for ERP Users

ERP User Type. At the beginning of the questionnaire, participants should assign themselves to the user types (1) occasional user, (2) end user, (3) expert, and (4) administrator or SAP consultant, each of which was described.

Self-Assessed Skills in Using the ERP System. The participants assessed cognitive, behavioral, and affective facets of using the ERP system (e.g., "When using the ERP system I feel very safe with the applications I need regularly" for the affective facet) on a five-point Likert

scale from 1 = *not agree at all* to 5 = *strongly agree*. The scale comprised three items and its consistency was good (Cronbach's alpha = 0.85).

Proactive Personality. Proactive personality was measured, using four of the five items, one slightly modified, from Goller (2017) (e.g., "I like to fight for my ideas, even against the resistance of others"), selected from the German version of the Proactive Personality Scale (Kaschube, 2003; Lang-von Wins & Triebel, 2005). The items were rated on a five-point Likert scale from 1 = *not agree at all* to 5 = *strongly agree*. The internal consistency was satisfactory (Cronbach's alpha = 0.73).

Big Five Personality Traits. To reduce participant burden, each of the five personality traits was measured by only one item that included four adjectives (e.g., "extroverted, talkative, communicative, cheerful" for extraversion) based on Saucier's (1994) Mini Markers and its German version by Weller and Matiaske (2009). The items were rated on a five-point Likert scale from 1 = *not agree at all* to 5 = *strongly agree*.

Characteristics of the Work Task. Task characteristics were measured, using selected items from Rausch (2012) that were answered on a five-point Likert scale from 1 = *not agree at all* to 5 = *strongly agree*. Four items were used to measure *task variety* (e.g., "At my workplace, I do a lot of different things"; Cronbach's alpha = 0.79), four items for *job complexity* (e.g., "… my job requires that I only do one task or activity at a time"; Cronbach's alpha = 0.80), four items for *information-processing requirements* (e.g., "… my job requires me to monitor a great deal of information"; Cronbach's alpha = 0.79) and four items for *problem-solving demands* (e.g., "… my job involves solving problems that have no obvious correct answer"; Cronbach's alpha = 0.75). *Autonomy* was assessed by four items. One item each covered work methods autonomy and work-scheduling autonomy and two items covered decision-making autonomy (e.g., "At my workplace I can plan how I do my work" for work-scheduling autonomy; Cronbach's alpha = 0.79).

Geographical Separation. The participants indicated in one item whether they were usually geographically separated from the core of their team (e.g., other site or home office) and whether they were in home office recently due to the Corona pandemic (yes or no).

Team Psychological Safety. Team psychological safety was measured using the scale of Harvey, Jean-François, Johnson, Kevin J. et al. (2019) (e.g., "In my team people are usually comfortable talking about problems and disagreements"), that comprises four items. Again, the five-point Likert scale from 1 = *not agree at all* to 5 = *strongly agree* was used. The internal consistency was $\alpha = 0.74$.

Availability of Problem-Solving Activities. The availability of problem-solving activities according to the above classification of Approaches to Problem-Solving in the Workplace (see Table 5-1) was measured by one single item on each activity (e.g., "At my workplace, if I have problems with the ERP system, I basically have the possibility to ask my colleagues for help"). With regard to our research focus, we included four items on potentially available EPSS features, that cover the three EPSS types external, extrinsic, and intrinsic. All items were answered on a five-point Likert scale from 1 = *not agree at all* to 5 = *strongly agree*.

Frequency of Use of Problem-Solving Activities. If a participant indicated that a problem-solving activity was at least partly available (from 3 = *partly* to 5 = *strongly agree*), then a further item "I often use this possibility" was administered and answered on a five-point Likert scale from 1 = *not agree at all* to 5 = *strongly agree*.

Perceived Usefulness of EPSS Characteristics. Regardless of their availability and frequency of use, participants were asked to rate the usefulness of various (hypothetical) characteristics of EPSS by six items. The self-developed items cover all three EPSS types (external, extrinsic and intrinsic) and are roughly based on Nguyen (2005). All items (e.g., "In the ERP system, you can use information provided next to the user interface of the ERP system to complete the current problem" for intrinsic EPSS) were rated on a five-point Likert scale from 1 = *not helpful at all* to 5 = *very helpful*.

5.5.3 Statistical Analysis

To address the research questions, we applied various statistical methods. For RQ1, we calculated two one-way repeated measures analyses of variance (ANOVA) to determine if there were statistically significant differences between the learning measures' current and future significance for employee learning. RQ2 was evaluated descriptively to identify which advantages and obstacles concerning EPSS were mentioned most frequently by the participants. For RQ3, we again calculated two one-way repeated measures ANOVAs to determine if there were statistically significant differences between the problem-solving activities' availability and frequency of use. To investigate if the ERP user types differ in terms of availability and frequency of use of EPSS (RQ4), we calculated two one-way multivariate analyses of variance (MANOVA). RQ5 was investigated by a hierarchical multiple regression analysis to identify significant predictors of EPSS' frequency of use. For RQ 6, a one-way repeated measures ANOVA was calculated to determine if there was a statistically significant difference between the perceived usefulness of the different EPSS characteristics. In addition, to investigate if the

ERP user types differ in their assessment of the perceived usefulness, a one-way MANOVA was performed.

5.6 Results

5.6.1 Significance of EPSS as a Measure for Learning (RQ1)

HR employees rated the current and future significance of six different learning measures for employees. A one-way repeated measures ANOVA with a Huynh–Feldt correction determined that mean current significance showed a statistically significant difference between the learning measures, $F(4.151, 1236.97) = 150.821$, $p < 0.001$, partial $\eta 2 = 0.34$. Bonferroni-adjusted post-hoc analysis revealed several significant differences between the learning measures for current significance indicating substantial differences in perceived current significance between these learning measures. A second one-way repeated measures ANOVA with a Huynh–Feldt correction determined that mean future significance showed a statistically significant difference between the learning measures as well, $F(4.087, 1217.91) = 139.604$, $p < 0.001$, partial $\eta 2 = 0.32$. Again, Bonferroni adjusted post-hoc analysis revealed several significant differences between the learning measures for future significance. Again, this result shows that there are substantial differences in terms of future significance among these learning resources. Figure 5-3 shows all significant post-hoc results as well as the mean values and confidence intervals.

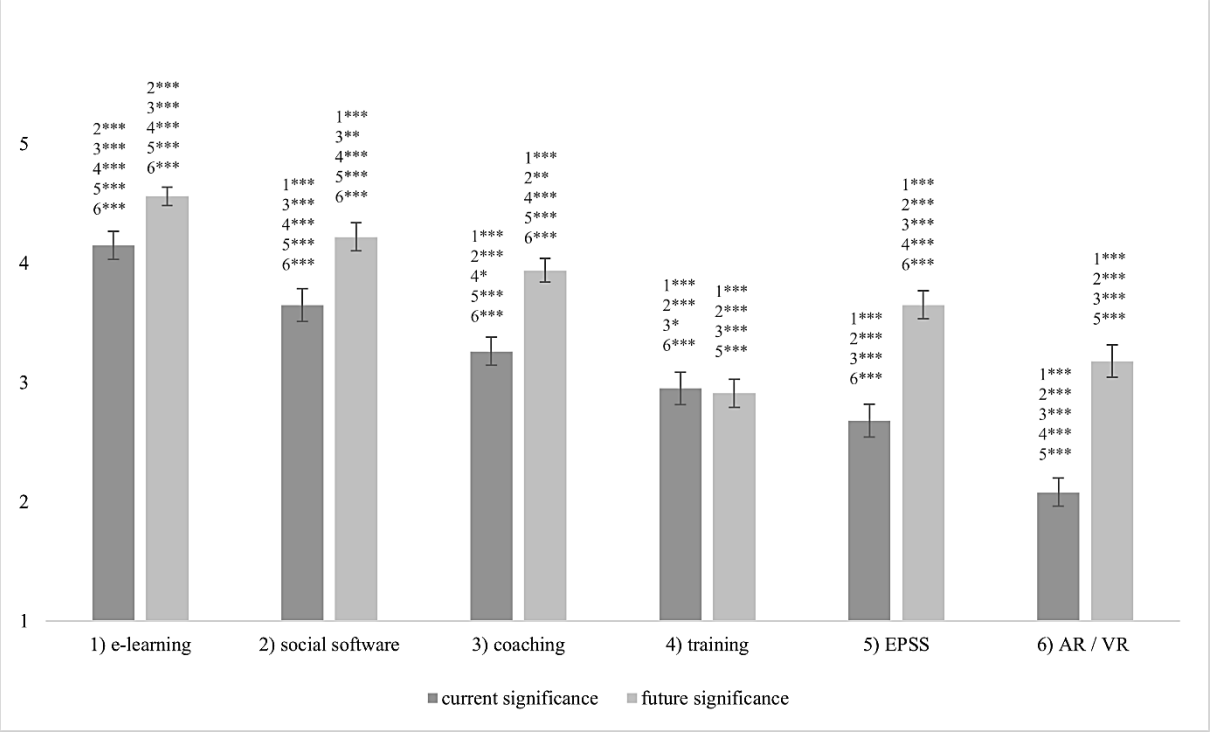

Figure 5-3: Current and future significance of different learning measures for employees as rated by HR employees. Significant differences, means, and confidence intervals

Notes. $N = 299$. Scale: 1 = irrelevant, 3 = partly relevant, 5 = very relevant. *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

Results show the HR employees rated e-learning, social software, and coaching as the most significant measures. EPSS were currently considered less important which could be due to the limited scope of EPSS as compared to e-learning that can be applied for almost any learning goals. In the future, the same three learning measures are seen as most significant. But with a clearly greater increase in significance, EPSS will also play an important role in employee learning in the future.

5.6.2 EPSS Advantages and Obstacles Concerning Their Implementation and Use (RQ2)

The participants selected from eight predefined potential advantages of EPSS those they considered to be applicable to their company. For potential obstacles concerning the implementation and use of EPSS, there were seven options to choose from. For both research questions, multiple answers were possible. Table 5-3 shows the proportions of participants that selected the given advantages.

Table 5-3: Perceived advantages of EPSS

Increased employee efficiency due to reduced search and problem-solving time	65
Supplement to classroom trainings as an aid to the practical application of what has been learned	63
Reduction of search and problem-solving time	53
Reduction of helpdesk costs due to fewer queries about system operation	48
Facilitated communication of changes within software systems (e.g., cloud-based systems)	47
Supplement to classroom training for mixed learning scenarios	44
Support of employees during change processes	40
Substitute for classroom trainings	20

Notes. Percentage of participants that selected the respective advantage. 1,142 answers in total (multiple answers possible).

The most frequently selected advantages were (1) an increased employee efficiency, (2) the possibility to supplement face-to-face training, and (3) the reduction of search and problem-solving time. Thus, about two-thirds of the HR employees agreed that EPSS supports employee efficiency. Surprisingly, a learning-related advantage—the possibility to supplement face-to-face training by EPSS—takes second place before further performance-related advantages. Only 20% of the respondents considered EPSS a substitute for face-to-face training.

Table 5-4 shows the proportions of participants that selected the given obstacles concerning the implementation and use of EPSS. The results show that obstacles were seen in (1) a lack of resources to produce and maintain content, (2) too high technical effort, and (3) an already implemented, competing Learning Management Systems (LMS) as an alternative to an EPSS.

Therefore, the HR employees considered monetary and technical efforts to be the biggest barriers to the implementation of EPSS, while acceptance problems by employees or work councils were expected by a small percentage of respondents. Altogether, the agreement with advantages (see Table 5-3) of EPSS significantly outweighed the agreement with disadvantages and obstacles.

Table 5-4: Perceived obstacles concerning the implementation and use of EPSS

My company does not have the resources to produce a large amount of learning and support materials for our employees or keep it up to date.	34
The technical effort for such a system seems too high to me.	33
My company already has a Learning Management System. A second system to access learning content does not make sense to me.	33
The costs for the acquisition of EPSS offers or content from external providers seems too high to me.	32
The information provided will rarely match the actual questions.	25
A digital help system will find little or no acceptance among employees.	17
I think that our works council or our employee representatives would not accept such a system. (This may or may not apply to you, depending in which country you are working.)	14

Notes. Percentage of participants that selected the respective obstacle. 564 answers in total (multiple answers possible).

5.6.3 Availability and Frequency of Use of Problem-Solving Activities (RQ3)

Based on study 2, Figure 5-4 shows to which degree different problem-solving activities are available to the surveyed ERP users and how frequently they use these activities. A one-way repeated measures ANOVA with a Greenhouse–Geisser correction determined that mean availability showed a statistically significant difference between the activities, $F(5.92, 3709.56) = 66.74$, $p < 0.001$, partial $\eta 2 = 0.10$. Bonferroni-adjusted post-hoc analysis revealed several significant differences between the activities for availability. The differences between these groups can be interpreted as substantial. A second one-way repeated measures ANOVA with a Huynh–Feldt correction determined that mean frequency of use showed a statistically significant difference between the activities as well, $F(7.04, 1245.80) = 5.42$, $p < 0.001$, partial $\eta 2 = 0.03$. Again, Bonferroni-adjusted post-hoc analysis revealed several significant differences between the activities for frequency of use, which are substantial differences. All significant post-hoc results are displayed in Figure 5-4.

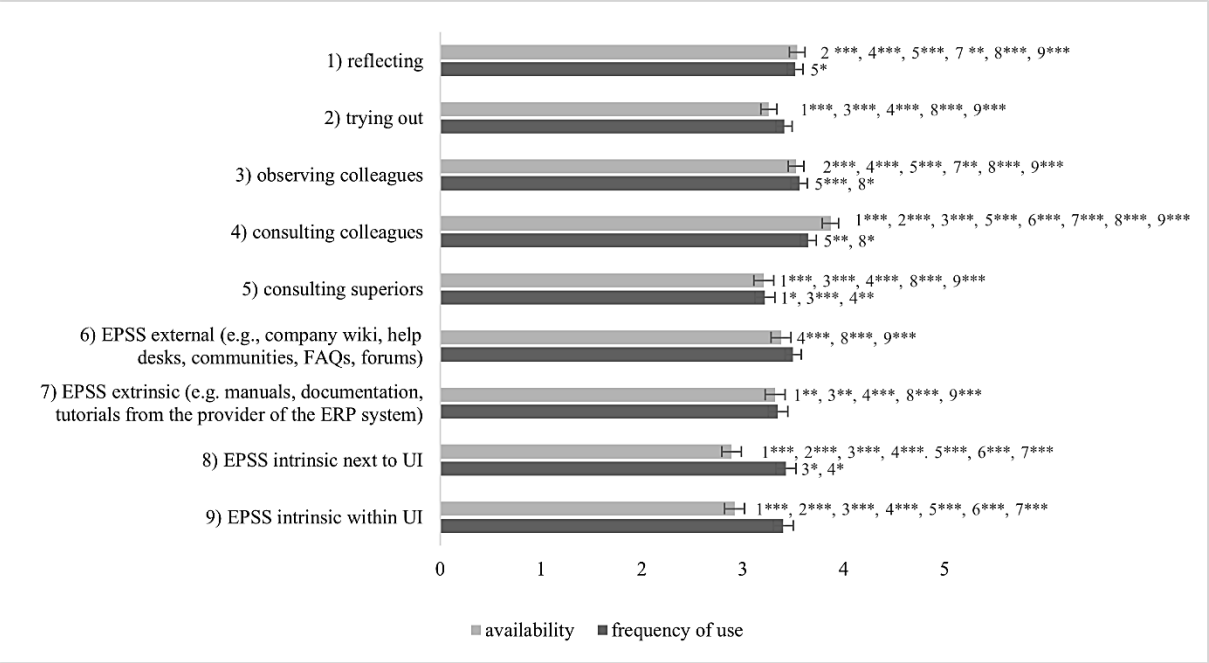

Figure 5-4: Significant differences, means, and confidence intervals of the availability and frequency of use of different problem-solving activities for ERP-related problems

Notes. Scale: 1 = not agree, 3 = partly, 5 = strongly agree. *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

Unsurprisingly, reflecting on one's own as well as consulting and observing colleagues were perceived as the most available activity and were also used most frequently when confronted with ERP-related problems, however with less significant differences. External and extrinsic types of EPSS are already available to many users, while intrinsic EPSS are less often available. However, when available, they are used quite often, but only for extrinsic EPSS with information presented next to the user interface (UI) with few significant differences.

5.6.4 Differences Between the ERP User Types in Terms of Availability and Frequency of EPSS Use (RQ4)

Two one-way MANOVAs were calculated to address RQ4. The first MANOVA was performed to determine the effect of ERP user types on the availability of EPSS. The test revealed statistically significant differences between the ERP user types on the combined dependent variables [$F(12, 1{,}688) = 3.247$, $p < 0.001$, Wilks' $\Lambda = 0.941$, partial $\eta 2 = 0.020$]. Follow-up univariate one-way ANOVAs were performed with Bonferroni adjustment due to alpha error inflation. Statistically significant differences were found for the availability of external EPSS and extrinsic EPSS with small effect sizes each. Tukey post-hoc tests showed that the group of administrators and SAP consultants has external EPSS more often available than end users, and extrinsic EPSS significantly more often available than occasional users and end users (Table 5-5). All other pairwise comparisons were not statistically significant.

Table 5-5: Descriptive statistics and MANOVA results among the four ERP user types for the availability of EPSS

	Occasional user (*n* = 181)		End user (*n* = 316)		Expert (*n* = 91)		Administrator or SAP consultant (*n* = 57)		*F*	*p*	η_p^2	Significant Tukey HSD
	M	SE	M	SE	M	SE	M	SE				
External EPSS	3.48	0.09	3.24	0.07	3.40	0.13	3.91	0.16	5.29	0.001	0.024	4 > 2
Extrinsic EPSS	3.16	0.09	3.25	0.07	3.54	0.12	3.90	0.16	7.27	<0.001	0.033	4 > 1 4 > 2
Intrinsic EPSS information next to UI	2.79	0.09	2.81	0.07	3.21	0.13	3.11	0.17	3.33	0.019	0.015	
Intrinsic EPSS information within UI	2.85	0.09	2.84	0.07	3.13	0.13	3.28	0.17	3.17	0.024	0.015	

Note. *N* = 645. 1 = occasional user; 2 = end user; 3 = expert; 4 = administrator or SAP consultant.

The second one-way MANOVA investigated the effect of ERP user types on the frequency of EPSS use. We only used a subset of 286 participants because the frequency of use was only asked for if the respective problem-solving activity was available. There are statistically significant differences between the ERP user types on the combined dependent variables [$F(12, 738) = 2.055$, $p < 0.05$, Wilks' $\Lambda = 0.917$, partial $\eta 2 = 0.029$] due to differences in the use of external EPSS with a small effect size. Follow-up univariate one-way ANOVAs with Bonferroni adjustment showed that the frequency of use of external EPSS differed statistically significantly between the user groups [$F(3, 282) = 6.417$, $p < 0.001$, partial $\eta 2 = 0.061$]. Tukey post-hoc tests showed that administrators and SAP consultants ($M = 4.18$, $SE = 0.16$) use external EPSS significantly more often compared to occasional users ($M = 3.37$, $SE = 0.10$), $p < 0.001$, end users ($M = 3.64$, $SE = 0.08$), $p < 0.05$, and experts ($M = 3.64$, $SE = 0.13$), $p < 0.05$. All other pairwise comparisons were not statistically significant.

5.6.5 Predictors of the Frequency of EPSS Use (RQ5)

A hierarchical multiple regression analysis was calculated in order to answer RQ5. Since not all respondents provided information on all investigated predictors, a subset of 568 participants was used. For each participant, the highest rating of frequency of EPSS use across all problem-solving activities including EPSS served as the dependent variable. Predictors were added in the course of five steps. In the first step, self-assessed ERP skills and the ERP user types were added as user characteristics. ERP user types were included by dummy coding (0/1) for each ERP user type with the group of administrators and SAP consultants as the reference group. In the second step, task characteristics regarding job demands and job control were added. Step three comprised the inclusion of the availability of the respective EPSS with the highest rating of frequency of use. This addresses the availability of the respective problem-solving activity. In step 4, we added the big five and proactive personality as personality traits. In the last step, team psychological safety as well as geographical separation were included. These are aspects regarding the social resources of a person and its working place. The results of the regression analysis are shown in Table 5-6. The correlation table for all variables included in the hierarchical regression can be found in the Appendix C.

The user characteristics contributed significantly to the regression model and explained 6.2% of the variance in the frequency of EPSS use. The inclusion of the job characteristics in step 2, $F(5, 561) = 8.054$, $p < 0.001$, as well as the inclusion of the availability of the respective EPSS in step 3, $F(1, 560) = 140.901$, $p < 0.001$, lead to significant increases in the explained variance of 6.3% respective 17.6%. Adding the personality traits in step 4, $F(6, 554) = 1.587$,

Table 5-6: Hierarchical multiple regression analysis summary for the MAX frequency of EPSS use

	Model 1		Model 2		Model 3		Model 4		Model 5	
Variable	**β**	**B**	**β**	**B**	**β**	**B**	**β**	**B**	**β**	**B**
Self-assessed ERP skills	0.09	0.07	0.08	0.07	−0.05	−0.04	−0.04	−0.03	−0.05	−0.04
Occasional user	−0.73***	−0.33	−0.64***	−0.29	−0.52***	−0.23	−0.50***	−0.23	−0.51***	−0.23
End user	−0.68***	−0.34	−0.55***	−0.27	−0.39***	−0.19	−0.38**	−0.19	−0.38**	−0.19
Expert	−0.44**	−0.15	−0.41*	−0.14	−0.29*	−0.10	−0.31*	−0.11	−0.30*	−0.10
Task variety			0.11	0.08	0.14	0.10	0.14	0.10	0.14	0.10
Complexity			−0.21***	−0.20	−0.21***	−0.20	−0.19***	−0.18	−0.20***	−0.19
Problem-solving demands			0.15	0.12	0.18**	0.14	0.14	0.10	0.14	0.11
Information-processing requirements			−0.05	−0.04	−0.22**	−0.15	−0.20*	−0.13	−0.20*	−0.14
Autonomy			0.03	0.02	−0.06	−0.05	−0.08	−0.06	−0.10	−0.08
Availability for MAX frequency of EPSS use					0.59***	0.46	0.60***	0.47	0.59***	0.47
Neuroticism							0.01	0.01	0.02	0.02
Extraversion							0.06	0.06	0.06	0.06
Openness							0.08	0.07	0.08	0.07
Agreeableness							−0.10	−0.08	−0.12*	−0.10
Conscientiousness							−0.03	−0.03	−0.03	−0.02
Proactive personality							0.02	0.01	0.00	0.00
Team psychological safety									0.11	0.09
Geographical separation									0.08	0.04
R^2	0.062		0.125		0.301		0.313		0.318	
F	9.34***		8.89***		24.08***		15.74***		14.32***	
ΔR^2	0.062		0.063		0.176		0.012		0.006	
ΔF	9.34***		8.05***		140.90***		1.59		2.33	

Notes. MAX frequency of EPSS use = highest frequency of use across all problem-solving activities including EPSS. Availability for MAX frequency of EPSS use = availability of the problem-solving activity with the highest frequency of use across all problem-solving activities including EPSS. $N = 568$. *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

p = n.s., and the aspects regarding the social resources in step 5, $F(2, 552) = 2.332$, p = n.s., did not improve the explained variance in the frequency of EPSS significantly. Of these variables only agreeableness ($\beta = -0.12$, $p < 0.05$) was a significant predictor of frequency of EPSS use. Both models were still statistically significant, $R^2 = 0.313$, $F(16, 554) = 15.740$, $p < 0.001$, adjusted $R^2 = 0.293$, respective $R^2 = 0.318$, $F(18, 552) = 14.318$, $p < 0.001$, adjusted $R^2 = 0.296$. However, as there were no significant increases in the explained variance, the variables included in the last two steps have only a very small influence on the frequency of EPSS use. Referring to the significant predictors, EPSS availability was a positive and also the strongest predictor of EPSS use. Furthermore, the dummy variables for the ERP user types were significant predictors and indicate that more intensive ERP users also use EPSS more frequently, while the self-assessed ERP skills were not significant. In addition, agreeableness as well as the task complexity and information-processing requirements showed small negative effects.

5.6.6 Perceived Usefulness of EPSS Characteristics (RQ6)

The ERP users indicated the perceived usefulness of different EPSS characteristics for solving ERP-related problems (Figure 5-5). A one-way repeated measures ANOVA with a Huynh–Feldt correction determined that mean usefulness showed a statistically significant difference between the EPSS characteristics, $F(3.86, 2488.19) = 21.18$, $p < 0.001$, partial $\eta 2 = 0.03$. Bonferroni-adjusted post-hoc analysis revealed several significant differences between the EPSS characteristics for usefulness. These are substantial differences that can be interpreted. Significant differences are also displayed in Figure 5-5.

All EPSS characteristics presented to the ERP users were rated as useful but only on a medium level. The displaying of context-sensitive information within the UI, the possibility to save one's own notes but also displaying information in an extra window were considered to be slightly more useful. As theoretically already expected, there was no general preference for intrinsic over extrinsic characteristics.

In order to investigate if the ERP user types differ in their assessment of the perceived usefulness, a one-way MANOVA was performed. The analysis revealed statistically significant differences between the ERP user types on the combined dependent variables [$F(18, 1{,}802) = 1.776$, $p < 0.05$, Wilks' $\Lambda = 0.951$, partial $\eta 2 = 0.016$] but no significant results for the follow-up univariate one-way ANOVAs with Bonferroni adjustment were found. This indicates that there are no substantial differences between the user groups that can be reported.

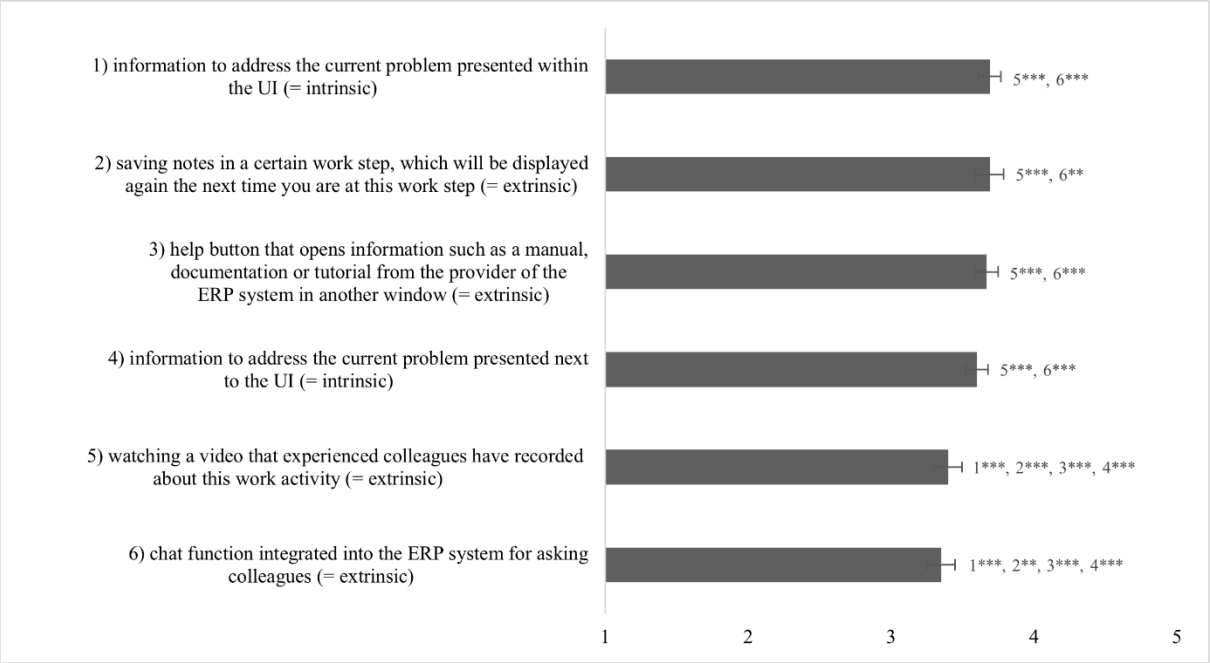

Figure 5-5: Significant differences, means and confidence intervals of the perceived usefulness of EPSS characteristics

Notes. Scale: 1 = not helpful at all, 3 = partly helpful, 5 = very helpful. *$p < 0.05$; **$p < 0.01$; and ***$p < 0.001$.

5.7 Discussion

Electronic Performance Support Systems (EPSS) are considered to support problem-solving and learning in the context of complex software tools, such as Enterprise Resource Planning (ERP) systems. In two survey studies, we asked 301 HR employees about their perception of EPSS as a learning measure in companies and 652 ERP users about their perception of EPSS when solving ERP-related problems. In general, EPSS can be viewed from two perspectives. On the one hand, EPSS can be viewed as a technological resource created to support employees' performance, problem-solving, and learning. This is a more general view on EPSS that includes, for example, how they are designed and supplied. On the other hand, EPSS can be considered regarding their actual use for problem-solving and potentially informal learning. Study 1 addressed the former perspective, while study 2 was based mostly on the latter perspective.

5.7.1 EPSS as a Trend in In-Company Learning Support

Asked about trends in in-company learning measures (RQ1), the HR employees rated e-learning, social software. and coaching as the most significant measures. EPSS were currently considered less important which could be due to the limited scope of EPSS as compared to e-learning that can be applied for almost any learning goals. Another reason might be the quite low penetration rate of EPSS in companies, which is also evident in the survey of ERP users in study 2. Furthermore, EPSS are primarily designed to support performance and only as a by-

product do they also support learning. Thus, they are a less obvious learning measure compared to e-learning. Still, HR employees assign high future significance to EPSS.

Asked about advantages and obstacles concerning the implementation and use of EPSS (RQ2), the HR employees selected significantly more pros than cons which again confirms their positive attitude toward EPSS. The most frequently selected advantages were (1) an increased employee efficiency, (2) the possibility to supplement face-to-face training, and (3) the reduction of search and problem-solving time. Obstacles were seen in (1) a lack of resources to produce and maintain content, (2) too high technical effort, and (3) an already implemented, competing Learning Management Systems (LMS) as an alternative to an EPSS. Anticipated acceptance problems on part of the employees or work councils played a minor role.

5.7.2 EPSS Use as an Activity for Solving ERP-Related Problems

Everyday problem-solving and informal learning go hand in hand. Starting from a classification of problem-solving approaches in the workplace (see Table 5-1), we developed a Model of Informal Workplace Learning Through Problem- Solving (see Figure 5-2), which integrates assumptions of Tynjälä's (2013) 3-P model, the JDCS model (Johnson & Hall, 1988; Karasek, 1979; Karasek & Theorell, 1990), the Approaches to Problem-Solving in the Workplace (Rausch, 2011; Rausch et al., 2015), the Technology Acceptance Model (Davis et al., 1989; Venkatesh & Bala, 2008), and the Affective Events Theory (AET) by Weiss and Cropanzano (1996). When confronted with an ERP-related problem, available personal, social, and technological resources are assessed, more or less consciously, regarding their potential contribution to the solution (i.e., usefulness) and regarding the effort required (i.e., ease of use). Ideally, EPSS provide useful and easy-to-use support that fosters problem-solving and learning. Therefore, EPSS conserve (social) resources in the short term (i.e., experts' working time, time spent on the problem) and expand personal resources in the long term (i.e., competence development). However, empirical research on EPSS use is scarce. While study 1 covered the potential that EPSS could have for competence development and workplace learning, study 2 investigated the contextual factors and individual factors/personal resources, including possible problem-solving activities (e.g., EPSS use), as well as the components of the interpretation and activities' frequency of use.

Regarding the availability and frequency of use of problem-solving activities (RQ3), the ERP users reported that consulting colleagues is the most frequently available and most frequently used activity, which was also reported in a diary study by Rausch et al. (2015). Reflecting is the second most frequently used activity, although it is assumed that reflecting on a

problem is included in any problem-solving process, at least to some degree. However, high time pressure or low self-efficacy could lead to shorter reflection. Observing colleagues was also rated as a frequently available and well-used activity. When colleagues show a problem solution, it can be assumed that they were asked beforehand. External and extrinsic types of EPSS are also available and used similarly frequently while intrinsic EPSS are less frequently available but if so, they are used intensively. This shows that EPSS, regardless of their categorization, are generally perceived as useful and easy to use. In line with our expectation, the results do not indicate a fundamental superiority of one EPSS type over another.

Investigating differences between the user types (RQ4) revealed that the group with the supposedly highest skills, administrators or SAP consultants, have external (i.e., company wiki, help desks, communities, FAQs, and forums) and extrinsic EPSS (i.e., manuals, documentations, and tutorials from the provider of the ERP system) more often available than other user groups and they also use external EPSS more often than other user groups. This could be related to the fact that forums and question-and-answer websites, for instance, fall into the category of external EPSS and that these are suitable for very specific and complex problems and questions, especially from experienced ERP users. It is conceivable that experts, in particular, may even only find help for their complex problems in such external EPSS because there is not enough expertise in their own team. In software programming, for instance, a lot of experts use Stack Overflow (a question-and-answer website for professional programmers) for their more complex problems.

Addressing contextual and individual/personal antecedents of the frequency of EPSS use (RQ5), a hierarchical multiple regression revealed that personality as well as aspects regarding the social resources were only less relevant for predicting frequency of EPSS use. EPSS availability was the strongest predictor, which is, of course, not surprising. Regarding further contextual factors, complexity and information-processing requirements were significant negative predictors of EPSS use. This would be in line with the results presented above that indicated a high frequency of use of external EPSS by experts with probably more complex problems. Regarding user characteristics, the ERP user role explained additional variance. This result also confirms the above findings that the most experienced user group uses EPSS rather frequently, due to the availability of external EPSS also in the case of more complex problems. The self-assessed ERP skills were not a predictor of EPSS use. Regarding the general personality traits, only agreeableness was a negative predictor which is not in line with the results by Devaraj et al. (2008) who found agreeableness to be a positive predictor of technology acceptance. Since people high in agreeableness tend to cooperate (McCrae & Costa, 1987), they may also tend to

consult others instead of using the EPSS. However, the same could be expected for extraverted people but was not found in our data. Altogether, general personality traits do not seem to play an important role in the use of EPSS. The same is true for team psychological safety and a person's geographical separation from the team as potential social resources.

Asked for the most favored characteristics of EPSS (RQ6), ERP users particularly valued context-sensitive information displayed within the UI of the ERP software, the possibility to save one's own notes within the system, and information displayed in an extra window. However, all EPSS characteristics were assessed as only moderately useful with small mean differences and participants did not receive detailed explanations or demos to illustrate the different characteristics. Therefore, the results should be interpreted with caution and further empirical results from the actual use of these characteristics are necessary. The possibility to watch a video that experienced colleagues have recorded about this work activity was rated as partly useful but only in fifth place. This is surprising as several authors emphasize the importance of employees' possibility to document and share their knowledge for colleagues (Gorecky et al., 2014; Ley et al., 2014). Perhaps the item was not worded precisely enough. Furthermore, results showed that there were no significant differences found between the ERP user groups' assessment of the usefulness of the different EPSS characteristics.

Altogether, HR employees attach a greater significance to EPSS in the future. They see an increased efficiency and a supplement to face-to-face training as the biggest advantages. External EPSS, including Web 2.0 services and applications, and extrinsic EPSS types are already available quite often, while intrinsic EPSS are less common. However, all EPSS types are actively used when available. The ERP users indicated context-sensitive information, integrated into the ERP system's UI, the option to save one's own notes for similar cases in the future, and information displayed in an extra window as more useful EPSS characteristics. In general, EPSS are more often available for more experienced users, such as ERP administrators and SAP consultants; and this user group uses external EPSS, such as company wikis, help desks, communities, FAQs, and forums more often than others. Still, consulting and observing colleagues are more common approaches when being confronted with ERP-related problems.

Regarding the developed Model of Informal Workplace Learning Through Problem-Solving, the results of study 2 found some of the individual factors/personal resources and contextual factors to be significantly related to EPSS use for solving ERP-related problems. Furthermore, the various activities for problem-solving generally available in the workplace according to the model could also be identified as empirically relevant. In addition, study 1 confirms the potential of EPSS for employee workplace learning, that is proposed by the model.

5.8 Limitations and Future Research

First of all, as the participants of both survey studies participated voluntarily, the results could be biased due to self-selection (Bickman & Rog, 2009; Henry, 2009). Furthermore, the participants of both survey studies were mainly from Germany, which also limits the generalizability of the results (Bickman & Rog, 2009). Moreover, given the cross-sectional study design, causal interpretations should be treated with caution (Bickman & Rog, 2009; Kelley & Maxwell, 2019).

Regarding study 2, we included a measure for the big five personality traits based on Saucier's (1994) Mini Markers and their German version by Weller and Matiaske (2009). However, we did not use separate items for each adjective, but to reduce participant burden, we used an array of adjectives in one item for each personality trait. This may have resulted in less accurate measurement of the big five personality traits, which could have affected the regression results by either overestimating or underestimating the effects. Furthermore, for measuring the availability and frequency of use of EPSS, as well as the perceived usefulness of EPSS characteristics, we generally referred to ERP-related problems in the workplace without specifying them in more detail. This allowed each participant to imagine a different ERP-related problem. It might be possible that depending on the problem imagined, the items on availability, frequency of use, and usefulness were rated differently. This may have negatively affected the precision and reliability of the results and further limited the generalizability of the results. In addition, as already mentioned, the EPSS characteristics and their function were only described verbally without seeing them in a system. This was very hypothetical and gave participants room for interpretation. This, again, may have led to less precise assessments of usefulness, on the one hand, and may limit the generalizability of the results on the other. Another limitation of our research is that we did not include the possibility that EPSS can proactively indicate a problem to the user, and only then does the user become aware of the problem. Such a feature would be feasible with AI. A further limitation of the study is that we did not investigate all components of the developed model. The components of contextual factors, individual factors/personal resources, interpretation, and problem-solving activities are covered, however not the actual outcomes as well as users' emotional experiences.

Addressing the above limitation, future research should also investigate actual EPSS use near the process, for instance, by using research diaries. They measure not only closer to the object under investigation but also reduce memory bias of retrospective questionnaires (Bolger et al., 2003; Ohly et al., 2010; Rausch et al., 2022). Furthermore, future studies could also investigate proactive EPSS as mentioned above. Regarding the developed model, further studies

addressing the assumed impact of the individual factors/personal resources and contextual factors should be conducted, as only some aspects of these factors were found to be empirically related to EPSS use so far. Moreover, the link between EPSS use, respective the use of information sources in general, and learning as well as the influence of emotional experiences were not investigated empirically yet. Thus, these variables should also be included in future empirical studies.

5.9 Practical Implications

Our findings suggest a positive impact of EPSS on employee performance in solving ERP-related problems, and also indicate that EPSS might positively influence employees' informal learning on some aspects. These results can be relevant for ERP system vendors as well as companies using ERP systems. For both, it can be recommended to integrate different EPSS characteristics into ERP systems. For vendors, this primarily includes content on standard processes and applications, as well as general content that supports rapid onboarding of new employees into the system. For the vendors, this can also serve as an USP. Companies that use ERP systems can then augment this content, for example, with more detailed help on specific processes or error-prone items as well as special aspects and areas of application. Although the possibility to watch videos that were recorded by experienced colleagues was not rated as especially helpful in our study, in our opinion, this is nevertheless a possibility that companies should take a closer look at. Our results suggest that external EPSS can be especially important for more experienced users. Here we assume that social communities, implemented through social technology, are of central importance. These can be established and explicitly promoted within the company. Furthermore, an additional link to user and competence profiles is conceivable. This would allow for the incorporation of prior knowledge and training already completed to provide context-specific and tailored support.

In line with Clark (1992), we assume that EPSS only foster particular skills, namely, the use of software tools, which are only one part of a broader set of professional competences that are required today (Rausch & Wuttke, 2016). Therefore, interaction with experienced coworkers and participation in collaborative problem-solving will still play an important role in workplace learning and socialization (Billett, 2001; Gery, 1991). It is not a question of either EPSS or other learning resources, but of an appropriate combination of different opportunities to learn in the workplace.

Data Availability Statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Author Contributions

All listed authors have made a substantial, a direct, and an intellectual contribution to this work and approved it for publication.

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6 Student's Tool Use in Computer Supported Collaborative Learning in Higher Education (Paper 4)

The paper was submitted in the version inserted here in *Jahrbuch der berufs- und wirtschaftspädagogischen Forschung 2023* (yearbook of vocational and business education research 2023)[5].

6.1 Abstract

This paper examines what tools were used by small student groups for problem-solving in CSCL as well as why these tools and for which activities within CSCL the tools were used. In sum, 110 students at a German university participated in a mixed-methods study. Data were collected by means of a self-report questionnaire and additional in-depth interviews with 12 of the participants. Results revealed that the most used tools were communication tools and sharing or co-construction tools. These tools were also perceived to be rather useful to very useful by the participants. As frequent usage reasons and resulting activities of communication tools, the participants reported amongst others the possibility to talk to each other, video streaming functionality as well as their use for detailed discussions and to organize the group work. For sharing and co-construction tools, for instance, shared access to files or a shared storage location, the timeliness of files and content or the prevention of multiple versions of one file, commentary function, and supporting group awareness or motivation were stated. The tools can serve several pedagogical purposes within CSCL. Major shortcomings of the study are its limited generalizability and the fact that no data on the effect of tool use on CSCL outcomes were collected. Practical implications point to learners' freedom in tool selection and the need to combine tools.

6.2 Introduction

The jobs of knowledge workers require increasingly complex and collaborative problem solving in technology-rich and oftentimes geographically separated working environments (Frey & Osborne, 2017; Ludvigsen & Steier, 2019). Higher education institutions prepare young people for these requirements by incorporating Computer Supported Collaborative Learning (CSCL) into their teaching (Ludvigsen & Steier, 2019; Miller & Hadwin, 2015). In general, there is a variety of technology and tools that can be used for CSCL (Al-Samarraie & Saeed, 2018; Chen et al., 2018; Jeong et al., 2019). Technology and tools in CSCL afford learners the opportunity to "(1) engage in a joint task, (2) communicate, (3) share resources, (4) engage in productive collaborative learning processes, (5) engage in co-construction, (6)

[5] For reasons of standardization within this thesis, the appendix for this paper was included in a common appendix for the entire thesis.

monitor and regulate collaborative learning, as well as (7) find and build groups and communities" (Jeong & Hmelo-Silver, 2016, p. 249).

Existing research on tool use in CSCL has major shortcomings. Firstly, empirical studies on CSCL have typically only investigated the effects of one or two selected tools (Al-Samarraie & Saeed, 2018; Jeong et al., 2019; Ludvigsen & Steier, 2019). Usually these tools were predefined by a teaching person or an instructor (Al-Samarraie & Saeed, 2018; Jeong et al., 2019). But oftentimes one tool is not sufficient for successful CSCL and in realistic contexts usually several tools are combined and alternated for different situations (Chen et al., 2018; Ludvigsen & Steier, 2019). Furthermore, in order to take learners' agency into account, they should be allowed to select and adapt the tools they use for CSCL and in general to choose the support they obtain from these tools (Ludvigsen & Steier, 2019; Tchounikine, 2019). This includes selecting tools that fit learners' ethics and values but also changing tools when activities evolve or do not work for the learners (Tchounikine, 2019). Moreover, empirical investigations should focus more on how commercial tools can support CSCL (Ludvigsen & Steier, 2019).

As far as it is known, no previous empirical study has investigated which (very likely commercial) tools students use for CSCL when they have the freedom to decide. Accordingly, no study has investigated the reasons behind students' tool choices in CSCL, for which activities the tools were then used and which conclusions can be drawn about the affordances of the individual tools. To address the presented research gaps, I conducted a mixed-methods study with German Economic and Business Education students. During the COVID-19 pandemic students' tool use and collaboration in CSCL was investigated. The following research questions are addressed: 1) What tools were used for collaboration in CSCL?; 2) How useful were these tools for collaboration?; 3) Why were these tools used? and 4) For which activities within CSCL were the tools used? The exploratory results can be helpful for instructors to make decisions about the freedoms in tool selection granted to students, as well as for specific tool recommendations and students' individual and collective tool choices.

6.3 Computer Supported Collaborative Learning and Empirical Evidence

Collaborative learning (CL) is defined as "a situation in which two or more people learn or attempt to learn something together" (Dillenbourg, 1999, p. 2). Collaborative learning includes every collaborative activity that takes place in an educational context (Dillenbourg, 1999) and may also include non-human collaboration (Jeong & Hmelo-Silver, 2016). These activities contain, in many cases, joint problem-solving, and learning is more of a by-product (Dillenbourg, 1999). However, it must be noted that collaboration does not guarantee learning per se, it only creates the framework in which learning can take place when group members

commit to shared goals and engage in interactions (Dillenbourg & Fischer, 2007; Dillenbourg et al., 2009; Kreijns et al., 2003). Collaborative learning activities that are facilitated or mediated by digital technology and digital tools are called CSCL (Chen et al., 2018; Kirschner & Erkens, 2013; Ludvigsen et al., 2021; Stahl & Hakkarainen, 2021; Stahl et al., 2006). Learning then occurs when the group members build and share knowledge as well as interact with the CSLC environment (Stahl & Hakkarainen, 2021). As already mentioned, technology and tools in CSCL allows learners to "(1) engage in a joint task, (2) communicate, (3) share resources, (4) engage in productive collaborative learning processes, (5) engage in co-construction, (6) monitor and regulate collaborative learning, as well as (7) find and build groups and communities" (Jeong & Hmelo-Silver, 2016, p. 249).

Engaging in a joint task refers to providing and enhancing tasks that are complex and worth the collaboration. *Communication* means enabling synchronous or asynchronous communication between the collaborating group members. *Sharing resources* is related to providing possibilities to share and organize resources between group members. *Engaging in productive collaborative learning processes* means providing support for asking and answering questions, giving, and receiving feedback and to expressing agreement or disagreement (Jeong & Hmelo-Silver, 2016). *Engaging in co-construction* refers to supporting learners in building a shared understanding of tasks and goals, building on each other's contributions and jointly constructing new knowledge, problem solutions and knowledge artifacts, with group discussion playing a vital role (Jeong & Hmelo-Silver, 2016; Stahl, 2006). *Monitoring and regulating collaborative learning* points to the central role of self-regulation within CL and CSCL and the affordances technology and tools offer for this (Järvelä & Hadwin, 2013; Jeong & Hmelo-Silver, 2016). Self-regulation refers to a learner's active planning, monitoring, controlling and regulation of his or her cognition, motivation and affect, behavior as well as a learner's environment (Pintrich, 2000; Zimmerman, 2000). Within CL not only self-regulation of every single group member is relevant, but also co-regulation and socially shared regulation of learning (Hadwin et al., 2011; Järvelä & Hadwin, 2013). Co-regulation refers to a group member's regulation of other group members' learning, while socially shared regulation is group members' collective, synchronized and productive regulation of the learning process (Hadwin et al., 2011; Järvelä & Hadwin, 2013). *Finding and building groups and communities* covers affordances for learners to find others to collaborate with (Jeong & Hmelo-Silver, 2016). Not all seven affordances are relevant in every CSCL situation. The last affordance, for instance, might not be relevant when participants are assigned to groups (Jeong & Hmelo-Silver, 2016).

A lot of studies confirm the positive impact of tool use in CSCL on learning and process outcomes and many of them are consolidated by more recent reviews and meta-studies. Jeong et al. (2019) found in their meta-study within Science, Technology, Engineering, and Mathematics (STEM) education a moderately but substantive positive effect of CSCL on different learning outcomes with the biggest effect on individual (e.g., individual time on task) and collaborative process outcomes (e.g., argumentation sequences). The results also yielded significant differences across the used tools, which were not only commercial tools. The biggest effect sizes were found for simulations, integrated environments (incorporating multiple tools), and participatory technology (e.g., wikis). In some included studies, multiple tools were used and seven tool combinations with five or more cases were found. The biggest effect was found for the combination of video conferencing and shared workspaces. Combining email, chat, and video conferencing, however, led to negative outcomes.

In their meta-study, Chen et al. (2018) found that the use of environments and tools was related to positive effects for all considered outcome and process measures, while also including non-commercial tools. There were significant differences between the environments and tools. Group awareness tools were found to be the most effective tools in supporting learning. Visual representation tools and virtual environments were the second and third most effective tools, respectively. Social interactions as process measure were affected by enhanced online discussion tools, visual representation tools, group awareness tools, and virtual environments. Moreover, a review on cloud-computing tools used for CSCL in higher education blended-learning was conducted (Al-Samarraie & Saeed, 2018). The authors categorized tools into synchronized tools, networking tools and Learning Management Systems (LMS) and derived different opportunities related to these tools. Synchronized tools were mainly used for sharing and editing files. Networking tools were mainly used for live chatting and instant messages and LMS were used to establish group discussions in different forms. Opportunities from using synchronized tools are, for example, saving time with activities like emailing, saving, and revising documents as well as the possibility to edit the same document at the same time and giving immediate feedback. Identified opportunities of social networking tools were, for instance, providing a sense of ownership of the CSCL process as well as multiple and collaborative interactions, and reflections. LMS tools offer students relevant examples, well-defined and organized instructions and support students' discussions (Al-Samarraie & Saeed, 2018).

Referring to studies not included in the previously presented meta-analyses and reviews, Vuopala et al. (2016) examined student interaction in successful CSCL in which Moodle (a learning environment) for asynchronous and SecondLife or a chat tool for synchronous

discussions were used. Results indicated that successful groups' interactions were more often group-related than task-related. Group-related interactions comprised especially the organization and planning of the group work and task-related interactions referred mainly to comments and answers to earlier messages. This finding was interpreted as confirming the central importance of the processes of regulating joint activities and coordinating group work in CSCL. In addition, in synchronous tools discussions were more often related to the organization of the group work, short comments to present new knowledge and socioemotional aspects like decreasing tension and accompanying, and discussions were generally more reciprocal. In asynchronous tools more messages expressing cohesion and messages presenting theory-based new knowledge were found.

Ishtaiwa and Aburezeq (2015) investigated Google Docs' potential to enhance interactions within CSCL as well as factors that limit students' collaboration using the tool. The results yielded that the tool enhances especially the behaviors of acquiring knowledge and skills in an interesting way, comparing work with others and checking process, learning from each other, giving and receiving feedback, enhancing motivation as well as promoting critical thinking and creativity. In general, the students perceived the tool as useful to support collaboration and the tool was appreciated in particular for its feature to leave comments, the ease of use, the access control, and the accessibility of revision history. In addition, the students also valued the absence of update conflicts and the absence of technical problems. As limiting factors regarding the use of Google Docs the students mentioned, for instance, limited editing features, a preference for other collaborative tools and a preference for face-to-face interactions.

One of the challenges in investigating tool use in CSCL is the lack of a comprehensive and precise classification of tools. Thus, I synthesized existing categorizations of meta-studies and reviews, which is presented in the following section.

6.4 Classification of CSCL Tools

By synthesizing existing tool categorizations in meta-studies and reviews (Al-Samarraie & Saeed, 2018; Chen et al., 2018; Jeong et al., 2019), seven tool categories could be derived (see Tab. 1). *Communication tools* enable synchronous or asynchronous communication between collaborative learners (Chen et al., 2018; Jeong et al., 2019). Examples are social media, videoconferencing or audioconferencing tools, discussion boards, chat tools, email tools and forums (Chen et al., 2018; Jeong et al., 2019). *Sharing and co-construction tools* provide efficient sharing and joint editing possibilities to support learning and creating artifacts within the CSCL process (Al-Samarraie & Saeed, 2018; Jeong et al., 2019). They refer to 1) sharing tools for storing and sharing artifacts and 2) synchronized tools for creating and joint online editing

of artifacts that also enable exchanging thoughts and giving each other feedback, for instance, by leaving comments (Al-Samarraie & Saeed, 2018; Jeong et al., 2019).

Table 6-1: Categorization of CSCL tools

CSCL tool category	Examples
1) Communication tools	Social media, videoconferencing tools, audioconferencing tools, discussion board, chat, email tools, forum
2) Sharing or co-construction tools	Sharing tools, synchronized tools
3) Representation tools	Tools to create mind maps, concept maps, diagram, matrixes, multimedia
4) Group awareness tools	Behavioral group awareness tools, social group awareness tools, cognitive group awareness tools
5) Systems or environments	Integrated environment, intelligent system, (intelligent) adaptive system
6) Dynamic tools	Simulations, digital games, immersive technologies
7) Miscellaneous tools	Tools that do not fit into the other tool categories

Source: own synthesis based on Al-Samarraie and Saeed (2018), Chen et al. (2018) and Jeong et al. (2019)

By means of *representation tools*, collaborative learners can design different forms of representations of their ideas and create a common ground of understanding (Chen et al., 2018). Examples are tools to create mind maps, concept maps, diagrams, matrixes or multimedia (Chen et al., 2018). With *group awareness tools*, learners can access information on the behavioral (e.g., on group members activities), cognitive (e.g., on group members expertise or knowledge) and social aspects (e.g., on group members participation and contribution) of the group members to coordinate and direct group activities as well as to improve the collaboration (Bodemer & Dehler, 2011; Janssen & Bodemer, 2013). Thus, behavioral, social, and cognitive group awareness tools can be distinguished (Chen et al., 2018; Janssen & Bodemer, 2013). Group awareness tools are oftentimes integrated into environments and other tools (Janssen & Bodemer, 2013). *Systems and environments* include integrated environments but also intelligent systems and (intelligent) adaptive systems (Al-Samarraie & Saeed, 2018; Chen et al., 2018; Jeong et al., 2019). Integrated environments comprise several tools, ranging from LMS to, for instance, online environments with pedagogical goals like problem-based learning (Al-Samarraie & Saeed, 2018; Jeong et al., 2019). Adaptive systems deliver learning materials depending on how a learner has previously interacted with prior content (Kerr, 2016). Intelligent systems apply Artificial Intelligence (AI) (Brusilovsky & Peylo, 2003). Adaptive systems that use AI

are referred to as intelligent adaptive systems (Brusilovsky & Peylo, 2003). D*ynamic tools* present information in dynamic forms like simulations, games or immersive technologies like virtual and augmented reality (VR / AR) (Jeong et al., 2019). Table 1 shows the CSCL tool categories with the presented examples for each category. Of course, the examples are not exhaustive. In addition, the categories for some tools may overlap and not be completely clear-cut and the categories may not cover every CSCL tool available. Thus, in accordance with Jeong et al. (2019) a further category called *miscellaneous tools* for tools that do not fit into the other categories was added.

6.5 Method

To answer the research questions, a mixed-methods study was conducted with German Economic and Business Education students in a university course over the course over an entire semester. The study was approved by the university's ethics committee and the participants provided written consent for the processing of their data. Students' participation in the study was voluntary. The course assignment for the students was to jointly create a test instrument to measure competencies and write a term paper on it. This test instrument creation can be seen as a collaborative problem-solving task. Test creation and term paper writing were done collaboratively in small groups of three to four students. The theoretical basics for this task were taught in a lecture, while the group task was presented in more detail in an accompanying exercise. During the exercise, the students presented their interim results twice and received feedback. The presentations were not graded. Thus, for the students the project was structured in the following main phases: 1) self-responsible group formation, 2) test instrument construction, 3) interim presentation, 4) test instrument construction and term paper writing 5) final presentation as well as 6) test instrument construction and term paper finalization with term paper submission. Between these phases, the students met independently in their groups to prepare the test instrument, the presentations, and the term paper. There were no instructions on when or how often they should meet or how the meetings should be structured.

Since the semester and the collaborative problem-solving tasks took place during a COVID-lockdown with digital-only teaching, the largest part of the student collaboration could only take place remotely and with the help of various digital tools. At the beginning of the semester the teachers also presented some exemplary tools for CSCL (i.e., Google Docs, Word Online, Trello). Trello enables boards, lists, and cards to be created in a kanban style to enhance collaborative working. The students were explicitly informed that the presented tools were only examples and that they were completely free to decide which tools they would like to use - especially if, for example, they had data protection concerns about the presented tools.

Data was collected with a self-report questionnaire at the beginning of the semester, which comprised demographical data, and with a further self-report questionnaire at the end of the collaboration. Additional in-depth interviews were conducted at the end of the collaboration with individual students for more in-depth information on groups' tool use. In sum, 110 students participated, 79 of which were female and 31 were male. Most of the participants were in their third semester (87 participants). Participants' mean age was 21.9 years and 99 percent of them were undergraduate students, while 1 percent were graduate students. On average, 94 percent of the group meetings took place entirely digitally, while for two percent of the meetings all group members met in person and for four percent of all meetings at least two of the group members met in person while the other group members joined digitally. Interviews were conducted with 12 students who were in 12 different collaborative groups.

Self-report questionnaire at the end of the semester. One question addressed how participants' groups met. The participants had to divide 100 percent of their group meeting time between the three possibilities of 1) meeting entirely digitally, 2) at least two group members meeting in person and the other group members joining digitally and 3) the whole group meeting in person. Another question addressed which tools the students used for collaboration. The participants could name up to eight tools that were used. For each named tool the participants were asked to also rate how often the tool was used (0 = *not very frequently* to 4 = *very frequently*) and how useful (0 = *not useful at* all to 4 = *very useful*) they perceived the respective tool.

Interviews. The semi-structured interviews were conducted by using an interview guide. The interviews included, among others, questions on the frequency of in person and digital group meetings, used tools, reasons for tool use and the activities in CSCL the tools were used for. In addition, ad-hoc questions were used to clarify some of the participants' answers. The 12 interviews were recorded and transcribed. In sum, 3 hours and 47 minutes of interviews were recorded, with an average duration of 18 minutes and 58 seconds per interview.

The first two research questions are addressed by descriptive analyses of the questionnaire data. The third and fourth research questions are answered based on the interview data. The questionnaire data was analyzed using the software SPSS. Interview data was analyzed by means of qualitative content analysis in the form of inductive category formation according to Mayring (2022) (see Appendix D). The software MAXQDA was used for this.

6.6 Results

6.6.1 Tools used for CSCL and perceived usefulness

Participants indicated that they used 26 commercial tools for CSCL in sum. Table 2 shows all tools that were used by the participants as well as the mean frequency of use and the perceived mean usefulness of all tools. The tools were also categorized into one of the tool categories of Table 1. Taking all potential functionalities and versions of a tool into account, some tools may be assigned to more than one category. For the sake of clarity, I assigned every tool to only one category referring to its main functionalities.

Table 6-2: Used tools for CSCL

Tool	Tool category	Mentions	Mean frequency of use	Mean usefulness
WhatsApp	1	99	3.70	3.76
Google Docs	2	80	3.54	3.54
Zoom	1	64	3.39	3.64
Microsoft Word	7	29	3.65	3.76
Skype	1	28	3.00	3.54
Trello	3	21	1.50	2.67
Discord	1	17	2.44	3.12
Email	1	9	2.38	3.11
FaceTime	1	9	3.14	4.00
Microsoft PowerPoint	3	8	1.43	3.25
Google Drive	2	6	3.80	3.67
Google Slides	3	6	2.33	3.83
Microsoft OneDrive	2	6	3.50	3.67
Microsoft Word Online	2	5	2.80	2.60
Dropbox	2	4	2.67	3.00
Microsoft Excel	7	4	2.50	3.50
Google Meet	1	4	4.00	4.00
Google Sheets	7	4	2.25	2.75
Microsoft Teams	1	3	3.50	4.00
Team Viewer	1	3	3.67	4.00
Zotero	7	2	4.00	3.50
Google Groups	1	1	-	4.00
Microsoft Office	7	1	4.00	4.00
Notability	3	1	2.00	4.00
Microsoft OneNote	3	1	4.00	4.00
Microsoft PowerPoint Online	3	1	1.00	2.00

Notes. Tool categories in accordance with Table 6-1: 1 = Communication tools, 2 = Sharing and co-construction tools, 3 = Representation tools, 4 = Group awareness tools, 5 = Systems or environments, 6 = Dynamic tools, 7 = Miscellaneous tools. Source: own table

The tools that were mentioned most by the participants were WhatsApp, Google Docs, Zoom, Microsoft Word and Skype. WhatsApp, Zoom and Skype can be categorized as communication tools, while Google Docs is a sharing and co-construction tool. Microsoft Word is a tool for text editing and is categorized as a miscellaneous tool, because it does not allow participants to work on the same document at the same time. These most mentioned tools were also indicated to have been used quite frequently. Some other tools were also used quite frequently when mentioned (e.g., GoogleMeet, Team Viewer, Microsoft Teams). Several representation tools (e.g., Trello, Microsoft PowerPoint, Google Slides) were mentioned by the participants, but used rather less frequently. Out of the frequently mentioned tools, the most useful tools were, in descending order, Google Slides, WhatsApp, Microsoft Word, Microsoft OneDrive, Google Drive (without specifying the used functionalities), Zoom, Google Docs and Skype.

6.6.2 Reasons for tool use and associated activities in CSCL

Research questions 3 and 4 addressed why and for which activities within CSCL students used the tools. As it was difficult for the students to differentiate between these aspects and as they are in fact interconnected, these two research questions are addressed together. The interview partners reported 15 tools they used as well as various usage reasons and activities for which the tools were used. For some tools the participants also mentioned reasons for not using them or rea-sons why they discontinued using the tools. The reasons for using a tool or the reasons for not using it and activities for which the tools were used are shown in Appendix E.

As communication tools, most interview partners reported WhatsApp, Zoom and Skype. For all tools, the reasons given for using them were the *possibility to talk to each other* and the *familiarity of the tool or its wide circulation*. For WhatsApp, further reasons and usage activities were, for instance, *communication speed*, its *support of group awareness or motivation* and it being used for *short queries*, to *share files* and to *organize the group work*. Regarding Zoom and Skype, the participants also stressed the *video streaming functionality* and using them for *detailed discussions*. As a reason for no longer using Zoom, one participant indicated the tool's *limited meeting time* (version-dependent). Referring to the seven affordances by Jeong and Hmelo-Silver (2016), the reported communication tools afford *communication*, partly *sharing of resources, engaging in productive collaborative learning processes* and *engaging in co-construction*. WhatsApp also allows *monitoring and regulating collaborative learning*.

Google Docs and Google Drive were the tools that were mentioned by most participants within the category of sharing and co-construction tools. Google Docs and Google Drive were used by several interview partners who emphasized the usage reasons and activities of *shared access to files or shared storage location* and the *timeliness of files and content or the*

prevention of multiple versions of one file. In addition, the *commentary function* and the support of *group awareness or motivation* were indicated. For Google Docs also *working simultaneously on one file* and its *ease of use* were mentioned. For both, Google Docs and Google Drive, a reason for discontinuing their use was that *formatting within documents* was perceived to be difficult. Microsoft OneDrive was indicated to be used for similar reasons and for similar activities to Google Docs and Google Drive, however, it was mentioned by only one interview partner. Dropbox was used because of its *shared access to files*. Again referencing the seven affordances presented (Jeong & Hmelo-Silver, 2016) the used sharing and co-construction tools mostly afford the *sharing of resources*, *engaging in productive collaborative learning processes* and *engaging in co-construction*. To a lesser degree, the tools also enhance *communication* referring to the commentary function. In addition, all tools but Dropbox further afford *monitoring and regulating collaborative learning.*

Four interview partners used the representation tool Trello. Reasons for its use and related activities were *shared access to files or a shared storage location*, *the notification function on changes* and the resulting *group awareness*. Thus, Trello affords the *sharing of resources* as well as *monitoring and regulating collaborative learning* (Jeong & Hmelo-Silver, 2016). Two other tools stated by the interview partners fall under the category of miscellaneous tools (i.e., Microsoft Word, Zotero). The reasons for using and resulting activities for Microsoft Word were its use for *completing the term paper and formatting* and *participants' familiarity with the tool or the habit of using it*. Zotero enabled the *automatic creation of a reference list*, enabled the *complete coverage of references* and was appreciated for its *clarity*. The activities mentioned in the context of using these two miscellaneous tools may point to the affordance of *engaging in co-construction* (Jeong & Hmelo-Silver, 2016).

6.7 Discussion

The first and second research questions addressed what tools the participants used for collaborating in CSCL as well as how useful the tools were perceived to be for collaborating. Results yielded that, in sum, the participants used 26 commercial tools. Out of these 26 tools, 15 tools were *communication* and *sharing or co-construction tools* and they were rated as rather useful to very useful. This is not surprising as communication between group members and the co-constructive writing of the term paper were expected to be central for the students. Moreover, such tools may be particularly relevant in a setting such as this one, where the students had little or no opportunity to meet in person. The combination of a video conferencing tool with a tool providing a shared workspace was also found several times in Jeong et al.'s (2019) meta-study with a positive effect on learning outcomes. The frequent use of Google Docs as a sharing

or co-construction tool is also in line with the findings of Al-Samarraie and Saeed (2018) and the perceived high usefulness of Google Docs' in CSCL (Ishtaiwa & Aburezeq, 2015). In general, the similarly high estimated usefulness of the used communication and sharing or co-construction tools probably indicates that the participants chose, in both categories, the tools they could work the most efficiently and effectively with, which would advocate for students' agency in tool selection (Tchounikine, 2019).

Several *representation tools* (e.g., Trello, Microsoft PowerPoint, Google Slides) were mentioned but used with medium frequency to rather infrequently. With regard to Microsoft PowerPoint and Google Slides this is probably due to the fact that the collaborative groups had to mandatorily present their actual progress twice. It is probable that because the presentations took place only twice and were more of a side task, the tools were used, but not frequently. Trello was used by 21 out of the 110 participants but they indicated that they used the tool rather infrequently and perceived it as less useful for collaboration. It is possible that because the instructor presented the tool to the students, many of the students tested it, but they then found it to be not very useful and stopped using it. There were indications of this in the interview data. However, this finding would not be in line with empirical research and assumptions that representation tools can support CSCL in different ways (Jeong & Hmelo-Silver, 2016). Perhaps participants only used the tools that were obviously useful to them for collaborating and writing their term paper, and a representation tool like Trello was not seen by them as so obviously useful to support these tasks or as some form of extra work. In general, it is rather surprising that Microsoft Teams in particular, which combines many functionalities (e.g., asynchronous and synchronous communication, even with video streaming and screen sharing functionalities; sharing and co-creating files) is not used by more participants, although Microsoft Teams was available for the students at the university. Maybe this tool, which is used in many organizations, is rather known to and used by students who have already gained practical experience in organizations. As most students were undergraduate students in their third semester many of them may not yet have gained any practical experience and thus may not yet have been introduced to this tool.

Research questions 3 and 4 addressed why participants used the tools and for which activities within CSCL the tools were used. The mentioned usage reasons and resulting activities for the *communication tools* WhatsApp, Zoom and Skype included, for instance, *organizing the group work* and the fact that they offer the *possibility to talk to each other*, *video streaming functionality*, *use for detailed discussions* and their *support of group awareness or motivation*. These findings are very much in line with the CSCL activities enabled by social networking

tools found by Al-Samarraie and Saeed (2018). In addition, using the tools to organize group work is in line with Vuopala et al.'s (2016) findings on the importance of coordinating group work in CSCL. The fact that one group stopped using one of the tools because it did not meet the group's requirements emphasizes the significance of learners' agency, including their ability to switch tools (Tchounikine, 2019).

The usage reasons and activities for the sharing and co-construction tools Google Docs and Google Drive were, for example, *shared access to files or a shared storage location*, the *timeliness of files and content or the prevention of multiple versions of one file*, the *commentary function*, and the *support of group awareness or motivation*. The participants additionally stated *formatting difficulties* when working with the two tools. These results suggest that participants, when referring to Google Drive, meant Google Docs as Google Docs files can be saved on Google Drive and accessed via Google Drive. In general, the results, including the stated formatting difficulties, are again in line with the identified CSCL activities and synthesized opportunities resulting from using synchronized tools as compiled by Al-Samarraie and Saeed (2018). The results on Google Docs are also consistent with the findings by Ishtaiwa and Aburezeq (2015) who found similar behaviors and difficulties related to the use of Google Docs as well as similar appreciated functionalities. As reasons for using and the activities associated with the representation tool Trello, for instance, *shared access to files or a shared storage location* was named. This is a good example of a tool's unexpected use in the context of learners' agency (Tchounikine, 2019) and that a tool's use influences its impact within CSCL (Janssen et al., 2011). The interview partners mentioned two tools in the category of miscellaneous tools (i.e., Microsoft Word, Zotero). Microsoft Word was used for *completing the term paper and formatting*. Data suggest that most groups used a sharing and co-construction tool for jointly writing the term paper and to format the final paper they then used Microsoft Word. Zotero enabled the *automatic creation of a reference list* and the *complete coverage of references* and was appreciated for its *clarity* and *ease of use*.

The findings from RQ3 and RQ4 were also categorized referring to the seven affordances of technology and tool use in CSCL (Jeong & Hmelo-Silver, 2016). Accordingly, the mentioned communication and sharing and co-construction tools afford to different degrees and different aspects *communication, sharing of resources, engaging in productive collaborative learning processes, engaging in co-construction* and *monitoring and regulation collaborative learning.* Trello as representation tool supports the *sharing of resources* as well as *monitoring and regulating collaborative learning*. The mentioned miscellaneous tools may enhance *engaging in co-construction.* Thus, all affordances that were relevant in the present CSCL situation were

supported by the tools the students used (affordances 2 to 6). These results also show that commercial tools in CSCL can serve several pedagogical purposes.

The research has several limitations. First, effects of tool use on learning outcomes (e.g., grades, knowledge construction) were not measured and as a result perceived tool usefulness was not reported in relation to CSCL outcomes. In addition, the influence of tool use on concrete subprocesses, especially in the context and areas of self-regulation, co-regulation, and socially shared regulation, were not investigated. Moreover, the generalizability of the results is limited due to the rather small convenience sample and different tool combinations and how they affected CSCL were not investigated.

Several practical implications can be derived from the results. First, students should be given the freedom to choose the tools they prefer to use for CSCL. When using commercial tools, a combination of several tools seems to be necessary as different tools afford different opportunities and activities in CSCL. At least one communication tool and one sharing and co-construction tool may be recommended here. Moreover, tools' pedagogical affects could be strengthened, for instance, by educating students about regulatory processes within collaborative learning and which functionalities in available tools promote them. Here instructors could also point out the use of representation tools.

6.8 References

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7 Discussion and further research

In this final chapter the main findings of the four research papers included in this thesis are recapitulated and light is shed on some selected aspects (7.1). The common limitations of the research papers are then discussed and based on these, various avenues for future research are presented (7.2). The chapter closes with practical implications and a global conclusion (7.3).

7.1 Summary of Findings

In the introduction, several developments and changes regarding modern and digitalized workplaces were presented. As a result, three actual and future major components of these workplaces could be identified: complex problem-solving, collaboration and communication as well as technology (use). These aspects and the resulting changes in working tasks and requirements not only necessitate continuous learning but also offer fruitful opportunities for employees to learn in the workplace, and, when integrated into tertiary education, can prepare young people for the demands of digitalized workplaces. Therefore, the aim of this thesis was to examine how employees' and tertiary education students' self-regulated learning (SRL), in the context of work-related formal as well as informal learning, can be supported in settings with different combinations of the three identified major components.

7.1.1 Findings on social interactions and informal workplace learning

The first research paper in this thesis addressed the aspect of communication and its impact on vocational education and training (VET) trainees' informal workplace learning. Within the paper it was examined how trainees' social interactions at work influenced their self-perceived informal workplace learning. The study also took contextual and personal antecedents as well as emotional experiences into account (Hökkä et al., 2020; S. Jeong et al., 2018; Rintala et al., 2019; Tynjälä, 2013). The results showed that several social interactions' situational characteristics impacted self-perceived learning (RQ1). The baseline level of instrumentality, an interruption of the social interaction, its above-average instrumentality as well as questions asked by the trainees during the interaction were found to be positive predictors, while trainees' speech proportion was a negative predictor of learning. Social interaction characteristics were also identified to be the strongest predictors of self-perceived learning from social interactions. The baseline level of instrumentality refers to an individual's general tendency to perceive interactions as instrumental for their work activities that may derive from interest or a general openness, but it can also be caused by contextual factors such as particularly supportive colleagues. Apart from the positive effect of an interruption of a social interaction, these identified predictors as well as their direction of affect were rather straightforward. An interruption's positive effect may, for instance, result from the time for reflection that it allows trainees and which, in turn, is conducive for learning. Furthermore, the results

revealed that emotional experiences were significantly related to learning as well (RQ2). Above-average experiences of feeling *motivated / delighted / curious* and *bored /dull / uninterested* were significantly positively related to learning, which led the authors to conclude that high levels at both ends of the continuum *arousal – sleep* seem to promote learning. The positive influence of states of moderate displeasure and high sleepiness was surprising, as it is not in line with previous findings on, for instance, boredom (Goetz & Hall, 2014). However, it was interpreted by the authors in a way that coping with boredom might lead to asking, for example, for tasks that are more interesting and challenging (Nett et al., 2011), which then, in turn, supports learning; or that feeling bored hints towards trainees being underchallenged (Csikszentmihalyi, 1988) and their already high competencies. Because the Big Five personality traits did not improve the model fit, the authors concluded that they have no significant relationship with self-perceived learning from social interactions (RQ3). However, the Big Five personality traits showed several significant correlations with emotional experiences.

7.1.2 Findings on technology-related problem-solving and informal workplace learning

The second and third research paper addressed problem-solving and learning in a technology context. In the second paper it was examined how solving software-related problems influenced employees' self-perceived informal workplace learning. Based on the model of Informal Workplace Learning Through Problem-Solving (Leiß et al., 2022), which synthesizes several existing models, different problem-solving activities, emotional experiences as well as contextual and personal factors were included in the analysis. Results yielded that experimenting on one's own was the most frequently used problem-solving activity, which was, however, significantly negatively related to learning; while asking others and using information from the internet were the second and third most commonly used activities and showed a significantly positive effect on learning (RQ1). In this context the negative effect of experimenting contradicts the albeit scarce empirical evidence (Andrade et al., 2009; Cuyvers et al., 2016; Haemer et al., 2017; Novick et al., 2009). It is probably that this activity is only suitable for less complex problems to foster learning or the participants lacked prior knowledge to be able to profit from experimenting (Haemer et al., 2017). An above-average experience of being *irritated / annoyed / angry* was found to be negatively related to self-perceived learning (RQ2). This result is in line with Pekrun et al. (2011), but the causality in our study was unclear because irritation and anger towards the respective software or problem at hand could also be the result of a lack of problem-solving and learning success. Regarding contextual factors (RQ3), working on site in the office (as opposed to working remotely) was found to be a significant negative predictor of learning from software-related problems, indicating that participants learned less when they dealt with a software-related problem that occurred while they worked in the office. One

possible explanation for this result may be that working remotely allows employees to take more time to reflect and elaborate on a problem, which, in turn, fosters learning (Haemer et al., 2017). In addition, the baseline level of guilt as well as the above-average experience of guilt significantly positively affected learning, which signifies the paper's contribution to the previous mixed empirical evidence (Liu & Xiang, 2018; Rausch et al., 2017; Zhao, 2011). The inclusion of personality factors, again, did not improve the model fit (RQ4). However, despite this, occupational self-efficacy was shown to be a significant positive predictor of learning, which is in line with previous research (Cerasoli et al., 2018; S. Jeong et al., 2018). Surprisingly, when controlling for personal factors, team psychological safety turned out to be a significant negative predictor of learning, which contradicts the findings of previous studies (Edmondson & Lei, 2014; Frazier et al., 2017; Newman et al., 2017). An explanation might be that high psychological safety may lead to turning to others too quickly without even trying to solve the problem by oneself, to delegating problems completely or to wasting time with unimportant things (Edmondson & Lei, 2014).

The third research paper included in this thesis was also based on the model of Informal Workplace Learning Through Problem-Solving (Leiß et al., 2022). Within the model, it is assumed that various problem-solving resources are available at a workplace, which are interpreted and enable different problem-solving activities to be carried out by employees. The resources include personal, social as well as technological resources. Technological resources comprise, for instance, tools like Electronic Performance Support Systems (EPSS) that are especially promising for solving software-related problems (Leiß et al., 2022). Three EPSS types can be distinguished by their increasing integration into the user interface and their context-sensitivity: external, extrinsic and intrinsic EPSS (Gery, 1995; Nguyen, 2005). Against this background the third research paper comprises two sub studies. The first sub study addressed how people working in Human Resources (HR)-related positions evaluated the significance of EPSS as a learning resource and how they assessed aspects concerning EPSS' implementation and use. The second sub study focused on Enterprise Resource Planning (ERP) software users' availability and usage of different problem-solving activities, with a special focus on EPSS. Furthermore, participants' perceptions of different EPSS characteristics and predictors of EPSS use, while again including contextual as well as personal antecedents, were investigated.

The first sub study's findings showed that the surveyed people working in HR-related positions perceived, in contrast to other measures for employee learning (e.g., e-learning, social software, coaching), EPSS to be currently less important (RQ1), which may be due to the limited scope of EPSS compared to e-learning, which can be applied for almost any learning goals or EPSS' actual low penetration rate in companies. However, for the future EPSS were expected to become more

important. Asked about advantages and obstacles concerning the implementation and use of EPSS (RQ2), the HR employees identified significantly more pros than cons. The most commonly identified advantages were increased employee efficiency as well as the possibility to supplement face-to-face training. The most frequently identified obstacles included a lack of resources to produce and maintain content or a technical effort that was perceived as too high. The second sub studies' results revealed that consulting colleagues and reflecting were the most frequently available and most frequently used activities to solve ERP-related problems (RQ3). The results were in line with Rausch et al. (2015), who found seeking support from others to be the most frequently used problem-solving approach as well. External and extrinsic types of EPSS were also available to some participants and were used with a similar frequency while intrinsic EPSS were less frequently available but if so, they were used intensively. Moreover, when comparing different ERP user types, for administrators or SAP consultants, external (i.e., company wiki, help desks, communities, FAQs, and forums) and extrinsic EPSS (i.e., manuals, documentations, and tutorials from the provider of the ERP system) were significantly more often available than for other user groups (RQ4). Administrators or SAP consultants also used external EPSS significantly more often than other user groups (RQ4). This may be since this user group deals with more complex problems for which forums or questions-and-answers websites like Stack Overflow are used. EPSS availability and a more experienced ERP user role were found to be significant positive predictors of the frequency of EPSS use (RQ5). Complexity, information-processing requirements, and agreeableness were significant negative predictors of the frequency of EPSS use. The results of a negative influence of complexity and information processing requirements can be linked to previous results of the study. Since a large proportion of participants use intrinsic EPSS more frequently, it could be interpreted as indicating that these EPSS may be, at least in their current form, less suitable for more complex and demanding problems. This would be in line with the findings that indicated a high frequency of use of external EPSS by experts with probably more complex problems. Regarding the most favored EPSS characteristics, the participants most frequently selected context-sensitive information displayed within the user interface (UI) of the ERP software, the possibility to save one's own notes within the system, and information displayed in an extra window (RQ6). However, all EPSS characteristics were assessed as only moderately useful with small mean differences.

7.1.3 Findings on tool use within CSCL in tertiary education

The last research paper combined the components of problem-solving, collaboration and communication, technology use and learning. To be successful in workplaces that are shaped by these central components and that require continuous learning, students need to be prepared for the demands of such workplaces. To achieve this, higher education institutions can incorporate

Computer Supported Collaborative Learning (CSCL) into their teaching (Ludvigsen & Steier, 2019; Miller & Hadwin, 2015). A central component of CSCL is technology and tools that afford learners opportunities to "(1) engage in a joint task, (2) communicate, (3) share resources, (4) engage in productive collaborative learning processes, (5) engage in co-construction, (6) monitor and regulate collaborative learning, as well as (7) find and build groups and communities" (H. Jeong & Hmelo-Silver, 2016, p. 249). Based on that, in the fourth paper, tertiary education students' tool use within remote CSCL was examined. Results yielded that in sum the participants used 26 tools for their CSCL (RQ1). They used mostly 1) communication and 2) sharing and co-construction tools. These tool categories may be particularly important in such settings as the given one where students have little to no opportunity to meet in person. The frequent use of Google Docs as a sharing or co-construction tool is also in line with the findings of Al-Samarraie and Saeed (2018) and the perceived high usefulness of Google Docs in CSCL (Ishtaiwa & Aburezeq, 2015). The most used tools were also perceived as rather useful to very useful by the participants (RQ2). Regarding why and for which activities within CSCL participants used the tools (RQ3+4), the results yielded that the communication tools WhatsApp, Zoom and Skye were used due to several reasons and for several activities. These included, for instance, *video streaming functionality, organization to the group work*, the *possibility to talk to each other* or their *support of group awareness or motivation*. The fact that one group stopped using one of the tools because it did not meet the group's requirements emphasizes the significance of learners' agency, including their ability to switch tools (Tchounikine, 2019). The reasons for using and the associated activities for the sharing and co-construction tools Google Docs and Google Drive were, for example, *shared access to files or a shared storage location*, the *timeliness of files and content or the prevention of multiple versions of one file* as well as the *commentary function*. In addition, the unexpected use of a mentioned representation tool was interpreted by the author in the context of learners' necessary agency in selecting technology and tools for CSCL (Tchounikine, 2019) and showed that a tool's use influences its impact within CSCL (Janssen et al., 2011). Based on the seven affordances of H. Jeong and Hmelo-Silver (2016), the mentioned communication and sharing and co-construction tools afford different degrees and different aspects of *communication*, *sharing of resources*, *engaging in productive collaborative learning processes*, *engaging in co-construction* and *monitoring and regulation collaborative learning*. These results show that commercial tools in CSCL can also serve various pedagogical purposes.

In summary, the above findings of the included research papers underpin the importance of social interactions, sometimes also in collaborative contexts (paper 1), as well as software-related problem-solving (paper 2) as activities that support informal workplace learning. The findings further point towards the use of EPSS as a tool for ERP-related problem-solving activities (paper 3).

In addition, the relevance of different contextual (paper 1 + 2) and to a lesser degree personal antecedents (paper 2) as well as emotional experiences (paper 1 + 2) for informal workplace learning was also shown. This also applies to the relevance of contextual and personal antecedents for EPSS use (paper 3), and thus tool or technology use. Lastly, the research findings confirm the significance of technology and tools for remote CSCL, with a focus on learners' agency within tool selection and the need for tool combination in CSCL (paper 4).

7.2 Limitations and Further Research

The four research papers included in this thesis share several limitations. These limitations result in several recommendations and avenues for further research. First, all included research papers share the limitation that the respective sample is a non-probability convenience sample whose results are potentially biased and in general not representative in regard to the respective population (Bickman & Rog, 2009; Henry, 2009). Especially paper 1 and 2 are potentially subject to a self-selection bias as potentially only highly motivated people are willing to participate in data collection that may be burdensome (Seifried & Rausch, 2022). Furthermore, participants in paper 1, 2 and 4 and most participants in paper 3 were from Germany and in paper 1, 2 and 4, the participants came from only one company or one educational institution. This diminishes the geographical generalizability of all research findings (Bickman & Rog, 2009). Due to the nature of the scientific research and publication process most research findings are publicized at least several months up to a few years after the data have been collected. Together with the fact that some research areas and topics change fast, these aspects further diminish generalizability of the results in regard to timeliness (Bickman & Rog, 2009). This limitation may especially apply to papers 1 and 4 included in this thesis. While paper 1 represents a secondary analysis, which per se has a time delay, data for paper 4 were collected during the COVID-19 pandemic and lockdown in Germany. Although this situation may be partly comparable to remote working and learning situations, for example, in an international and highly geographically distributed work environment, the time during the pandemic was characterized by extraordinary conditions. Therefore, now that the pandemic has slowed down, I suggest performing a replication study to compare the results. Moreover, in regard to all four papers, replication studies considering probability sampling as well as more geographically diverse participants could be carried out. Due to the rather small sample sizes, especially in paper 1, 2 and 4, these replications studies may also draw data from greater samples.

For papers 1, 2, and 3 the causality of the findings can be questioned due the cross-sectional nature of the studies (Bickman & Rog, 2009; Kelley & Maxwell, 2019). While in paper 3 data for both sub studies were gathered at only one point in time, which is clearly cross-sectional, data for paper 1 and 2 were collected by using an initial questionnaire addressing more time-stable variables

and information and a subsequent data collection near the process by using a research diary to reduce retrospective bias (Bolger et al., 2003; Ohly et al., 2010; Rausch et al., 2022; Seifried & Rausch, 2022). Some authors categorize using research diaries as an intensive longitudinal data collection method (e.g., Bolger et al., 2003; Bolger & Laurenceau, 2013; Rausch et al., 2022). However, in paper 1 and 2 the data were treated and analyzed as multiple observations nested in persons. They were not analyzed longitudinally because the intra-individual variations of social interactions and problem-solving situations over the survey period were not considered as a function of time (Enders & Tofighi, 2007; Nezlek, 2001). In this context, a further limitation of paper 1 and 2 that both encompassed diary studies, is that this method can produce measurement reactivity or treatment effects meaning that participants observe their behavior or experiences more closely than usual, behaviors like reflection are triggered, the construct under investigation is reinforced or, for instance, reporting one's own mood in turn impacts the mood itself (Rausch et al., 2022; Seifried & Rausch, 2022). Thus, the diary method can be seen as an pedagogical intervention by itself (Rausch et al., 2022). The described effects that arise from this may harm the validity of the collected data (Rausch et al., 2022). In addition, diary entries can be delayed so that the results are again more retrospectively biased (Bolger & Laurenceau, 2013; Rausch et al., 2022). In general, however, using research diaries holds great potential. Nevertheless, research diaries are still rather rare in research on workplace learning (Seifried & Rausch, 2022). Future studies on workplace learning should consider collecting data near the process by, for example, using diaries, especially when fluctuating constructs are assessed. In such studies, diary data could be further enriched by also measuring physiological indicators like heart rate, blood pressure or the temperature, by collecting additional observational data, for instance, via GPS tracking or by using log data (Dasborough et al., 2008; Rausch et al., 2022; Seifried & Rausch, 2022). Because in sub study 2 of paper 3 availability and use of problem-solving activities for ERP-related problems as well as antecedents of EPSS use to solve such problems were measured by retrospective questionnaires, future studies investigating these topics with the help of a research diary would be promising. Additionally, for a future study building on paper 4 in situ investigations of how tool use affects concrete SRL sub process and learning would be interesting and expand the so far mainly descriptive results.

A further limitation concerning especially papers 1, 2 and 3 is that none of them specified clearly what was learned by the participants. Paper 1 and 2 investigated the dependent variable of self-perceived informal learning, however, it was not further assessed what exactly was learned. In sub study 1 of paper 3 participants were asked in general terms what significance they attach to selected learning measures for employee learning at present and in the future. Again, employee learning was not concretized, and the questions were very unspecific regarding potential different

areas for employee learning. Smet et al. (2022) offer with their literature review a comprehensive framework for categorizing outcomes of informal workplace learning. Although it might be difficult to establish a concise and yet comprehensive categorization for learning outcomes that can be used in questionnaire and diary studies, I propose to make such efforts in future studies on informal workplace learning. This would concretize results and provide new insights. This limitation also applies in a modified form to paper 4. Although it was investigated how useful the tools were perceived to be and which CSCL activities they supported, no data was collected on the impact of tool use and associated activities on CSCL outcomes such as knowledge gain or grades. Therefore, it is not possible to say whether the use of the tools perceived as useful and the activities for which they were used are actually related to learning success in CSCL.

A further limitation arises from the fact that papers 1 and 2 were based on the Model of Informal Workplace Learning through Problem-Solving but in both papers only parts of the model were examined. Future research may address additional parts of the model and may also consider some moderation or mediation analyses.

A limitation that applies to all four research papers is the missing integration of concrete SRL subprocesses and mechanisms although SRL can be seen as the common underlying construct of all papers and conducted studies. In paper 4 tool use for CSCL was investigated, however with no reference to how the tools concretely affected different SRL subprocesses in the areas of cognition, motivation and affect, behavior as well as context (see chapter 2). Interview data gave first indications, but in future studies it should be assessed in more detail how tools impact and leverage concrete SRL subprocesses. This also applies to co-regulation and socially shared regulation processes within CSCL that may be leveraged by digital tools. Referring to papers 1, 2 and 3, although, the papers included workplace learning and problem-solving activities that are similar to some resource management SRL strategies (see chapter 2) concrete regulatory subprocesses and mechanisms, SRL processes' potentially interrelated, dynamical, and cyclical nature as well as the factor time were not considered. As a result, in line with Cuyvers et al. (2020) I suggest that future research projects on workplace learning within the SRL framework focus more on process-oriented research questions and data collection methods, possibly by using research diaries that measure SRL near the process and capture changes in SRL and the interaction of different SRL strategies. The data should then be treated as longitudinal. Such studies should also assess SRL in all SRL areas and related SRL strategies. In this context first attempts to include SRL strategies into workplace learning research were made for instance by addressing in a diary study emotion regulation in learning from errors in the workplace (Rausch et al., 2017) or by examining in an experience sampling study the

influence of changing aspects of work activities and discussing work-related problems with others on workplace learning (Daniels et al., 2009).

Moreover, I recommend some further avenues for future research that are independent of the limitations of the papers included in the thesis. Emotional experiences were addressed in papers 1 and 2. However, in general studies assessing emotions in workplace learning are still scarce (Benozzo & Colley, 2012; Hökkä et al., 2020). Thus, I propose that future studies continue this path. Hökkä et al. (2020) explicitly proposes research on emotions and learning in the digitalized workplace and in workplaces where robots are used. I would like to concretize and expand this suggestion. I suggest focusing not only on the relationship between emotions and learning in digitalized workplaces but to investigate how concrete technology use impacts emotions and emotional experiences in workplace learning. Furthermore, the impact of technology (use) on workplace learning should be placed more in the foreground. This applies especially to rather new technologies because for new technologies there may be no formal learning opportunities available leading employees to experimental learning with high requirements on their self-regulatory capabilities (Harteis et al., 2022). Due to the recently rapid advance of Artificial Intelligence (AI) in companies and software applications, examining workplace learning in the context of AI would be especially interesting in my view. Again, for such studies data collection near the process may be suitable and may potentially be enriched by physiological data.

In addition, there are other, newer areas of research that are either not yet or only very rarely considered in workplace learning research. As a result, these areas are not encompassed in recent reviews and meta-studies on (informal) workplace learning and were also not addressed in the papers and studies included in this thesis. In light of increasingly demanding work tasks and working environments, I propose that research on workplace learning consider the topics of thriving at work and mindfulness and their relationship to workplace learning. Thriving is defined as a desirable psychological state in which individuals experience a sense of vitality and learning (Kleine et al., 2019; Spreitzer et al., 2005). Thus, learning is already inherent to the definition of thriving at work. In addition, Kleine et al. (2019) found in their meta-analysis antecedents of thriving at work that are also antecedents of workplace learning and as outcomes of thriving at work the authors identified amongst others positive attitudes toward self-development. Originally rooted in Buddhism (Brown & Ryan, 2003; Good et al., 2016), mindfulness can be defined as “the state of being attentive to and aware of what is taking place in the present” (Brown & Ryan, 2003, p. 822). It is “neither mysterious nor mystical, but rather can be reliably and validly measured” (Sutcliffe et al., 2016, p. 55). While there is evidence, for instance, of mindfulness’ impact on individuals’ attention, motivation and emotional valence or emotion regulation (e.g., Eberth & Sedlmeier, 2012; Good et al.,

2016), which are relevant in learning processes, research on mindfulness and workplace learning is still very rare (Hanson et al., 2021). However, there is first empirical evidence for a positive relationship between mindfulness and workplace learning (Lawrie et al., 2018). In addition, Hanson et al. (2021) discuss several mechanisms in detail regarding how mindfulness may enhance workplace learning in organizations. In my opinion, considering the presented empirical evidence and conceptualizations of thriving at work and mindfulness, their future integration in studies on workplace learning would be interesting.

7.3 Practical implications and conclusion

Several practical implications can be derived from the results of the four research papers included in this thesis. The first implication is that performing regular working tasks including communication and collaboration, problem-solving and technology use support employees' informal workplace learning. Organizations can and should in my view explicitly communicate this learning potential to their employees in combination with an emphasis on the fact that such informal learning and related behaviors are supported and advocated within the organization. On the one hand, such communication could establish or strengthen a learning culture in the organization (Marsick & Watkins, 2003). On the other hand, raising employees' awareness of the learning potential could lead them to be more attentive during their regular work activities and to reflect more often on their learning processes and outcomes. A conducive organizational learning culture as well as employees' reflection are both likely to improve learning (Cerasoli et al., 2018; Haemer et al., 2017; S. Jeong et al., 2018; Rintala et al., 2019). Employees could also dare to take time to reflect due to the high value placed on learning and its promotion in the company.

Furthermore, the results showed that several contextual factors impact informal learning in the workplace. Many of these contextual factors can be directly addressed and altered by organizations and some factors like team variables or working task characteristics can even be influenced, at least to a certain degree, by the single direct manager. In this way, organizations can actively construct a contextual framework that is conducive to the informal learning of their employees. Contextual factors that may pertain to a whole organization and that can be influenced on this higher level are, for example, the general availability, accessibility and quality of information and technological resources as well as their ease of use. More concretely this can encompass the provision of state-of-the-art software and technology, for instance, for social communities, to communicate or to document information and knowledge and to make them easily and effectively accessible to employees. Especially for problem-solving, context-sensitive, proactive, and possibly personalized assistance systems or chatbots based on AI could be introduced. A further contextual factor that can be shaped is related to the instruction and guidance of VET trainees in organizations. Results of this

thesis yielded that asking questions and listening to more experienced colleagues is conducive for trainees' learning. To support trainees' learning organizations can encourage skilled colleagues to engage in instructing and guiding trainees and grant them extra time to do so. In addition, in order to foster not only VET trainees' but all employees' learning from social interactions, organizations can foster social interactions, for instance, by establishing a coffee corner culture where spaces are created, and employees are actively encouraged to exchange information and ideas with each other (Weijs-Perrée et al., 2020).

Another implication is that learners should be aware and make use of their active role in learning processes and the scope of action they have. This refers, for instance, to using SRL strategies, including choosing the right learning activities or tools, combining, and switching them when needed. This makes it possible to influence the current learning process in the short term, while there are also possible longer-term measures such as developing self-efficacy beliefs or practicing mindfulness that impact potential future learning processes (Bandura, 1995; Hanson et al., 2021; Lawrie et al., 2018). Learners should also be allowed, via the learning framework conditions, to take on this active role in their learning process. This includes, for instance, that learners should be given the freedom to choose their tools for CSCL by themselves so that they can work and learn with the tools with which they get along best and are most effective and efficient (Tchounikine, 2019).

In conclusion, the results of this thesis showed that changes in the context of digitalized workplaces and the emerging central workplace components of complex problem-solving, collaboration and communication as well as technology (use) not only make demands on the continuous learning of employees, but also provide various opportunities to enhance SRL. Personal and contextual antecedents, different available informal learning, and problem-solving activities as well as emotional experiences play a role here. Furthermore, the results demonstrated the significance of technology and tools for remote CSCL, with a focus on learners' agency within tool selection and the need for tool combination in CSCL. These identified influencing factors point to many areas where organizations and tertiary education institutions, as well as individual learners themselves, can take action to enhance SRL to be successful in digitalized workplaces.

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Appendix

All parts of the appendix were originally published as appendix of the respective paper. in order not to disturb the flow of reading, they have been included in a common appendix for the entire thesis.

Appendix A: Means, standard deviations and correlations between study variables paper 2

Table A-1: Means, standard deviations and correlations between study variables

	Person level (Level 2)		Problem level (Level 1)						
Variable	**M**	**SD**	**M**	**SD**	**1**	**2**	**3**	**4**	**5**
Personal factors and team psychological safety			-	-					
1. Team psychological safety	4.36	0.66	-	-	-	0.33*	0.20	–0.04	0.06
2. Occupational self-efficacy	4.05	0.50	-	-	-	-	0.36*	0.21	0.26
3. Technology self-efficacy	4.27	0.47	-	-	-	-	-	0.11	–0.12
4. Extraversion	3.90	0.95	-	-	-	-	-	-	0.09
5. Conscientiousness	4.34	0.45	-	-	-	-	-	-	-
6. Agreeableness	4.45	0.49				-	-	-	-
Problem-solving activities									
7. Asking others	0.39	0.35	0.34	0.47	–0.05	–0.12	–0.11	0.00	–0.21**
8. Using information from the internet	0.37	0.35	0.37	0.48	–0.04	0.13*	0.22**	–0.14*	0.11
9. Using internal information	0.09	0.19	0.08	0.27	0.04	0.03	0.09	–0.07	0.00
10. Using software-integrated information	0.07	0.17	0.07	0.25	0.10	–0.01	–0.01	–0.02	–0.02
11. Experimenting	0.52	0.35	0.51	0.50	0.16*	0.08	–0.05	–0.05	0.21**
Emotional experiences									
12. Motivated / delighted / curious	0.79	0.83	0.85	1.15	–0.01	0.03	0.19**	–0.03	–0.18**
13. Confident / happy / glad	0.79	0.80	0.88	1.11	0.04	0.06	0.15*	0.02	–0.22**
14. Contented / accepted / proud	0.41	0.61	0.38	0.84	0.01	0.06	0.19**	–0.05	–0.13*
15. Calm/even-tempered/daydreaming	0.44	0.64	0.41	0.81	0.03	–0.05	0.08	–0.02	–0.08
16. Nervous / worried / afraid	0.43	0.49	0.44	0.81	–0.14*	–0.07	–0.06	–0.05	0.09
17. Bored / dull / uninterested	0.31	0.50	0.28	0.68	0.12	–0.08	0.02	–0.06	0.13*
18. Unhappy / gloomy / sad	0.14	0.27	0.22	0.60	0.08	0.01	0.00	0.07	–0.03
19. Irritated / annoyed / angry	1.02	0.76	0.96	1.03	0.07	0.01	–0.11	0.12	0.12
Contextual factors									
20. Location of work (0 = remote work,1 = work in the office)	0.14	0.28	0.14	0.35	–0.19**	–0.07	–0.06	0.01	0.04
21. Own guilt	2.53	1.46	2.88	2.09	–0.09	–0.08	0.02	–0.06	–0.07
22. Negative consequences	3.24	1.26	3.36	1.78	–0.07	–0.14*	0.12	0.00	–0.04
23. Urgency	3.41	1.09	3.40	1.45	–0.01	0.12	0.22**	0.20**	0.09
Learning									
24. Self-perceived learning	2.92	1.23	3.09	1.75	–0.15*	0.04	0.17**	–0.06	–0.06

Notes. $*p < 0.05$, $**p < 0.01$, $***p < 0.001$; Means and standard deviations at the person level are displayed in Columns 1 and 2; means and standard deviations at the problem level are displayed in Columns 3 and 4; correlations above the diagonal refer to person-level data (Level 2) (n = 48), with problem-level variables aggregated at the person level; correlations below the diagonal refer to problem-level diary data (Level 1) (n = 240). Source: Authors' own work

Table A-1: Means, standard deviations and correlations between study variables (continued)

Variable	6	7	8	9	10	11	12	13	14	15	16
Personal factors and team psychological safety											
1. Team psychological safety	0.01	0.06	0.01	0.12	0.24	0.22	0.02	0.07	0.10	0.08	–0.25
2. Occupational self-efficacy	–0.04	–0.22	0.26	0.05	–0.04	0.26	0.06	0.07	0.20	–0.31*	–0.17
3. Technology self-efficacy	0.02	–0.17	0.22	0.14	0.04	0.07	0.22	0.23	0.25	0.03	–0.07
4. Extraversion	0.01	–0.12	–0.04	–0.06	0.06	0.11	–0.08	–0.01	0.07	0.06	–0.31*
5. Conscientiousness	0.36*	–0.36*	0.30*	–0.20	–0.25	0.16	–0.30*	–0.17	–0.22	0.01	–0.08
6. Agreeableness	-	0.09	–0.06	0.00	–0.22	0.12	0.09	–0.12	–0.11	0.03	0.17
Problem-solving activities											
7. Asking others	0.05	-	–0.46**	0.33*	0.10	–0.31*	0.09	–0.05	–0.01	0.06	0.08
8. Using information from the internet	0.00	–0.25**	-	0.03	0.01	0.12	0.03	0.24	0.39**	–0.09	–0.10
9. Using internal information	0.10	0.15*	0.13*	-	0.55**	0.12	–0.31*	–0.06	0.28	–0.15	0.03
10. Using software-integrated information	–0.08	–0.08	0.11	–0.02	-	0.19	0.12	–0.19	0.21	–0.12	–0.12
11. Experimenting	0.11	–0.33**	–0.16*	0.07	–0.04	-	–0.26	–0.45**	0.08	–0.35*	0.11
Emotional experiences											
12. Motivated / delighted / curious	0.12	0.02	0.20**	0.11	–0.08	–0.14*	-	0.68**	0.35*	0.27	–0.13
13. Confident / happy / glad	–0.01	–0.02	0.17**	–0.05	–0.06	–0.22**	0.51**	-	0.37**	0.35*	–0.19
14. Contented / accepted / proud	0.09	–0.01	0.20**	0.02	–0.08	–0.02	0.46**	0.40**	-	–0.07	–0.15
15. Calm/even-tempered/daydreaming	0.01	–0.04	0.05	0.04	–0.05	–0.15*	0.19**	0.26**	–0.05	-	–0.31*
16. Nervous / worried / afraid	0.07	0.05	–0.02	0.15*	–0.06	0.09	–0.20**	–0.32**	–0.21**	–0.23**	-
17. Bored / dull / uninterested	0.19**	–0.04	0.00	0.04	0.01	0.19**	–0.20**	–0.28**	–0.14*	–0.12	0.11
18. Unhappy / gloomy / sad	–0.01	0.07	–0.09	0.10	0.01	0.05	–0.18**	–0.08	–0.15*	–0.14*	0.23**
19. Irritated / annoyed / angry	–0.06	–0.02	–0.16*	–0.02	0.06	0.22**	–0.42**	–0.51**	–0.34**	–0.32**	0.11
Contextual factors											
20. Location of work (0 = remote work,1 = work in the office)	–0.13*	0.00	–0.05	–0.07	–0.11	0.03	–0.02	–0.05	–0.08	0.10	–0.10
21. Own guilt	–0.18**	–0.11	0.25**	–0.02	0.10	–0.13*	0.20**	0.28**	007	0.13*	–0.09
22. Negative consequences	0.00	–0.15*	0.08	0.02	0.11	–0.04	0.08	0.03	0.00	0.07	0.02
23. Urgency	0.14*	–0.15*	0.09	0.12	–0.02	0.08	–0.07	0.00	–0.04	0.01	0.21**
Learning											
24. Self-perceived learning	0.03	0.06	0.28**	0.07	0.06	–0.28**	0.29**	0.30**	0.20**	0.11	–0.10

Notes. *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$; Means and standard deviations at the person level are displayed in Columns 1 and 2; means and standard deviations at the problem level are displayed in Columns 3 and 4; correlations above the diagonal refer to person-level data (Level 2) (n = 48), with problem-level variables aggregated at the person level; correlations below the diagonal refer to problem-level diary data (Level 1) (n = 240). Source: Authors' own work

Table A-1: Means, standard deviations and correlations between study variable (continued)

Variable	17	18	19	20	21	22	23	24
Personal factors and team psychological safety								
1. Team psychological safety	0.26	0.04	0.05	–0.19	–0.17	–0.10	0.00	–0.21
2. Occupational self-efficacy	–0.18	–0.07	0.07	–0.07	–0.21	–0.24	0.08	–0.03
3. Technology self-efficacy	–0.05	0.06	–0.04	–0.08	0.00	0.12	0.29*	0.03
4. Extraversion	–0.24	0.02	0.20	0.10	–0.12	0.03	0.31*	–0.18
5. Conscientiousness	0.05	–0.09	0.16	0.15	–0.08	–0.07	0.07	0.07
6. Agreeableness	0.25	–0.01	0.20	–0.17	–0.23	–0.05	0.01	0.16
Problem-solving activities								
7. Asking others	0.33*	–0.13	0.01	–0.23	–0.10	0.01	–0.05	0.12
8. Using information from the internet	–0.17	0.07	–0.18	–0.19	0.16	–0.11	–0.06	0.22
9. Using internal information	0.03	0.08	0.09	–0.19	0.10	0.06	0.08	0.14
10. Using software-integrated information	–0.08	0.01	0.13	–0.18	0.16	0.15	–0.03	–0.02
11. Experimenting	0.09	0.18	0.43**	0.02	–0.35*	–0.230	0.03	–0.44**
Emotional experiences								
12. Motivated / delighted / curious	–0.13	0.01	–0.43**	–0.02	0.47**	0.28	–0.10	0.35*
13. Confident / happy / glad	–0.23	0.11	–0.71**	0.00	0.47**	0.19	0.03	0.24
14. Contented / accepted / proud	–0.20	0.02	–0.24	–0.23	0.16	–0.10	–0.10	0.04
15. Calm/even-tempered/daydreaming	0.10	–0.04	–0.24	0.18	0.32*	0.21	0.170	0.20
16. Nervous / worried / afraid	0.48**	0.19	0.17	–0.16	–0.17	0.01	0.05	–0.08
17. Bored / dull / uninterested	-	0.12	0.32*	–0.10	–0.08	0.02	0.20	0.00
18. Unhappy / gloomy / sad	0.10	-	0.09	–0.12	0.15	–0.03	0.07	–0.05
19. Irritated / annoyed / angry	0.26**	0.17**	-	0.01	–0.23	–0.14	0.00	–0.11
Contextual factors								
20. Location of work (0 = remote work,1 = work in the office)	–0.02	–0.06	0.04	-	0.06	0.14	0.09	–0.10
21. Own guilt	–0.02	0.05	–0.17**	–0.06	-	0.46**	0.08	0.56**
22. Negative consequences	0.08	–0.01	–0.03	0.02	0.30**	-	0.30*	0.22
23. Urgency	0.08	0.07	0.07	0.00	0.08	0.31**	-	0.00
Learning								
24. Self-perceived learning	–0.09	–0.07	–0.31**	–0.15*	0.36**	0.14*	0.11	-

Notes. *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.; Means and standard deviations at the person level are displayed in Columns 1 and 2; means and standard deviations at the problem level are displayed in Columns 3 and 4; correlations above the diagonal refer to person-level data (Level 2) (n = 48), with problem-level variables aggregated at the person level; correlations below the diagonal refer to problem-level diary data (Level 1) (n = 240). Source: Authors' own work

Appendix B: Survey items used in paper 3

Survey items used in sub study 1

Significance of different learning measures for employees

What is the significance of the following measures for employee learning in your company at present? (from 1 = *irrelevant* to 5 = *very relevant*)

- Classroom training (seminars and training courses lasting several hours to several days)
- Coaching (targeted support and advice from other people)
- E-learning (Web-based trainings, MOOCs, Webinars, virtual classrooms)
- Augmented Reality / Virtual Reality
- Social software (communication channels between employees, chats, forums, yellow pages etc.)
- Electronic Performance Support (context-specific help for user software, e.g., in text editing programs or in the ERP system)

What is the significance of the following measures for employee learning in your company in the future (in the next 3 to 5 years) (from 1 = *irrelevant* to 5 = *very relevant*)?

- Classroom training (seminars and training courses lasting several hours to several days)
- Coaching (targeted support and advice from other people)
- E-learning (Web-based trainings, MOOCs, Webinars, virtual classrooms)
- Augmented Reality / Virtual Reality
- Social software (communication channels between employees, chats, forums, yellow pages etc.)
- Electronic Performance Support (context-specific help for user software, e.g., in text editing programs or in the ERP system)

Advantages and obstacles concerning the implementation and use of EPSS

What advantages do you see in the launch or use of Electronic Performance Support Systems (EPSS) in your company?

- Substitution for classroom trainings
- Supplement to classroom trainings as an aid to the practical application of what has been learned
- Supplement to classroom training for mixed learning scenarios
- Reduction of helpdesk costs due to fewer queries about system operation
- Reduction of search and problem solving time
- Increased employee efficiency due to reduced search and problem solving time
- Support of employees during change processes
- Facilitated communication of changes within software systems (e.g., cloud-based systems)

What obstacles do you see for the launch or use of Electronic Performance Support Systems (EPSS) in your company?

- A digital help system will find little or no acceptance among employees.
- The information provided will rarely match the actual questions.
- The technical effort for such a system seems too high to me.
- I think that our works council or our employee representatives would not accept such a system. (This may or may not apply to you, depending in which country you are working.)
- My company does not have the resources to produce a large amount of learning and support materials for our employees or keep it up to date.

- The costs for the acquisition of EPSS offers or content from external providers seems too high to me.
- My company already has a Learning Management System. A second system to access learning content does not make sense to me.

Survey items used in sub study 2

ERP user type

What kind of ERP user would you most likely describe yourself as?

- Occasional user (I use the ERP system, for example, to have my vacation approved, to submit a travel request, or for actions that only occur quarterly or once a year.)
- End user (I regularly use the ERP system as part of my normal work activities.)
- Expert (I own the Key User role and/or I am the person in my team or department who is contacted for questions regarding the ERP system.)
- Administrator or SAP consultant (As part of my job, I am responsible for the configuration and adaptation of the ERP system. Or: Within the scope of my work, I advise other companies regarding SAP software.)

Self-assessed skills using the ERP system

Please assess to what extent the following statements apply to you and your use of the ERP system (from 1 = *not agree at all* to 5 = *strongly agree*). When using the ERP system…

- …I feel very safe with the applications I need regularly.
- …I complete my tasks very quickly.
- …I know my way around very well.

Proactive personality

Please assess to what extent the following statements apply to your behaviour at work (from 1 = *not agree at all* to 5 = *strongly agree*).

- When I see something I think is bad, I try to change it.
- I like to fight for my ideas, even against the resistance of others.
- I am always looking for ways to make things better.
- If I have a problem, I take care of it immediately.

Big five personality traits

Please assess how well the following adjectives describe your personality (from 1 = *not agree at all* to 5 = *strongly agree*).

- easily provoked, sensitive, touchy, moody
- extroverted, talkative, communicative, cheerful
- innovative, creative, educated, well-read
- helpful, kind, sympathetic, warm-hearted
- careful, tidy, conscientious, systematic

Characteristics of the work task

Please now assess to what extent the following statements apply to your current job and workplace (from 1 = *not agree at all* to 5 = *strongly agree*). At my workplace…

- …I do a lot of different things.
- …my job requires that I only do one task or activity at a time.
- …my job requires me to monitor a great deal of information.
- …my job involves solving problems that have no obvious correct answer.
- …I can plan how I do my work.
- …I do something new every now and then.
- …the tasks of my job are simple and uncomplicated.
- …my job requires that I engage in a large amount of thinking.
- …my job requires me to be creative.
- …I can make a lot of decisions on my own.
- …I have to deal with a variety of tasks.
- …almost anyone could do my work without much training.
- …my job requires me to keep track of more than one thing at a time.
- …my job often involves dealing with problems that I have not met before.
- …I have significant autonomy in making decisions.
- …my work is very varied.
- …my work is not very demanding.
- …my job requires me to process a lot of information.
- …my job requires unique ideas or solutions to problems.
- …I can make decisions about what methods I use to complete my work.

Geographical separation

Are you usually geographically separated from the core of your team (e.g., other site or home office)? If you have been in the home office for all or most of the time due to the Corona pandemic, please click "yes" (yes/no).

Team psychological safety

Please assess to what extent the following statements apply to your team (from 1 = *not agree at all* to 5 = *strongly agree*). In my team…

- …it is easy to speak up about what is on your mind.
- …people are usually comfortable talking about problems and disagreements.
- …people are eager to share information about what does and doesn't work.
- …it is often held against you if you make a mistake.

Availability of problem-solving activities and *frequency of use of problem-solving activities*

Imagine the following situation: You have a problem in the ERP system. Please answer the following questions (from 1 = *not agree at all* to 5 = *strongly agree*). If the possibility is at least partly available, you are then asked how often you use the possibility ("I often use this possibility."; from 1 = *not agree at all* to 5 = *strongly agree*). At my workplace, if I have problems with the ERP system, I basically have the possibility to…

- …think longer in order to come to a solution by myself.
- …keep trying until I find a solution myself.
- …watch colleagues who are solving such problems.
- …ask my colleagues for help.
- …ask my superior for help.
- …access internal company information sources (e.g., company wiki, help desks, communities, FAQs, forums).

- …access help integrated in the ERP system (e.g., manuals, documentation, tutorials from the provider of the ERP system).
- …use integrated help systems, which are displayed next to the user interface of the ERP system and support me specifically with my current problem.
- …use integrated help systems, which are displayed within the user interface of the ERP system and support me specifically with my current problem.

Perceived usefulness of EPSS characteristics

Please assess how helpful you find the following help offerings within an ERP system for solving a specific problem, regardless of whether these options are actually available to you at your workplace (from 1 = *not helpful at all* to 5 = *very helpful*). In the ERP system, you can…

- …click on a help button, which opens another window with information such as a manual, a documentation or a tutorial from the provider of the ERP system.
- ...use information provided next to the user interface of the ERP system to complete the current problem.
- …use information provided within the user interface of the ERP system to complete the current problem.
- …save your own notes in specific steps within the ERP system, which are displayed again when you reach this step the next time.
- …use an integrated chat function to ask colleagues.
- …watch videos that experienced colleagues in your company have recorded on their actions.

Appendix C: Correlation table paper 3

Table A-2: Correlation table of hierarchical multiple regression variables (RQ5)

	M	SD	1	2	3	4	5	6	7	8	9
1. MAX frequency of EPSS use	3.73	1.00									
2. Self-assessed ERP skills	3.90	0.79	0.13**								
3. Occasional user	0.28	0.45	-0.11**	-0.25***							
4. End user	0.49	0.50	-0.09*	-0.03	-0.60***						
5. Expert	0.14	0.34	0.08*	0.22***	-0.25***	-0.39***					
6. Task variety	3.94	0.70	0.14***	0.26***	-0.05	-0.08*	0.03				
7. Complexity	3.60	0.96	-0.19***	0.07	-0.02	0.06	-0.08*	0.26***			
8. Problem-solving demands	3.63	0.77	0.20***	0.13**	0.00	-0.15***	0.04	0.69***	0.05		
9. Information-processing requirements	4.03	0.68	0.07*	0.26***	-0.02	-0.07*	0.02	0.71***	0.32***	0.59***	
10. Autonomy	3.66	0.76	0.19***	0.25***	-0.03	-0.13**	0.08*	0.59***	-0.09*	0.59***	0.42***
11. Availability for MAX frequency of EPSS use	4.00	0.79	0.46***	0.33***	-0.06	-0.10*	0.08*	0.25***	0.06	0.20***	0.31***
12. Neuroticism	2.16	1.07	0.06	-0.14***	0.03	-0.09*	0.06	-0.12**	-0.35***	-0.01	-0.14**
13. Extraversion	3.39	1.01	0.15***	0.08*	0.03	-0.08*	0.03	0.18***	-0.14**	0.18***	0.12**
14. Openness	3.78	0.82	0.18***	0.19***	0.01	-0.12**	0.03	0.40***	-0.05	0.41***	0.38***
15.Agreeableness	4.16	0.79	0.05	0.23***	0.06	-0.08*	-0.04	0.29***	0.07*	0.13**	0.33***
16. Conscientiousness	4.05	0.90	0.01	0.24***	-0.02	0.03	-0.03	0.22***	0.08*	0.07*	0.29***
17. Proactive personality	3.86	0.64	0.17***	0.35***	-0.08*	-0.06	0.09*	0.46***	0.03	0.44***	0.47***
18. Team psychological safety	3.86	0.76	0.11**	0.29***	0.03	-0.06	-0.02	0.37***	0.24***	0.23***	0.36***
19. Geographical separation	0.61	0.49	0.08*	-0.03	0.01	-0.05	0.02	-0.06	-0.11**	0.08*	-0.06

Notes. MAX frequency of EPSS use = highest frequency of use across all problem-solving activities including EPSS. Availability for MAX frequency of EPSS use = availability of the problem-solving activity with the highest frequency of use across all problem-solving activities including EPSS = 568. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table A-2: Correlation table of hierarchical multiple regression variables (RQ5) (continued)

	10	11	12	13	14	15	16	17	18
1. MAX frequency of EPSS use									
2. Self-assessed ERP skills									
3. Occasional user									
4. End user									
5. Expert									
6. Task variety									
7. Complexity									
8. Problem-solving demands									
9. Information-processing requirements									
10. Autonomy									
11. Availability for MAX frequency of EPSS use	0.26***								
12. Neuroticism	-0.03	-0.10*							
13. Extraversion	0.23***	0.11**	0.13**						
14. Openness	0.39***	0.21***	-0.13**	0.22***					
15.Agreeableness	0.22***	0.28***	-0.22***	0.16***	0.29***				
16. Conscientiousness	0.09*	0.18***	-0.16***	0.01	0.26***	0.35***			
17. Proactive personality	0.45***	0.32***	-0.12**	0.22***	0.47***	0.35***	0.37***		
18. Team psychological safety	0.34***	0.25***	-0.34***	0.04	0.26***	0.35***	0.20***	0.38***	
19. Geographical separation	0.08*	0.02	0.09*	0.02	0.01	0.00	-0.11**	-0.08*	-0.10**

Notes. MAX frequency of EPSS use = highest frequency of use across all problem-solving activities including EPSS. Availability for MAX frequency of EPSS use = availability of the problem-solving activity with the highest frequency of use across all problem-solving activities including EPSS = 568. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Appendix D: Coding guideline paper 4

Table A-3: Coding guideline

Tool category / Tools	Codes	Reasons for using / associated activities	Reasons for not using / associated activities	Explanation	Examples	Codes
Communication tools						
WhatsApp	11	Organization of the group work		Statements related to the use of WhatsApp for general organizational aspects of group formation, group work, and group tasks, as well as information about group members' progress on group tasks.	So we just listened to the lecture and then thought "oh, we're still missing this and that" and one of us wrote in the WhatsApp group that we still needed this and that. And then someone came and said "oh, I could take over that part" and the other person said, "I'll take over that part". (6)	6
		Short queries		Statements that refer to the use of WhatsApp to clarify shorter questions outside of or between regular meetings.	And if there were any questions, they were clarified in the WhatsApp group that we had especially for the assignment. (4)	5
		Communication speed		Statements that refer to the use of WhatsApp because of the speed of communication or statements that refer to speed as a benefit or result of using WhatsApp.	Yes, WhatsApp because... Because it was always quick, because everyone actually always has their mobile phone there and can reply quickly. (3)	5
		Familiarity / tool circulation		Statements that refer to the use of WhatsApp because group members are familiar with the tool, or statements that refer to the fact that many group members or many people in general use WhatsApp.	We used WhatsApp because everyone has it on their mobile phones. (8)	5

Table A-3: Coding guideline (continued)

Tool category / Tools	Codes	Reasons for using / associated activities	Reasons for not using / associated activities	Explanation	Examples	Codes
		Ease of use		Statements that relate to the use of WhatsApp because it is easy to use.	Yes, so WhatsApp, it was quick, it was easy. (4)	3
		Possibility to talk to each other		Statements referring to the possibility of talking to each other in person with WhatsApp.	And we used WhatsApp and Zoom and things like that because we could talk more personally. (10)	2
		Wide range of functionalities		Statements referring to the fact that WhatsApp combines many different functionalities.	WhatsApp is great because you can write messages, you can open groups, you can use individual chats, you can make phone calls and you can make video calls. It's all in one, so no matter how you want to reach the person, it's just perfect. (6)	2
		Group awareness / motivation		Statements referring to the fact that WhatsApp allows group members to provide other group members with information on how far they are with their tasks and to inform them that new content has been created. This can result in additional statements that this information can encourage and motivate group members.	On WhatsApp you could send short messages to each other and then you knew approximately in... How far the other person is and that put you under a bit of pressure because you realized okay, the other person is almost finished with their text and you only have... So almost nothing at all or is just... Is still looking for literature. Then you realized okay, you have to hurry a bit here. (4)	2
		Sharing files		Statements referring to the fact that WhatsApp allows sharing files with the group members.	We had a WhatsApp group and have actually also sent in literature via WhatsApp. (4)	1

Table A-3: Coding guideline (continued)

Tool category / Tools	Codes	Reasons for using / associated activities	Reasons for not using / associated activities	Explanation	Examples	Codes
Zoom	6	Possibility to talk to each other		Statements referring to the possibility of talking to each other in person with Zoom.	Zoom and Google Groups we simply used for ehm the meetings to talk to each other. (5)	3
		Familiarity / tool circulation		Statements that refer to the use of Zoom because group members are familiar with the tool, or statements that refer to the fact that many group members or many people in general use Zoom.	Then we used Zoom because that's what we know from university. (8)	3
		Video streaming		Statements related to the use of Zoom as it allows video streaming when talking to each other.	Zoom makes it really easy to even see the other person. It gives you a bit more of a feeling of actually interacting with someone instead of just like on the phone or WhatsApp, where your face, movements, gestures and facial expressions don't play a role at all. (7)	3
		Screen sharing		Statements related to the use of Zoom as it allows screen sharing.	Zoom simply because it's super practical, ehm you can see people directly, you can share the screen. (7)	3
		For detailed discussions		Statements about Zoom allowing in-depth discussion and feedback, as well as discussions of larger issues and how to move forward as a group.	Yes, well, in Zoom it was of course the case that we could see all four faces at the same time and could really discuss things with each other and have lively conversations. (6)	3

Table A-3: Coding guideline (continued)

Tool category / Tools	Codes	Reasons for using / associated activities	Reasons for not using / associated activities	Explanation	Examples	Codes
		Easy account creation		Statements related to the use of Zoom because of the ease of account creation.	And because it's also easy to create an account yourself. (8)	1
		Good connection / few dropouts		Statements about the use of Zoom because of the good connection and the few dropouts when using the tool.	Ehm, and it actually has a relatively good connection, so it doesn't break often or anything. That's why Zoom is relatively good. (7)	1
			Limited meeting time (depending on version)	Statements related to not using Zoom or discontinuing using Zoom because meeting time is limited in some versions.	With Zoom we were actually sometimes very disappointed because after 40 seconds - ehm 40 minutes it just stops. Ehm that's why we switched to Google Groups halfway through and did it over there. (5)	1
Skype	5	Familiarity / tool circulation		Statements that refer to the use of Skype because group members are familiar with the tool, or statements that refer to the fact that many group members or many people in general use Skype.	Skype because we knew it at the beginning, or rather everyone knew it. (9)	3
		Video streaming		Statements related to the use of Skype as it allows video streaming when talking to each other.	Of course, it was cool that we could at least see each other face-to-face. (1)	2
		For detailed discussions		Statements about Skype allowing in-depth discussion and feedback, as well as discussions of larger issues and how to move forward as a group.	And then we just thought that might be a good thing. Because especially for things that you then discuss in real detail. (11)	1

Table A-3: Coding guideline (continued)

Tool category / Tools	Codes	Reasons for using / associated activities	Reasons for not using / associated activities	Explanation	Examples	Codes
		Possibility to talk to each other		Statements referring to the possibility of talking to each other in person with Skype.	And as I said, Skype was simply useful to... That there didn't have to be such a confusion of texts and that everyone could always hear what one person was saying. And everyone could also refer to it live, so to speak. (1)	1
Facetime	2	Short queries / short conversations		Statements that refer to the use of WhatsApp to clarify shorter questions and shorter conversations outside of or between regular meetings.	And WhatsApp and Facetime only when we wanted to clarify small things without showing anything. (10)	2
Microsoft Teams	1	Wide range of functionalities		Statements referring to the fact that Microsoft Teams combines many different functionalities.	So in the end, Teams was the fact that you had everything in one tool. Ehm you could make phone calls, you could work on your work at the same time and then you could always see directly what the others were doing. (3)	1
		Group awareness		Statements referring to the fact that Microsoft Teams allows to see when and what other group members change in a shared file.	And then always saw directly what the others were doing. (3)	1
Email	2	Sharing files		Statements that refer to the use of email to exchange files with group members.	And then at the beginning we sent a lot of documents by email. (1)	2
Discord	1	Intuitive tool		Statements referring to the use of Discord due to its intuitiveness.	That's why we switched to Discord because it's much more intuitive and much more practical in my eyes. (9)	1

Table A-3: Coding guideline (continued)

Tool category / Tools	Codes	Reasons for using / associated activities	Reasons for not using / associated activities	Explanation	Examples	Codes
Google Groups	1	Possibility to talk to each other		Statements referring to the possibility of talking to each other in person with Google Groups.	We simply used Zoom and Google Groups for the meetings to talk to each other. (5)	1
		No limited meeting time		Expressions related to the use of Google Groups because it does not limit the time of meetings.	Google Groups because Zoom has this 40-second ehm 40-minute limit. (5)	1
		Screen sharing		Statements related to the use of Google Groups as it allows screen sharing.	We simply used Zoom and Google Groups for the meetings to talk to each other about the individual things... To share the screen and simply give feedback and continue working on things. (5)	1
Sharing and co-construction tools						
Google Docs	9	Simultaneous working on one file		Statements about the fact that Google Docs enables several people to work on a file at the same time.	Just like Google Docs, simply because Google Docs also allows you to work on a document with four people and you can see how it changes in real time. (7)	5
		Commentary function / feedback		Statements about Google Docs providing a commenting function and/or statements that Google Docs allows for direct feedback.	And you could also make alternative suggestions and then... The others were then able to comment directly on whether they thought it made sense or whether it was stupid and so during the week when we didn't see each other, we were able to get a lot of little things out of the way that might otherwise have been	5

Table A-3: Coding guideline (continued)

Tool category / Tools	Codes	Reasons for using / associated activities	Reasons for not using / associated activities	Explanation	Examples	Codes
					discussed for an extremely long time. (1)	
		Timeliness of files and content / no different versions		Statements that Google Docs enables the timeliness of files and content and/or statements that Google Docs enables the avoidance of different versions of a document.	And we used Google Docs because it works well... It just works so well that everyone writes something in at the same time and you don't have ten different documents and somehow don't know what's the most up-to-date afterwards. (8)	4
		Shared access to files / shared storage location		Statements about the fact that Google Docs provides shared access to files and/or a shared storage location for files.	We just used Google Docs because everyone could simply insert everything there and everyone had access to the file. (10)	3
		Efficiency increase		Statements that Google Docs leads to an increase in efficiency in the form of time savings.	So in general... Ehm that actually made the collaboration relatively ehm easier. That you just... Yes, and it was also much quicker, it was also much quicker. So the time factor and ehm eff- that was simply more efficient, the most efficient of all the tools. (4)	2
		Mention in the lecture		Statements that refer to the use of Google Docs because it was mentioned in the lecture.	I can't remember whether it was in the exercise or in the lecture. In any case, it was recommended there. Exactly, and then we simply continued to use it because it had already helped us. (11)	2
		Group awareness / motivation		Statements referring to the fact that WhatsApp allows users to see when and what other group members	So when I was working on something, my partner could see that I was writing on the paper and then	2

Table A-3: Coding guideline (continued)

Tool category / Tools	Codes	Reasons for using / associated activities	Reasons for not using / associated activities	Explanation	Examples	Codes
				change in a shared file and reacting to that, which may impact group members' motivation.	she... That was also a bit of motivation, because then you saw "oh, there are four members in the ehm... Inside the file. And they are writing and typing in their text". That was of course cool. And ehm yes then there was also accordingly also faster progress. (4)	
		Access via different devices		Statements that referred to the fact that Google Docs can be opened and used via different devices.	And you could also access it on your mobile phone or other devices if you have an internet connection and a Google account. (4)	1
		Familiarity of the tool		Statements that refer to the use of Google Docs because group members are familiar with the tool.	I think that's the best known one. Personally, I don't know of any others off the top of my head that I would say could be used in the same way. (1)	1
		Ease of use		Statements that refer to the use of Google Docs because of its ease of use.	[...] for the sake of simplicity. (2)	1
		Avoidance of storage space problems		Statements about avoiding storage space problems on group members' computers by using Google Docs.	There are also some who don't have any... Or they have a bit of a storage space problem that was then also ehm... That was also cancelled because it was all on Google Docs. (4)	1
			Difficulties with formatting documents	Statements related to not using Google Docs or discontinuing the use of Google Docs because formatting within documents is per-	At the very end, which I forgot to mention, we switched to Word for formatting. That didn't work at all with Google Docs. (9)	2

Table A-3: Coding guideline (continued)

Tool category / Tools	Codes	Reasons for using / associated activities	Reasons for not using / associated activities	Explanation	Examples	Codes
				ceived to be difficult.		
			Poor tool performance	Statements related to not using Google Docs or discontinuing the use of Google Docs because its performance is perceived to be poor.	In the beginning, we always started using Google Docs and, because everyone has access to it and can contribute ideas, we quickly realized that the tool itself was overwhelmed because it often got stuck and so on, and that made collaboration more difficult in the beginning. (3)	1
Google Drive	3	Shared access to files / shared storage location		Statements about the fact that Google Drive provides shared access to files and/or a shared storage location for files.	And we used Google Drive to really upload everything, everything we created, so that everyone could access it at any time. could access it at any time. (6)	3
		Timeliness of files and content/ no different versions		Statements that Google Drive enables the timeliness of files and content and/or statements that Google Docs enables the avoidance of different versions of a document.	Ehm, that was very important. So we also used Google Drive a lot, for example, to upload and send us all the results and that you don't have to send it to four people by e-mail, but that everyone can access it at any time and always has the latest version and stuff like that. That was very, very important. (6)	2
		Group awareness		Statements referring to the fact that WhatsApp allows users to see when and what other group members change in a shared file and what the status of group work is.	And we used Google Drive to really upload everything, everything we created, so that everyone could access it at any time... could access it at any time and had all the information at any time and also knew	2

Table A-3: Coding guideline (continued)

Tool category / Tools	Codes	Reasons for using / associated activities	Reasons for not using / associated activities	Explanation	Examples	Codes
					"okay, we're at such and such a point". (6)	
		Commentary function		Statements about Google Drive providing a commenting function.	And towards the end, Google Drive also became very, very important again, because we could create the comments there with the content and so that the other person could see what we had revised. (6)	1
		Clarity of the tool		Statements about clarity when using Google Drive.	Ehm Google Drive in general simply because you can create a super clear folder there that you can share with everyone. (7)	1
			Difficulties with formatting documents	Statements related to not using Google Drive or discontinuing the use of Google Drive because formatting within documents is perceived to be difficult.	Ehm exactly and we used Trello, where we always uploaded our things, because the formatting didn't work with Google Drive. (5)	1
Dropbox	2	Shared access to files / shared storage location		Statements about the fact that Dropbox provides shared access to files and/or a shared storage location for files.	So we also created the file in the tool and then we could write everyone in there so that everything was complete. So that everyone had access to it and could also proofread it. (10)	1
OneDrive	1	Shared access to files		Statements about the fact that OneDrive provides shared access to files.	Ehm and One Drive simply that you always have the latest version, that you don't always have to go back and forth with the Word files. (12)	1

Table A-3: Coding guideline (continued)

Tool category / Tools	Codes	Reasons for using / associated activities	Reasons for not using / associated activities	Explanation	Examples	Codes
		Efficiency increase		Statements that OneDrive leads to an increase in efficiency in the form of time savings.	Yes, you simply always have the current extract, so to speak, and you don't have to meet up with the others to look over it together, but you can simply call up the document from your room and then talk about it together via facetime. And yes, it has saved us having to meet in person, I'd say. And it also saved us the effort of always having to save the current Word document and then send it to the other two group members by e-mail. Yes, that saved us that. (12)	1
		Timeliness of files and content		Statements that OneDrive enables the timeliness of files and content.	OneDrive had... Yes, you simply always have the current extract, so to speak. (12)	1
		Group awareness		Statements referring to the fact that OneDrive allows users to see when and what other group members change in a shared file.	OneDrive that everyone then always had the current document ehm quasi available and could read about it, could inform themselves "where is he now, what is he doing right now". (12)	1
Representation tools						
Trello	4	Shared access to files / shared storage location		Statements about the fact that Trello provides shared access to files and/or a shared storage location for files.	And we have Trello... And Google... And the Google Drive more or less, we used to store our stuff and then ehm a place where	1

Table A-3: Coding guideline (continued)

Tool category / Tools	Codes	Reasons for using / associated activities	Reasons for not using / associated activities	Explanation	Examples	Codes
					everyone has access to update the stuff. (5)	
		Notification function on changes		Statements referring to the fact that Trello offers a notification function on changes.	With Trello you even get notifications when something happens and you were always reminded that you had to do something, that was very good. (5)	1
		Group awareness		Statements referring to the fact that Trello allows users to see when and what other group members change in a shared file.	And they were relatively important, so everyone could access them, and everyone knew what the others were doing. (5)	1
			Tool only suitable for unclear tasks	Statements related to not using Trello or no longer using Trello because it is perceived as a tool that is only suitable for unclear tasks.	We've started that now, but it wasn't necessary because you realized relatively quickly which points were ticked off and which weren't, whether you'd finished your text or not. Maybe with larger assignments. (4)	1
Miscellaneous tools						
Microsoft Word	6	Completion of the term paper / formatting		Statements regarding the use of Microsoft Word to finalize the term paper and / or formatting.	Ehm and then at the very end, which I forgot to mention before, we switched to Word because of the formatting. That didn't work at all with Google Docs. (9)	3
		Familiarity / habit		Statements that refer to the use of Microsoft Word because group	However, with GoogleDocs, I would say ehm, I don't like working	1

Table A-3: Coding guideline (continued)

Tool category / Tools	Codes	Reasons for using / associated activities	Reasons for not using / associated activities	Explanation	Examples	Codes
				members are familiar with the tool and were used to using it.	with it as much as ehm Word. Most of the time I actually- at least I personally, wrote in Word and then pasted it into Google Docs. Because it was ehm personally easier for me that way. I mean, maybe it's also a matter of habit, but yes, I work with it- I just didn't like working with it that much. (2)	
Zotero	1	Automatic creation of the reference list		Statements about Zotero allowing the automatic creation of a reference list.	Ehm We used Zotero because it is simply easier and clearer with the sources. Ehm then ehm at the end of the ehm table of contents no no to make the list of sources. (12)	1
		Complete coverage of references		Statements about Zotero allowing the complete coverage of reference.	Then here and there a source was missing and when one of us discovered Zotero and then suggested using it, it was much easier. (12)	1
		Clarity of the tool		Statements about clarity when using Zotero.	We used Zotero because it is simply easier and clearer with the sources. Ehm then ehm at the end of the ehm table of contents no no to make the list of sources. (12)	1
		Ease of use		Statements that refer to the use of Zotero because of its ease of use.	We used Zotero because it is simply easier and clearer with the sources. Ehm then ehm at the end of the ehm table of contents no no to make the list of sources. (12)	1

Source: own table

Table A-4: Reasons for using and activities associated with tool use in CSCL

Tool category / tool	Reasons for using / activities	Reasons for not using / activities	Codes
Communication tools			
WhatsApp	Organization of the group work		IP4, IP5, IP6, IP7, IP8, IP11 (total = 6)
	Short queries		IP1, IP3, IP4, IP7, IP10 (total = 5)
	Communication speed		IP3, IP4, IP6, IP7, IP8 (total = 5)
	Familiarity / tool circulation		IP1, IP4, IP5, IP8, IP9 (total = 5)
	Ease of use		IP2, IP4, IP9 (total = 3)
	Possibility to talk to each other		IP2, IP10 (total = 2)
	Wide range of functionalities		IP4, IP6 (total = 2)
	Group awareness / motivation		IP4, IP5 (total = 2)
	Sharing files		IP4 (total = 1)
Zoom	Possibility to talk to each other		IP4, IP5, IP10 (total = 3)
	Familiarity / tool circulation		IP6, IP7, IP8 (total = 3)
	Video streaming		IP6, IP7, IP8 (total = 3)
	Screen sharing		IP5, IP7, IP10 (total = 3)
	For detailed discussions		IP4, IP5, IP6 (total = 3)
	Easy account creation		IP8 (total = 1)
	Good connection / few dropouts		IP7 (total = 1)

Table A-4: Reasons for using and activities associated with tool use in CSCL (continued)

Tool category / tool	Reasons for using / activities	Reasons for not using / activities	Codes
		Limited meeting time (depending on version)	IP5 (total = 1)
Skype	Familiarity / tool circulation		IP1, IP9, IP11 (total = 3)
	Video streaming		IP1, IP11 (total = 2)
	For detailed discussions		IIP11 (total = 1)
	Possibility to talk to each other		IP1 (total = 1)
FaceTime	Short queries / short conversations		IP10, IP12 (total = 2)
Microsoft Teams	Wide range of functionalities		IP3 (total = 1)
	Group awareness		IP3 (total = 1)
Email	Sharing files		IP1, IP4 (total = 2)
Discord	Intuitive tool		IP9 (total = 1)
Google Groups	Possibility to talk to each other		IP5 (total = 1)
	No limited meeting time		P5 (total = 1)
	Screen sharing		IP5 (total = 1)
Sharing and co-construction tools			
Google Docs	Simultaneous work on one file		IP2, IP4, IP7, IP8, IP9 (total = 5)
	Commentary function / feedback		IP1, IP2, IP4, IP9, IP10 (total = 5)

Table A-4: Reasons for using and activities associated with tool use in CSCL (continued)

Tool category / tool	Reasons for using / activities	Reasons for not using /	Codes
	Timeliness of files and content / no different versions		IP2, IP7, IP8, IP9 (total = 4)
	Shared access to files / shared storage location		IP3, IP7, IP10 (total = 3)
	Efficiency increase		IP1, IP4 (total = 2)
	Mention in the lecture		IP9, IP11 (total = 2)
	Group awareness / motivation		IP4, IP11 (total = 2)
	Access via different devices		IP4 (total = 1)
	Familiarity of the tool		IP1 (total = 1)
	Ease of use		IP2 (total = 1)
	Avoidance of storage space problems		IP4 (total = 1)
		Difficulties with formatting documents	IP9, IP11 (total = 2)
		Poor tool performance	IP3 (total = 1)
Google Drive	Shared access to files / shared storage location		IP5, IP6, IP7 (total = 3)
	Timeliness of files and content / no different versions		IP6, IP7 (total = 2)
	Group awareness		IP6, IP7 (total = 2)
	Commentary function		IP6 (total = 1)
	Clarity of the tool		IP7 (total = 1)

Table A-4: Reasons for using and activities associated with tool use in CSCL (continued)

Tool category / tool	Reasons for using / activities	Reasons for not using / activities	Codes
		Difficulties with formatting documents	IP5 (total = 1)
Dropbox	Shared access to files		IP10 (total = 1)
Microsoft OneDrive	Shared access to files		IP12 (total =1)
	Efficiency increase		IP12 (total =1)
	Timeliness of files and content		IP12 (total =1)
	Group awareness		IP12 (total =1)
Representation tools			
Trello	Shared access to files / shared storage location		IP5 (total = 1)
	Notification function on changes		IP5 (total = 1)
	Group awareness		IP5 (total = 1)
		Tool only for unclear tasks	IP4 (total = 1)
Miscellaneous tools			
Microsoft Word	Completion of the term paper / formatting		IP8, IP9, IP11 (total = 3)
	Familiarity / habit		IP2 (total = 1)
Zotero	Automatic creation of the reference list		IP12 (total = 1)
	Complete coverage of references		IP12 (total = 1)

Table A-4: Reasons for using and activities associated with tool use in CSCL (continued)

Tool category / tool	Reasons for using / activities	Reasons for not using / activities	Codes
	Clarity of the tool		IP12 (total = 1)
	Ease of use		IP12 (total = 1)

Source: own table

Declaration in Lieu of Oath

Declaration in lieu of oath according to section 8 subsection 2 No. 1(b) of the Regulations and Procedures Governing the Doctoral Dissertation to Earn a Doctoral Degree in Business at the University of Mannheim

Eidesstattliche Versicherung

Eidesstattliche Versicherung gemäß § 8 Absatz 2 Satz 1 Buchstabe b) der Promotionsordnung der Universität Mannheim zur Erlangung des Doktorgrades der Betriebswirtschaftslehre (Dr. rer. pol.)

1. The submitted doctoral dissertation on the subject "*Explaining Self-Regulated Learning in the Context of Work: The Role of Problem-Solving, Collaboration, Communication, and Technology Use*" is my own work and to the rules of proper scientific conduct.

   Bei der eingereichten Dissertation mit dem Titel "Explaining Self-Regulated Learning in the Context of Work: The Role of Problem-Solving, Collaboration, Communication, and Technology Use" handelt es sich um mein eigenständig erstelltes Werk, das den Regeln guter wissenschaftlicher Praxis entspricht.

2. I did not seek unauthorized assistance of a third party and I have employed no other sources or means except the ones listed. I clearly marked any direct and indirect quotations derived from the works of others.

   Ich habe nur die angegebenen Quellen und Hilfsmittel benutzt und mich keiner unzulässigen Hilfe Dritter bedient. Insbesondere habe ich wörtliche und nicht wörtliche Zitate aus anderen Werken als solche kenntlich gemacht.

3. I did not yet present this doctoral dissertation or parts of it at any other higher education institution in Germany or abroad.

   Die Arbeit oder Teile davon habe ich bislang nicht an einer Hochschule des In- oder Auslands als Bestandteil einer Prüfungs- oder Qualifikationsleistung vorgelegt.

4. I hereby confirm the accuracy of the affirmation above.

   Die Richtigkeit der vorstehenden Erklärung bestätige ich.

5. I am aware of the significance of this affirmation and the legal ramifications in case of untrue or incomplete statements. I affirm in lieu of oath that the statements above are to the best of my knowledge true and complete.
   Die Bedeutung der eidesstattlichen Versicherung und die strafrechtlichen Folgen einer unrichtigen oder unvollständigen eidesstattlichen Versicherung sind mir bekannt. Ich versichere an Eides statt, dass ich nach bestem Wissen die reine Wahrheit erklärt und nichts verschwiegen habe.

I agree that for the purpose of assessing plagiarism the dissertation may be electronically forwarded, stored and processed.

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Mannheim,	Tamara Vanessa Leiß
Place, Date / *Ort, Datum*	Signature / *Unterschrift*

Curriculum Vitae

Professional Experience

Since 2022	Product Knowledge Specialist, SAP Deutschland SE & Co. KG
2019 – 2022	Working Student, SAP SE
2018 – 2022	Research Assistant at the University of Mannheim, Business School Area Economic and Business Education, Chair Workplace Learning (Prof. Dr. Andreas Rausch)
2018 – 2019	Student counselling and program management for the Economic and Business Education degree programs, University of Mannheim
2017 – 2018	Working Student, HIMA Paul Hildebrandt GmbH
2012 – 2015	Dual Student, Voith Paper GmbH & Co. KG

Education

Since 2018	Doctoral Study Program, University of Mannheim
2018	Master of Science, Economic and Business Education, University of Mannheim, Germany
2016	Bachelor of Science, Economic and Business Education, University of Mannheim, Germany
2015	Bachelor of Arts in Business Administration – Management in Industry Baden-Württemberg Cooperative State University (DHBW), Ravensburg

Teaching activities

2021	Grundlagen der Wirtschaftspädagogik (Tutorium) / Basics of Education and Business Education (Tutorium)
2020 - 2021	Empirische Instruktionsforschung / Research on Learning and Instruction
2019 + 2022	Betriebspraktische Studien / Company Placement
2019 – 2022	Supervising bachelor theses and master theses
2018 - 2020	Wirtschaftsberufliche Kompetenzentwicklung I / Development of commercial competences I