The Relevance of KES-Oriented Processes for the Implementation of ERP Systems: Findings From an Empirical Study in German SMEs

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Past and current research has shown that Knowledge and Expertise Sharing (KES) is central to the appropriation of enterprise software such as Enterprise Resource Planning (ERP) systems. ERP implementation projects in Small and Medium-sized Enterprises (SMEs) are often driven by research and practice. However, they tend to focus on the 'go live' moment rather than on the subsequent, much longer post-implementation phase. This, we argue, results in decreased utilisation over time and an increased need for workarounds. In this paper, we draw on an empirical study within four organisations which exposes the limitations of KES in ERP implementation projects in SMEs, especially in regard to the preparation of key users. Our findings suggest that, despite key users' essential role in these projects, they are often chosen haphazardly and are ill-prepared. As a result, they cannot fulfil their role of facilitating KES with end users, who end up appropriating ERP systems mostly through 'learning by doing'. This stems directly from complex and largely unrecognised processes involving consultants, hotlines, management, key users and end users. In this paper, we introduce and discuss specific socio-technical, KES-oriented measures which can potentially lead to sustainable KES throughout the ERP life-cycle for longer-term success.

CCS Concepts: • **Human-centered computing** → *Empirical studies in HCI*; **Human computer interaction (HCI)**.

Additional Key Words and Phrases: ERP Systems, Knowledge and expertise sharing, ERP system implementation

ACM Reference Format:
Philipp Rutz, Christoph Kotthaus, Aparecido Fabiano Pinatti de Carvalho, Dave Randall, and Volkmar Pipek. 2023. The Relevance of KES-Oriented Processes for the Implementation of ERP Systems: Findings From an Empirical Study in German SMEs. *Proc. ACM Hum.-Comput. Interact.* 7, CSCW2, Article 313 (October 2023), 34 pages. https://doi.org/10.1145/3610104

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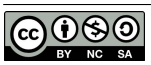

2573-0142/2023/10-ART313
https://doi.org/10.1145/3610104

1 INTRODUCTION

Small and medium-sized enterprises (SMEs) are under constant competitive pressure due to global market challenges. Automating business processes through digitalisation is one way of coping with this [43], and Enterprise Resource Planning (ERP) systems are often the foundational business application underpinning these processes [38]. Nevertheless, and as we argue in this paper, ERP systems are not always fit for purpose from the outset. The fact that they are, in principle, configurable does not mean that they are configured at the right time, appropriately or by the right people. Our research highlights some problems in the overall implementation process that can reduce ERP systems' effectiveness.

According to Xu et al. [90], ERP systems are configurable online interactive system packages or multi-module application software used to plan and control resources in a company. They cover many areas of an organisation, such as sales, purchasing, warehousing and production, and therefore are a key element in the articulation work necessary to coordinate these different areas. These systems are important workplace information technologies for supporting the coordination of companies' work, but the practical business of implementation, especially in SMEs, remains relatively unexamined. They are usually described in the literature as 'highly integrated monolithic systems that are quite efficient at integrating data with respect to routine or expected tasks, but [are] quite rigid with respect to free access and unexpected processing'[89].

Although many SMEs use such highly complex systems, these are often used intermittently and in a fragmented manner. Such haphazard handling of business processes mostly results in unrealised potential and 'local' workarounds with unpredictable results [53, 59]. A clear element of this, as we show, is the fragmented nature of the knowledge and expertise sharing (KES) that might otherwise underpin successful implementation [50, 69].

The complexity of business processes and their implementation into ERP systems often make it challenging for employees to comprehend the effect of their actions, so they often rely on the 'to-hand' expertise of more experienced colleagues. One reason for this, we argue, is that too little attention is paid to the post-implementation phase of such projects. Attention is primarily focused on meeting standards for a successful 'go live' at the end of the project. Typically, the vendor's project team is disbanded and re-assigned to other projects. The customer is then handed over to the support staff, which often leads to a significant loss of customer-specific knowledge.

ERP system implementation is usually driven forwards by a project team consisting of consultants from the ERP vendor as well as a project manager and key users from the application company. Managing wider dissemination tends to be a local responsibility, usually given to a key user, with varying results [88].

Using the analytical lens of KES, this study sets out to investigate how ERP implementation projects are carried out in practice and introduces socio-technical and KES-oriented measures to support the different actors involved in them to deliver sustainable results, looking beyond the 'go live' and keeping the ERP life-cycle in mind [56]. In particular, we reflect upon how ERP systems can be better prepared to support cooperation between those actors so that KES can be successful despite the layers of complexity involved. We therefore address a core theme of CSCW research, that of designing tools to support the highly collaborative processes involved in KES.

In general, we seek to shed light on relevant aspects that can help answer the following research questions:

RQ1. To what extent are ERP implementation processes adequate in SMEs?
RQ2. What role does KES, or its absence, play in such implementation processes?
RQ3. How can sustainable KES be supported in ERP implementation projects?

To answer our research questions, we have carried out an in-depth qualitative study predicated on interviews, workshops and observations with participants from different companies and a variety of roles to afford multiple perspectives on our topic. The empirical findings have been analytically developed with the help of the *thematic analysis* approach according to Braun and Clark [9], which is commonly used within CSCW and other human-centric fields [14].

Our contribution here is twofold: (1) We contribute an empirical study of an implementation process, focusing on the practical issues which mediate it after systems 'go live'. We will argue that, while there is limited literature on ERP's failure in the CSCW literature and elsewhere, there have been no empirical studies which examine in detail why that is the case from a KES perspective [50], not least in SMEs, where access to resources is limited. The work of Pollock and colleagues is an exception, which we discuss ahead. (2) In the second part of our contribution, we suggest approaches to solve the problems identified in our empirical results and aim to propose methods for a KES-oriented implementation of an ERP system and a sustainable use phase.

The remainder of this paper is organised as follows: section 2 presents related work on ERP implementation and life-cycle models and the role of KES in implementation projects and beyond; section 3 introduces our research context and methodological approach concerning data collection and analysis; section 4 introduces five themes that works together to answer our research questions; section 5 elaborates on the themes introduced in section 4, marshalling them into measures for the longer-term success of ERP implementation in SMEs; and section 6 lays out some concluding remarks as we summarise our answers to the research questions that we have posed.

2 RELATED WORK

In the following sections, we first examine ERP implementation models and life-cycles and then discuss success factors for, and problems with, ERP implementations. We will also examine current CSCW literature concerning KES in general and in the ERP context. This section sets the framework for our analysis in later sections.

2.1 ERP Implementation Models and Life Cycles

In ERP implementation, a distinction has traditionally been made between a 'big bang' implementation and a phased implementation [52]. In the 'big bang' approach, the whole new ERP system, with all its modules and functionalities as well as potential new processes, is introduced. In contrast, in the phased ERP implementation, modules and processes are introduced iteratively.

In their literature review, Kraljic et al. [39] did a comprehensive study and evaluation of several ERP implementation models . They show that no one model nor 'typical' sequence of phases can be discerned, but rather a variety of different implementation models exist. They also criticise these approaches, as well as ERP research in general, as not having been researched deeply enough, which also arguably applies to CSCW analysis [50, 69]. Indeed, the comparison of methodologies in Table 1 shows that, although the implementation steps are listed in most cases, these tend to be pitched at a rather abstract level.

Nagpal et al. [52] built on the work of Kraljic et al. and extended the overview of ERP implementation models by adding vendor-specific implementation methodologies and considering the influence of agile methods on ERP implementation [52]. In their research, they distinguished three variations: custom-made, vendor-specific and consultant-specific. In addition to these developments in the field of ERP implementation, Nagpal et al. also addressed the procedures for ERP implementation based on the Critical Success Factors (CSF).

Based on the CSF, Leyh [42] developed an ERP implementation model for SMEs. He analysed the CSFs' frequency in the literature and conducted interviews in German SMEs. From this, an ERP implementation model was derived. He describes five phases: (1) project preparation, (2)

as-is analysis/target concept, (3) software selection, (4) concept fine-tuning and (5) realisation and introduction. Leyh describes these phases as a collection of activities gathered from the literature that are typically carried out in these phases and indicates which roles the company's management, project team and employees should play [42]. What is striking about Leyh's model is that the post-implementation phase – the actual use phase where the return for the customer should come into effect – is only briefly considered. Also, measures regarding knowledge transfer, such as training, only play a subordinate role. The topic of documentation is not considered at all.

Table 1. ERP Implementation Models - Source: Kraljic et al.[39]

Author(s)	ERP implementation Method
Bancroft et al. (1998)	(1)Focus, (2)Creating As – Is picture, (3) Creating of the To-Be design, (4) Construction and testing and (5) Actual Implementation
Kuruppuarachchi et al. (2000)	(1) Initiation, (2) Requirement definition, (3) Acquisition/development, (4) Implementation, and (5) Termination
Markus and Tanis (2000)	(1) Project chartering, (2) The project, (3) Shakedown, and (4) Onward and upward
Makipaa (2003)	(1) Initiative, (2) Evaluation, (3) Selection, (4)Modification, Business Process Reengineering, and Conversion of Data, (5) Training, (6) Go – Live, (7) Termination, and (8) Exploitation and Development
Parr and Shanks (2000a)	(1) Planning, (2)Project: a. setup, b. reengineer, c. design, d. configuration and testing, e. installation (3) Enhancement
Ross (1999)	(1) Design, (2) Implementation, (3) Stabilisation, (4) Continues improvement and (5) Transformation
Shields (2001)	Rapid implementation model of three phases and 12 major activates
Umble et al. (2003)	(1) Review the pre-implementation process to date, (2) Install and test any new hardware, (3) Install the software and perform the computer room pilot, (4) Attend system training, (5) Train on the conference room pilot, (6) Established security and necessary permissions, (7) Ensure that all data bridges are sufficiently robust and the data are sufficiently accurate, (8) Document policies and procedures, (9) Bring the entire organisation on – line, either in a total cutover or in a phased approach, (10) Celebrate, and (11) Improve continually
Verville and Halingten (2003)	(1) Planning, (2) Information search, (3) Selection, (4) Evaluations, and (5) Negotiation

2.2 Success Factors and Problems in ERP Implementation

At the beginning of the ERP wave in the USA, Bingi et al. [6] assessed critical success factors for ERP implementation. They found that the introduction of ERP systems is not only a technical challenge, but primarily an organisational one [6]. They suggest a number of success factors, including the commitment of top management, implementation costs, implementation time, employee training, employee morale and the selection of the right employees to be involved in the ERP implementation project [6].

In 2013, Schniederjans and Yadav examined success criteria in a systematic literature review. They point out that in previous literature, the main factors were listed, but the connections between them were not thoroughly investigated [72]. They present a model that primarily distinguishes between the three dimensions of technology, organisation and environment. In the organisational dimension, they show that top management support, good project management, a good implementation team and a well-thought-out implementation plan that, among other things, also takes user training into account, all play an important role for implementation. In addition to these factors, they also emphasise the relevance of trust amongst all those who are actively involved in the implementation, as well as those who will later use the ERP system [72].

Ahmad and Cuenca [5] put a special focus on success factors for ERP implementation in SMEs. They conducted a literature review to identify success factors and, based on this, they carried out a study to identify the important criteria for SMEs with the aim of finding out which factors play the most important role in which phase of the implementation. They found that, while there are a similar number of operational and organisational factors, the ones addressing the organisational level are most important in the implementation's success [5]. Their factors include project team skills, an experienced project manager, resources, cultural change, management support, cooperation, communication and evaluation of progress [5]. Leyh [41] also addressed ERP implementation in SMEs using a similar methodological approach. He showed that the criteria found in the literature, which were primarily collected in large companies, can also be transferred to SMEs.

However, according to Leyh [41], the prioritisation is different for SMEs, as technological implications are given more weight than organisational aspects. The study also showed that user training plays the most important role in ERP implementation for the respondents [41]. Leyh and Sander [42] extended this research by presenting a summary of success factors from their literate review, showing that very little research considers the role of KES in ERP implementation projects. Documentation, for example, is not listed as a distinct factor [42]. In the following, we will demonstrate the relevance of KES with some emphasis on documentation in the overall ERP implementation and maintenance process. Documentation, as we shall see, is at the core of KES processes and can play a relevant role in coordinating the work among cooperative actors.

In a case study in the pharmaceutical industry, Taylor and Virgili [83, p.72] point to the many socio-technical issues that arose before implementation, most of which could be described in terms of communication difficulties, but they also say that

> *The complexity of the system itself, they had discovered, never mind that of the organisation, precludes any easy solution to the implementation problem [83]. Both Labopharma staff and the consultants, moreover, now had no choice but to acknowledge that the learning process they had been submitted to [...] would not end with the official implementation. Even afterwards, it would still be a work in progress, with more adaptations still to be worked out.*

In 2014, Seymour and Van Vuuren could still argue that

> *The biggest problem SMEs face in achieving the full value of their investment has been attributed less with the capabilities of the technology itself and more with the people using*

> *the technology to understand and take advantage of what the system has to offer [...] and a poor fit between the information systems design and the organisational setting into which that system is being introduced.*

Exactly how those problems manifest and how they might be dealt with through the implementation process is, of course, of interest to us [74].

2.3 KES in ERP Projects and in General

Computer-Supported Cooperative Work (CSCW), Information Systems (IS) and Organisational Management (OM) research has recurrently shown that KES is arguably one of the most relevant processes within companies. As extensively discussed in the literature [7, 32, 54, 63, 76], knowledge is one of the most valuable assets within organisations, as it is directly related to competitiveness and the capability to improve processes and respond to market demands. Within CSCW, three generations of KES have been identified [1, 15].

The first generation, which emerged around the mid-1990s, emphasised the importance of organisational knowledge as another important production factor from a business perspective and focused on attempts to generate an organisational memory which could afford, among other things, collective intelligence [63]. This generation was influenced by the OM literature, which has abundantly discussed ways to record knowledge in databases or other forms to conserve it and make it reusable. A great deal of attention has been dedicated to finding ways to account for what Polanyi [58] referred to as tacit knowledge, a type of knowledge which is often acquired through learning-by-doing and is either so ingrained in people's minds that it is taken for granted or so deeply rooted in action and context that it is difficult to codify or explicate [46, 66].

CSCW systems belonging to this first generation of KES were mainly geared towards generating and giving access to repositories [1]. In practice, their application has led to many problems, such as the 'management trap' or the 'ICT trap', which describe misconceptions about the controllability of knowledge work or the quality and reusability of technically stored knowledge [33]. In particular, the focus on tacit knowledge has proven problematic and subject to criticism from part of the CSCW community [68].

In response to the limitations of the first generation of KES research and practice, there was a move towards a second generation, where the focus was on supporting KES in an unstructured, situational and predominantly interpersonal way. In this generation, greater attention has been put into the human components of the process and the associated cognitive, social, cultural and organisational aspects of knowledge [2]. The focus moved towards expertise 'i.e., embodied, socially arranged, and organised knowledge' and expertise holders [1]. Investigations in this generation mainly concerned finding expertise, issues of social capital impacting KES and establishing and maintaining communities of practice [18, 20, 21, 65]. In parallel, work in management science [35] has drawn attention to the importance of organisational culture and 'cultural fit' when designing knowledge management solutions [34].

More recently, a third generation of KES has been claimed in response to current technological developments. It has been argued that the affordances of cyber-physical systems would facilitate significant improvements in the realisation of KES, especially in regard to capturing and sharing knowledge embodied in action and reducing the overhead work associated with KES through the use of augmented reality and sensor technologies [15, 32].

The research presented herein can be seen as part of this third generation, as it focuses on investigating how new and innovative technology predicated on data analytic mechanisms can be integrated into ERP systems to support aspects of KES in SMEs. These aspects, we argue, are

of great importance in both the ERP implementation phase and the post-implementation phase, which span ERP configuration and the assimilation of new work processes.

ERP configuration, then, evolves comprehension of the complexity of an ERP system, its dependencies and effects when the extensive configuration is done. Tailoring ERP implementation projects is often accompanied by redesigning current business processes. Comprehending, assimilating or appropriating these new ways of working and how this works with the new ERP system poses another knowledge barrier.

Robey et al. [67] have identified critical knowledge barriers regarding ERP implementation projects. The authors found that successful companies participating in their study maintained a strong core team throughout the implementation phase and beyond. These teams were dedicated almost entirely to the implementation project, often involved external consultants and maintained these relationships consistently. This was central to all formal and informal knowledge transfer within the team and to the end users. They also point out that situated learning within communities of practice rather than formal training might be an effective means to overcome knowledge barriers.

Furthermore, an ongoing fundamental problem in the context of research on ERP systems is the disproportionate focus on the early phases and first-generation concepts [79, 82]. Questions concerning the systems' use and collective appropriation are hardly considered. As a result, many system functions often remain unused and necessary knowledge about business processes and conditions and consequences of collective, system-supported action in the organisational context is insufficiently communicated among the various actors. As a consequence, erroneous data dumps are created that lead to poor decision-making [47, 48]. A serious basic problem is unacknowledged KES in general, both among users and consulting firms [22]. However, even if users are aware of this, they lack the ability to capture and store the knowledge provided by the consultancies sustainably. The loss of knowledge, especially among users of ERP systems, is another major barrier [23, 82].

Although there have been numerous attempts to describe the life-cycle of ERP systems, to derive maturity models from them [30] and to propose procedures in relation to late-phase KES [49], these are mostly based on models and theoretical studies [56]. However, as mentioned previously, these attempts lack a practice-centred approach focusing on the social, cultural and organisational aspects of KES. The research we detail in this paper sets out to address this gap in the literature.

2.4 CSCW and ERP Systems

Valdebenito and Quellopana [85] provide a useful, and fairly recent, summary of research into ERP implementation, and CSCW-related work remains largely absent. It remains the case that CSCW, with a few notable exceptions, has had little to say about ERP system design and implementation, perhaps because their 'monolithic' nature, as Michelis has called it [89], precludes much in the way of contextual analysis. This does not mean that CSCW has been inattentive to the kinds of issues we are interested in. As Schmidt and Bannon put it:

> *In other words, the model underlying coordination technologies (from "office automation" to ERP systems) breaks down in view of the "situated" nature of work. Consequently, in designing coordination technologies it is necessary to support practitioners in making coordination technologies work, that is, making them an integral part of their practices.* [70]

Attention has progressively been drawn to the complex interplay of organisational routines, new technology and knowledge work practice over the long term with the development of concepts like 'knowledge infrastructures'. The concept arguably evolved from Hanseth et al.'s [28] concept of 'information infrastructures', which reminds us that the storage and transmission of knowledge is

not a mechanical process but is increasingly constituted in '... robust networks of people, artefacts, and institutions that generate, share, and maintain specific knowledge about the human and natural worlds' [19], which nevertheless respond to an increasingly dynamic and fluid situation to facilitate connectivity and communicative processes. The analysis has focused primarily on scientific infrastructures and has no direct relevance to the problems faced by SMEs, which typically are not part of wider networks, but they focus attention away from the more static and episodic approach to knowledge and expertise sharing towards a longer time frame [36] that recognises 'interrelated social, organisational and technical components or systems (whether the data will be shared, systems interoperable, standards proprietary, or maintenance and redesign factored in' [36]. These changes can negatively impact these infrastructures if they are not successfully implemented. Edwards et al. argue that it is therefore important to focus on all parts of the knowledge infrastructure and not only on the ones that are rapidly changing [19].

Pollock and Williams [50, 60] are rare in that they explicitly address ERP systems as an example of shortcomings in the way that research has focused on technology adoption as a 'before and after' problem. As they put it:

> *Implementation studies are typically medium-term studies starting in the course of, or shortly after, the introduction of a new technology. There is thus a temporal framing—both upstream and downstream of the implementation process. The upstream framing concerns the difficulty of researching directly the "pre-project" phase in which particular problems and the possibility of technical solutions are articulated together. The decision to adopt thus typically becomes a feature taken for granted, addressed only in hindsight.* [60]

They draw attention to:

> *... the enormous effort involved in bridging generic supplier offerings to specific organisational settings through intertwined processes of innofusion – in adapting these complex information systems to particular organisational settings and of domestication – as organisations learn to exploit the affordances of complex technologies in redeveloping their information and work practices.* [60]

Furthermore, they propose what they call 'strategic ethnography' as a means to deal with these lacunae. Such an approach would be long-term, multi-sited and investigate moments of innovation. Similarly, Schubert and Glitsch [73], in a discussion of ERP and Enterprise Collaboration Systems (ECS), point to the absence of detailed use cases in CSCW and elsewhere. They further describe ERP systems as process-driven, whilst ECS are 'socially enabled'.

The need for some integration of the two should, in principle, be of interest to CSCW, but this appears as yet to be an unrealised ambition. Our concern is a specific one – how SMEs deal with the implementation challenges they face – but it can also be seen as an attempt, empirically and conceptually, to integrate the two agendas.

3 METHODS

In the following, we provide contextual information regarding the settings where our study have been carried out and introduce the data collection and analysis methods employed.

3.1 Context – Companies and Industries

The findings presented in this contribution come from a study conducted within six German SMEs as part of a government-funded research project. The six companies consisted of two ERP consultancies, an ERP selection consulting company, a business process consulting organisation, a metal processing company and a beverage wholesaler. The study was conducted with participants from different areas of the companies to get a broader understanding and a deeper insight into

practical exigencies. At the consultancies, the study primarily featured consultants and hotline staff. On the clients' side, the interviews were conducted with key users, end users and IT staff.

Our research field is characterised by the fact that all companies are typical German SMEs. This means that formal organisational roles seldom fully describe the ad hoc way work tasks are allocated nor the flexibility typically found among employees. During the ERP implementations that we observed in our study, the system was typically implemented by initially running the old and new ERP systems in parallel. This is partly because, typically for SMEs, the implementation has to be managed alongside ongoing daily business.

As is often the case for SMEs, our study showed that the IT department plays a strong role in the ERP implementation. In the SME from the metal industry, the project was led by a commercial project manager, but IT was strongly involved in the project. In the company from the beverage sector, the implementation project was managed centrally by IT in close cooperation with the consultancy. IT, then, normally plays a decisive role in shaping the processes and end users, for the most part, do not have any role to play.

3.2 Data Collection

Our study consisted of two workshops, a series of 12 interviews, and observations. Each workshop lasted from one to three hours, and the average length of the interviews was one hour. In total, 17 participants were involved in the data collection activities, as shown in Table 2. The interviews were conducted online in a semi-structured format via Microsoft Teams©, not only due to the Corona pandemic, but also because of the physical distance between the participants and the researchers.

The two workshops were also conducted online. The first workshop was implemented with two business process engineers. The aim of this workshop was to discuss the special features of ERP implementation in SMEs, the role of key users in SMEs and process models for ERP implementation.

The second workshop included participants from the management department of the companies involved and from a consulting firm specialising in recommending ERP systems. The aim of the workshop was to understand the requirements for becoming a key user and the hurdles that key users usually face during and after ERP implementation projects.

The workshop was conducted via Microsoft Teams© with the support of a Miro© whiteboard [1]. The workshop was divided into four brainstorming sessions, in which each of the participants individually collected ideas before they were discussed in plenary and clustered on the Miro board.

[1] https://miro.com/

Table 2. Empirical study participants

Empirical Method	Participant	Background
Interviews 1	IT 1	Beverage Industry
Interviews 2	IT 2	Beverage Industry
Interviews 3	IT 3	Beverage Industry
Interviews 4	Accounting 1	Beverage Industry
Interviews 5	Wholesale 1	Beverage Industry
Interviews 6	Wholesale 2	Beverage Industry
Interviews 7	Store manager 1	Beverage Industry
Interviews 8	Logistics 1	Beverage Industry
Interviews 9	IT 4	Metal Industry
Interviews 10	Sales 1	Metal Industry
Interviews 11	Purchasing 1	Metal Industry
Interviews 12	ERP consultant 1	ERP Consulting (Beverage Industry)
Expert Workshop	Business process engineer	Business Process Consulting
Expert Workshop	Business process engineer	Business Process Consulting
Key user Workshop	Management 1	ERP Selection Consulting
Key user Workshop	Management 2	ERP Consulting (Beverage Industry)
Key user Workshop	Management 3	ERP Consulting (Beverage Industry)
Key user Workshop	Management 4	Metal Industry

3.3 Data Analysis

All data artefacts generated during the data collection phase of our study have been submitted to a systematic thematic analysis according to Braun and Clark's [9] approach. This approach has been increasingly used within HCI and CSCW research to generate analytical and conceptual results and illuminate relevant research questions to the field, especially within practice-centred computing [14]. It provides researchers with a flexible and powerful method to identify patterns of meaning while suspending theoretical commitments [40]. The approach entails engaging deeply with the data to become familiarised with it; coding the data, possibly using a combination of bottom-up (inductive) and top-down (deductive) approaches; searching for relationships between codes to elucidate themes; defining themes, so the relationships that they imply are clearly described; revising themes to ensure that each of them significantly contributes to the analysis; and marshalling these themes for reporting purposes. This careful and systematic data handling contributes to trustworthiness and authenticity, two major quality criteria of qualitative research [27].

For our purposes, thematic analysis turned out to be the most appropriate approach. Should our focus be on theory building, which is not the case, a Grounded Theory approach, such as the one introduced by Strauss and Corbin (1998), or an abductive analysis, as described by Timmermans and Tavory (2022) would have been better options [81, 84].

The analysis took place within the research team established in the context of the research project from which the findings of this contribution stem. This group is composed of the three first authors and two student assistants working on the project. The analysis started with members of the analysis group going through the data collection instruments (e.g. interview guides and workshop planning documents) in search of apriori codes. *Apriori codes* refer to codes that analysts

anticipate finding in the data based on their prior knowledge about the data collection activities or associated literature. They are therefore used in a top-down manner (i.e. deductively) [24]. Once the analysis group agreed upon the initial code schema, the three first authors coded the same interview using the initially developed schema, which has been recurrently extended with codes identified during analysis. Empirical codes are unexpected and are developed in a bottom-up manner (i.e. inductively), as analysis engages with the data and listens to it. As discussed by Braun and Clarke [8, 9, 13], codes inductively identified in initial phases of the analysis process are naturally used deductively in later phases, as analysts keep looking for patterns in the data to illuminate their phenomenon of interest. By the same token, a pure deductive analysis would be restrictive and most likely prevent analysts from identifying new codes that could be key in shedding light on the topic under investigation. Our experience reflects this view.

After this initial coding event, the analysis group met to discuss newly identified codes, discuss overlaps between slightly different codes and agree on a new version of the code scheme. Data artefacts were distributed among the members of the group, who coded the artefacts with the newly developed code schema. The team met weekly to discuss newly identified empirical codes, refine the coding schema and coordinate the coding activity. Once the artefacts were coded, the team worked to find, define and revise the themes together. The analysis results were discussed with the other authors as we prepared to write the paper.

For this contribution, we concentrated on themes concerning the research questions we set out to answer. Overall, around 115 codes were generated during the analysis. Taking the research questions into consideration, five main themes were identified: ***jack of all trades, holder of all knowledge***, which includes codes like *jack of all trades* and *de-facto key user, as one is asked by many colleagues*; ***overwork, overtime***, concerning codes like *no time for (or revision of) documentation* and *no time for training*; ***key user by circumstances***, which includes codes like *key user role in day-to-day business*, *optimal key user is almost utopian*, *roles and responsibilities defined in the beginning of the project*; ***expected versus effective ways of learning the ERP system***, which has codes like *learning the ERP system through training*, *being thrown in to the deep end* and *no time for training*; and ***documentation***, which includes codes like *process-oriented documentation important for practice*, *users update their own documentation* and *standard ERP documentation is insufficient*. In the following, we introduce each of these themes and illustrate them with data excerpts, which are then analysed accordingly in relation to our research question.

4 EMPIRICAL FINDINGS

As we began to understand the challenges behind deploying and maintaining an ERP system, we were exposed to aspects concerning KES and issues concerning the amount of work that must be invested during the whole process, including the work necessary to learn the system with regard to actual working practices. These issues are elaborated on in the following themes, which suggest that the deployment and maintenance of an ERP system is a highly collaborative and technology-mediated process involving many layers of complexity (see Figure 1 and Figure 2). Understanding these layers of complexity, as discussed previously, is key to devising solutions to support the deployment and maintenance practices which guarantee the effective use of the system and, consequently, increased coordination between different departments within a company. All our empirical findings concerning the various themes presented are summarised in Appendix A.1 to A.5. To help connect the summary in the Appendix to the empirical evidence presented across the following sections, we have signalled each empirical finding with the (EF a.b), where 'a' refers to the number of the subsection and 'b' to the order of first appearance in the section.

4.1 Jack of All Trades, Holder of All Knowledge

As we progressed with our analysis, we noticed that the smaller the number of employees in an SME, the more roles or duties a single person typically has to take on. This contrasts with the situation in larger companies with a higher degree in the division of labour (EF 1.1). In addition, we observed that the departments (i.e. colleagues performing the same tasks) are typically far smaller, including single-person assignments with no adequate substitute. These roles often do not follow specific or well-known job titles but were developed over time through challenging situations, such as departing colleagues or new circumstances developing as the result of changes to a company's business model. In the interviews, employees expressed this by mentioning that it was difficult to name their actual job title or stating that they act as jacks of all trades. As Accounting 1 makes clear in the following quote, these workers do not only see themselves as jacks of all trades but are also perceived by others in the company as important knowledge sources because of their wide-ranging knowledge, regardless of whether they possess formal qualifications or organisational status:

> *My activities in the company, in the administration, are very varied. I work in the accounting department. Financial accounting. I am involved in merchandise management. I am involved in reconciliation work. I am involved in inventory management, in merchandise management. I also do stocktaking. So, I can be used in many different ways. But I am actually only a part-time employee.* (Accounting 1, Beverage Industry)

Many participants stated that the extra amount of work resulting from an ERP implementation project almost always has to be handled in addition to daily business. There are limited options to support key users by handing over work to others, for example, as necessary knowledge is missing or potential substitutes do not have time to take on extra work themselves. As a result, many key users state that they put in extra hours throughout the implementation project.

4.2 Overwork, Overtime

Our interviews have shown that, during an ERP implementation, the companies do not normally take measures to relieve their key users, so they often achieve this by working overtime, as mentioned previously. However, this lack of time also has an impact on the implementation project itself insofar as training is often limited:

> *There was no training, in the sense that we take a whole team from one of our markets and invite them to the headquarters. This would not be possible because the market needs to stay open. This is not possible.* (IT 1, Beverage Industry)

Trying to fit the extra work into their daily business can lead to frustration and demotivation among key users (EF 2.3). This frustration also derives from the lack of transparency about the amount of work that comes with the role of a key user.

> *You try to integrate it somewhere in your daily business and then you realise: 'Oh, it's not that easy, it takes even more time.' Then frustration follows. And then there's a whole chain of problems if it's not communicated from the outset, I think, that it also takes time and that you're aware of the fact that it takes one or two days a week. And I think that is a very important point.* (Management 3, Beverage Industry)

The only exception in handling the additional workload for employees in SMEs due to an ERP implementation is in the respective IT departments. Our observations showed that the companies often invest in additional personnel during the introduction (EF 2.4) but apparently only from a technology perspective. This did not happen in other departments:

> *Basically, you need time for the project, and you should be realistic about it. So don't just say: 'Yes, you can do it with 5 hours a week'. And then stick to it. That's the conflict we had earlier with the day-to-day business.* (Management 1, ERP Selection Consulting)

4.3 Key User by Circumstance

Our workshops demonstrated that certain expectations are placed on an ideal key user. A key user should have characteristics such as: a desire for change, knowledge of the company processes, technical interest, affinity for knowledge sharing, acceptance by colleagues, trustworthy character, and ability to have a broad view of the processes. They also should not be prone to act in a departmental-egoistic way - i.e., neglecting other departments' needs. Our findings suggest these characteristics should play an important role in selecting key users.

Nevertheless, it became evident through our interviews that this selection process is strongly influenced by the practical circumstances occurring in SMEs, as previously discussed. As a result, the specific key users are often selected to represent a department because they are deemed, for various reasons, to be the only ones who can fulfil this role (EF 3.1). The following quote makes this clear. As it can be seen, key users seemingly do not have a say in their appointment as a key user and are often chosen by the project manager.

> *Key users were named when it was clear that we were getting a new ERP system and then one was appointed for each department.* (Purchasing 1, Metal Industry)

This indicates that key users are in urgent need of help. One way to help them would be to precisely define the role of the key user at the beginning of the project (EF 3.2). Put differently, one could clarify to key users exactly which tasks and responsibilities their new role entails. This could give the key users a better understanding of their role and the time commitment that comes with it. This way, key users could prepare for and plan their work and prevent frustration (EF 3.3).

> *You should definitely keep an eye on this project organisation and also define the roles exactly. So that you know exactly what tasks the key user has, what the project manager has... or how they interact with each other. I think at this point you should keep in mind that it is also a point to define the key user as a role in the specific project and to differentiate between them.* (Management 3, ERP Consulting (Beverage Industry))

Empirical evidence shows these new tasks require additional commitment from the selected key users. Even so, we found that the companies we looked at did not offer additional material or other incentives, such as bonus payments or additional leave, for the key users to cope with the new tasks successfully. (EF 3.3). According to the results of our workshops, the management must prioritise the introduction project (EF 3.4). Otherwise, it can be difficult to reconcile the key user role with day-to-day business. In addition to support from management, colleagues in the department and the consulting firm, key users might also be given formats to support one another, which currently does not happen (EF 3.5).

According to our interviews, such a format could be a formal or informal key user meeting that takes place regularly where key users can engage in a mutual exchange. Participants suggested that these meetings should take place the entire time the employees are in their key user roles.The key user activities not only help design the processes in the ERP system, but also train the users in their own departments and support them in learning the system. Above all, they say they must be given time for this time-consuming process which our data suggests is not the case (EF 3.6). In addition, they argue they need to be trained methodically to pass on the knowledge they get. Furthermore, they have indicated that they would need constant support from the consulting firm. As mentioned previously, one might expect the factor of 'suitability to teach' to play a role in the selection of key users, but due to the issues associated with SMEs (EF 3.1), it is often not considered.

Thus, key users are simply expected to have the skills to pass on knowledge as a matter of course, as seen in the following quote. However, this is not always the case (EF 3.7).

> *That is basically what is meant by it. Because it's not enough that I know the program, I also have to have skills: How do I communicate something to other people? Not everyone who knows the process well or does his job well is also a good mediator of this knowledge and you have to pay attention to that and, if necessary, you can also train on it.* (Management 4, Metal Industry)

Key users tend to be self-taught and do not receive the necessary support in the task of educating others. They are not trained and must create the concepts for training their colleagues on their own (EF 3.8). The respondents listed all these requirements for the support of key users in our empirical study. Nonetheless, according to our findings, these requirements are rarely met in practice. Our findings suggest that key users have to somehow reconcile their tasks with day-to-day business without being given much freedom. Therefore, it becomes evident that the idea of an optimal key user is almost utopian and can hardly be implemented satisfactorily (EF3.9).

4.4 Expected versus Effective Ways of Learning ERP Systems

Learning how to use ERP systems effectively is not a trivial task. Our study indicates that there are at least two main reasons for that. First, users need a certain understanding of the business processes they are engaged in, especially their specific tasks (EF 4.1). Second, users must know how to perform these tasks using the ERP system (EF4.2).Users know their specific tasks very well at some point in time. However, ERP implementation projects often pose an opportunity for rethinking at least some current practices, resulting in changing procedures and the possibility of process reengineering [37]. Users need to be well-prepared for this new work environment.

During our study, we found quite contradictory measures taken in adapting to these new working environments. Usually, ERP consultancies perform basic training for end users. Also, during the many meetings throughout the implementation project, key users typically create the new business processes and tasks together with the ERP consultant, learning the implementation in the new ERP system along the way (EF 4.3).

However, there is a particular problem with timing. Standard basic or department-oriented training is often conducted when users or even key users do not have a corresponding task at hand (EF 4.4). This often occurred for scheduling reasons, such as finding a common date that fit all participants' and trainers' schedules but did not always fit the current state of the implementation project. It is arguably more cost-efficient to train as many people as possible per training session instead of one-on-one individual training, which is why companies often chose the former. In one case, one company (client) offered internal training for new middle managers every eight weeks when a marketing event took place in the headquarters. These managers are responsible for subsidiaries in three neighbouring counties and had often started working with the system up to several weeks before the meeting, so they did not always feel the need for this training (EF 4.5).

> *So, you learn [an ERP system] in such a way that they really work with us and then it actually runs relatively quickly. Because it's actually the same thing over and over again. Other employees from the markets outside, we hold training sessions in our house, and when new ones come, we have another day like that. And they are also shown on the screen what they have to pay attention to. What the files that they have to process look like and so on. So that's what we do with staff training.* (Wholesale 1, Beverage Industry)

User training by the consultancy companies is mostly conducted during the implementation phase. Users hardly ever undertake such training in the post-implementation phase (EF4.6). This was rarely requested by new users nor approved by superiors. In these circumstances, users have to

rely partly on existing documentation but in practice, they mostly rely on experienced colleagues or their IT department, as suggested in the following quote (EF 4.7).

> *And then they were left to their own devices to cope with it. Of course, always in cooperation with the IT department. So, when questions came up, we were available around the clock.* (IT 1, Beverage Industry)

In almost every case in the post-implementation phase, users stated that they learned how to perform their tasks from their colleagues. Also, at the consultancy companies, new consultants depended on their experienced colleagues, even referring to them as their mentors, as they themselves underwent no structured trainee phase.

However, these experts cannot always be available when new employee users start their job. Many users stated that they had been thrown into the deep end or learned their tasks by doing (EF 4.8).

> *You really only learn how to use it properly when you work with it. When you become active with it yourself. You have done it a few times. Then you also internalise it a bit.* (Wholesale 2, Beverage Industry)

They also stated that they were expected to self-educate to a certain extent by proactively addressing colleagues (EF 4.9). There was often little to no useful documentation for self-training. One consultancy company, however, did provide new consultants with some updated documentation on the systems' functionality but not on business processes or their different variations.

4.5 Documentation

In our interviews, when asked about methods applied for KES in their companies, the participants often referred to the theme of documentation. In this context, we found that there were two major issues. First, participants perceived the classical documentation or handbooks provided by the consultancies as useless. Second, such documented knowledge seldom fit the users' needs in specific situations when they required help quickly. In the following section, we will elaborate on our findings concerning these two issues.

4.5.1 Useless Documentation. Handbooks seem to be the most common form of documentation for ERP software delivered by vendors, either in a printed book, PDF file or integrated into the software. In all cases, the way the software and its functionality are described is often the same: masks, fields or functions are described in a general, generic way so every customer can possibly relate. Although standard software, such as ERP systems, cannot cover all eventualities from the beginning, these are typically highly customisable through parameters. These well-known options are also described in this documentation, resulting in hundreds of pages of system-oriented documentation.

> *But at the moment it is still the case that the merchandise management manual from the previous version is now a complete manual that contains everything. But it is more system-oriented and not process-oriented.* (ERP Consultant 1, ERP Consulting (Beverage Industry))

The software developers or consultants typically create documentation, but mainly to keep effort to a minimum, avoiding unnecessary costs. Also, they intend to avoid many different versions, which would result in a large amount of updating effort (EF 5.1). During the interviews, especially with end users on the customer side but also with consultants, it became clear that these handbooks were rarely used, if at all. This is consistent with research in other areas, which demonstrates fairly consistently that handbooks are a last resort [62].

The sheer size of the documents acts as a deterrent for the users. They state, for example, that they do not know where to start searching or are unsure how to find what they need in a reasonable

time (EF 5.2). However, the extent of the handbook was not the main issue, but rather the system-oriented content. All users stated that when they first engaged with the ERP software, they created notes or sometimes annotated the handbook or handouts from the consultants during the meetings, noting the exact steps they had to perform to complete a specific task (EF 5.3). Some users even took screenshots with annotations in, for example, MS Word©, to create step-by-step, process- or task-oriented documentation. In other contexts, users sometimes refer to these personalised documents as their Bibles.

> *So, I made hard copies and saved it to my own storage. Made a folder in my computer. So that I always have it digitally. I can call it up [when I need]. Because you also have to pass it on to colleagues who may come back to work at some point, or colleagues. With the help of - I can't always explain it. They have to do it on their own at some point. So, I have my own manual. I have created this manual for myself. Just like the other colleagues, I would say.* (Accounting 1, Beverage Industry)

These user-specific, process-oriented forms of documentation were primarily created for the authoring users themselves at the beginning of their work. Mostly, they did not need this documentation later on as they became familiar with the activities and their variations. However, there were cases where users documented tasks for infrequent processes, such as annual inventory (EF 5.4). Also, these documents were reused or even created for temporary replacement (holiday, sick leave, etc.) or onboarding of new colleagues. In such cases, the users stated that by the time such documentation could be reused it was often outdated due to system updates or processes that had changed (EF 5.5). These documents were reused and maintained, but rarely preventively. Thus, such outdated documentation was often of little use for its purported functions. This is a recurrent challenge concerning KES as demonstrated in the CSCW literature [1, 15].

4.5.2 Situated Problem, Situated Help. Our study's findings demonstrate that users usually turn to immediate colleagues, internal IT or sometimes directly to the ERP provider when they face problems instead of using the manual or other documentation. As our empirical research shows, this is often because they need help as directly as possible because the problem is time-critical (EF 5.6). One example is the situation at the store checkout counter when there is a rare transaction, and the cashier is under pressure because the customer is waiting. At this point, the cashier often does not reach for the manual but calls his colleague or the IT department to solve the problem. The participants in our study even stated that these manuals were still unused, because they are not appropriate for the situations in which they are needed (EF 5.7).

Masks, functions or fields are explained in technical rather than business terms according to activities or processes. Many participants stated that they preferred to ask someone instead of investing time in searching the manual, suggesting a stronger focus on expertise sharing rather than on knowledge sharing. First, they were not sure they would find a suitable solution, and second, the structure of these manuals seemed so extensive and confusing that a targeted search was hardly possible (EF 5.8). So, from their experience, it is usually quicker and more convenient to ask a colleague or the hotline than to look into any manual [1, 15, 63]. In some cases, electronic manuals are stored inside the ERP systems, providing full-text search. However, these are also rarely used in practice for the reasons mentioned previously.

5 DISCUSSION

Our research questions concerned developing an understanding *of ERP implementation processes and assessing their adequacy in small and medium-sized enterprises.* We were specifically interested in *the role that KES took in these processes.* Further, and with an eye on design as a socio-technical endeavour, we were interested in *how ERP implementation projects are supported both organisationally and by*

technology. We have argued that there is a significant research gap to be addressed regarding how SMEs manage projects of this kind. As we have seen, the existing literature tends to view success and/or failure in such projects through a 'before/after' lens, with little attention paid to how KES plays a critical role. As we have seen, this pans out in some very detailed ways.

Factors fostering or impeding ERP success in the literature have been dealt with as an issue in specific phases of the ERP life-cycle (see, e.g., the summary by Leyh [42]). These factors, however, are rarely discussed with respect to the specific methods facilitating this success or reducing the chance of failure. The effects on ERP implementation projects, especially in SMEs, are soberingly modest [10, 12]. This might lead to the assumption that the socio-technical aspects of such projects regarding KES and technology in organisations have not been adequately addressed yet [10, 11]. CSCW insights, though seldom directed towards ERP systems, have nevertheless thrown light on the epistemological differences underpinning process-driven, large-scale applications such as ERP systems and the need for context-relevant enquiry. Not least, recent developments around, for instance, concepts such as knowledge infrastructures have reinforced the need to undertake enquiries which focus on more than the technology in play. At least to some degree, we take on board the idea of 'strategic ethnography' as a means to bridge that gap.

The findings of our paper support the impression that ERP systems in the implementation phase and during post-implementation still suffer from the same issues. As we have seen, several key issues need to be dealt with if adequate solutions are to be designed:

(1) ERP implementation is highly complex due to business process details and interdependencies, as well as its adequate manifestation in the ERP system. A specific complicating feature is that coordination is a tripartite problem involving the SME, its clients and the consultant firm.
(2) Documentation remains hugely problematic. We are not the first to identify the various reasons why documentation is often not fit for purpose, but again, some specific features relate to SMEs and their use of ERP. The fact that the use of the ERP is task-contingent and those tasks are often customer-facing and/or time-critical makes it unlikely that any generic form of documentation, least of all one organised on the basis of technical definitions, will prove sufficient.
(3) Personal contact is preferred over documentation or any other form of knowledge sharing for reasons of insufficient or poorly conceived on-the-job training, promptness or lack of relevant or useful documentation.
(4) Too little effort is put into customer post-implementation support, and key users are often under-trained when dealing with new problems as they arise. New processes, exceptions and rare events are especially difficult to handle, and no formal procedures exist to manage them.
(5) There is significant overhead for the relatively small number of adequately trained people.

In the following, we further elaborate on our empirical findings, discussing how they demonstrate that the deployment and maintenance of ERP systems and their use have several layers of complexity. In particular, we discuss potential strategies and implications for the design of solutions that can foster KES across the ERP life-cycle, which go beyond the go live [56]. We chose to address a greater selection of themes concerning the ERP implementation instead of a few phases following the literature on knowledge infrastructures [19]. We argue these strategies and implications supplement current ERP implementation frameworks, such as those summarised by Leyh [42].

5.1 Layers of Complexity and Whispers Down the Lane in the Deployment and Maintenance of ERP Systems

Findings from the existing literature [72] and our own work show that many actors are involved in the introduction and operation of ERP systems. Depending on the situation, the actors serve as knowledge sources or knowledge recipients. Often, that knowledge flows through several people until it possibly arrives at its destination. Our findings indicate that relevant knowledge often does not reach the final recipients, at least in a useful form. For example, the documentation that a new employee receives to learn their job may already be outdated (EF5.5).

Knowledge must therefore flow through a complex network of actors [87] and needs to flow seamlessly to avoid problems in the configuration or use of the ERP system. Also, knowledge about complex business processes and their specific manifestations in ERP systems is difficult to comprehend [67], not only during the implementation phase, but also, and importantly, during the transition to the post-implementation phase. Thus, when suggesting KES-oriented methods for ERP implementation and use, we suggest that designers should not only be well aware of these layers of complexity (see Figure 1), but also of the ways knowledge flows across these layers and which actors are responsible. As much as anything, this is a matter of 'knowing who knows' and getting access to them [1, 25, 26, 64], i.e., a matter of expertise sharing. Such mapping for content, practical responsibility and contextual sensitivity to appropriate language is, as yet, not a feature of ERP training.

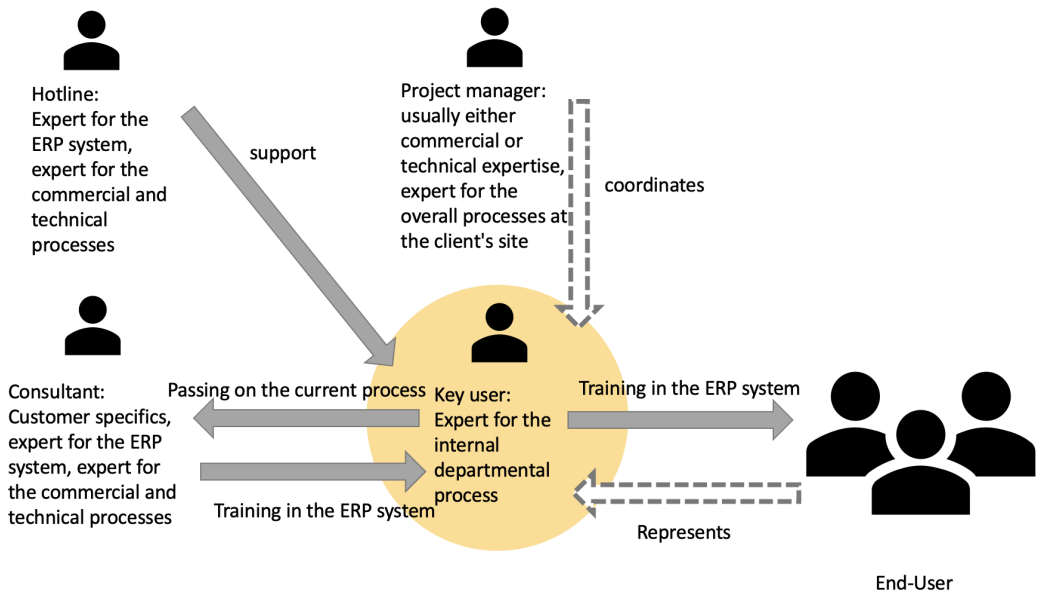

Fig. 1. Detailed layers of complexity with focus on the key user

Knowledge is fundamentally situated. It is held and understood to different degrees in different ways by different actors. Our findings show that implementation projects are often mainly conducted by a core team consisting of a project leader and possibly key users at the client's side as well as a project leader and possibly further experts at the consultant's side. Within this group, knowledge of the client's particularities and experiences and knowledge of the ERP system are shared more

or less intensively during the implementation phase. Towards the go-live date, key users are expected to train their colleagues about the new ways of working, passing on their knowledge and understanding (EF3.6).

Although separate training primarily by the consultants is provided during this phase, the specifics of every business process action in every department cannot be fully covered but are handled superficially. This way of passing on knowledge from one person to the next becomes even more problematic after go-live, as the implementation project officially ends and the project team disperses, at least on the consultant's side (see Figure 2). Customer support takes over further communication and problem-solving with the client. We found that handover and therefore the passing of project knowledge from the consultant or the project team to customer support in general is rather insufficient and superficial. In some customer-specific cases, consultants remain involved, undermining the intended division of labour post-implementation. Also, over the years of usage on the client side, new employees are almost always trained by their colleagues, preferably by their predecessor or someone of similar expertise.

Acknowledging that, knowledge about these complexities also decreases over time, and knowledge is often passed on in a very ad hoc manner, like whispers down the lane. Based on these findings and the literature, we now suggest socio-technical strategies for KES that might help to overcome these layers of complexity with knowledge whispered down the lane over time.

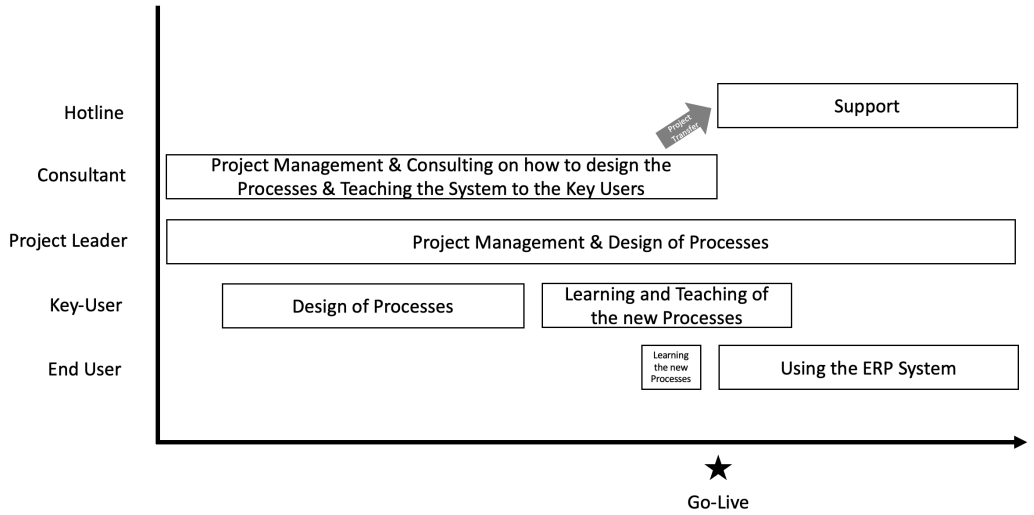

Fig. 2. Layers of complexity over the course of the implementation project

5.2 Towards KES-oriented ERP Implementation

We suggest a series of potential measures to address the problems regarding KES during the implementation and post-implementation phases. These measures are based on the findings presented across section 4 and grounded in the relevant literature, as detailed in the following.

5.2.1 Keeping It Small and Simple. Previous CSCW contributions [10, 11, 17, 50] and our own research indicate that the main difficulty with ERP systems and their implementation is the complexity of business processes, their manifestation in the system [67] and the complexity of the

communication and coordination between the flow of knowledge amongst the actors involved (see Figures 1 and 2). Also, many SMEs still follow a hierarchical, department-oriented structure, which thwarts a process-oriented, cross-departmental approach. Thus, we argue it would be important to reduce the complexity of ERP implementation from a methodological perspective by choosing an iterative, step-by-step procedure, starting with simple products and processes rather than facing complicated eventualities from the start. This calls for an iterative or agile project implementation approach along a relatively simple end-to-end business process as a first minimum viable product (MVP) that is more likely to be comprehended by the entire project team [44, 77].

One effect of this procedure might be that users could interact with the ERP system at a much earlier time, fostering familiarisation with both the system and the current state of business processes. This could also be considered building trust into the system and extending the understanding of trust amongst the core team, as suggested by Schniederjans [72].

5.2.2 Equipping Key users. Regardless of the implementation method, special attention should always be paid to preparing key users for their new roles and responsibilities during the implementation project and after. The literature suggests that project success depends on a strong [67], experienced and skilled core team [5]. However, according to our observations, ERP implementation projects only rarely occur, and many participants have little to no prior experience (e.g., EF3.3, 3.5, 3.6, 3.9). Building up relevant skills in SMEs, and maintaining them, seems to be important. However, this should not only imply business process reengineering and training on the system but also much earlier consideration by carefully selecting [6] and then preparing key users, bearing in mind the expectations of key users presented earlier (EF3.9). This primarily involves project and time management skills as well as didactic skills for teaching their colleagues.

As this might be beyond the scope of classical training sessions, constant support or mentoring by experts inside or, rather, outside the company seems necessary for SMEs. Thus, additional time is needed to prepare the core team at the beginning of a project on top of the additional time needed to do the project itself. This is especially important given that key users in our study stated that project work had to be handled on top of daily business (EF1.3). Our data shows that in such environments, the project team only meets in formal meetings. Some key users, however, expressed that they do not feel part of a team and would appreciate informal exchanges among peers (EF 3.5). Hence, there is even more need to make time for key users to grow into their new role.

5.2.3 Caring for Documentation. Since this paper takes on the perspective of KES, it acknowledges the relevance of externalising and sharing knowledge across the entire ERP life cycle. Keeping notes or documentation, which was seen as useful was one of the strongest findings of our study (EF5.1 to 5.8), has received little attention in the ERP implementation literature (see e.g., Leyh [42]). Our findings suggest that ambivalence about providing generic, system-oriented handbooks on the one hand and the need for customer-specific, process-oriented how-to manuals on the other hand seems to be a common issue when implementing ERP systems. This might be the result of 'generification work' as suggested by Pollock et al. [61], where system documentation might correspond to the standardisation of software across local settings.

Fluent and persistent KES can thus be identified as one of the key factors in such projects, requiring both the client and the provider to record all kinds of structured and unstructured, official and personal information. This demands storing, sharing and re-using knowledge during the implementation project, such as trainings, internal meetings or meetings with consultants as well as daily business, in a practice-oriented way, considering the characteristics of each phase during the project. Providing methods that allow the different actors to create documentation as they continue to accomplish their work without creating large overhead is key [15].

In any event, and as has been occasionally remarked upon in the CSCW literature, the documentation problem has to do with several features [1, 64], all of which are important in the context of resource-challenged enterprises like SMEs. First, as our data shows, finding relevant solutions in manuals is often difficult. Manuals are constructed to provide potential solutions to all envisaged problems, but how those problems are defined and indexed matters. In turn, the language used is critical insofar as technical terms are not universally understood across the organisation.

5.2.4 Consistent Documentation Practices from Day One. Our observations show that documentation during the implementation phase was neither discussed nor organised in the consultant meetings or training sessions. The only source was the provider's system handbook, but in many cases, the users were not given any source material prior to meetings or any training. For instance, training material was often only handed out after training to motivate users to participate rather than use it for self-training. It was up to the users how they supplemented meeting content. This implicates the notion of 'timeliness'. It is not enough that documentation is appropriately formatted, indexed and described. It must also be available at the right moment and in short order.

We would argue that documentation and note-taking should be organised before the beginning of an implementation project and clearly based on the respective project context (e.g. existing tools, practices, habits, etc.). New employees should be familiarised with these documentation practices at the very beginning. Their lack of relevant expertise is a feature of what has been termed the 'social distribution of expertise' [55], to whit that its unequal distribution has serious consequences for its robustness.

Note-taking is typically situated in a specific organisational context, in meeting rooms, at the workplace, during training (e.g., EF 5.3), and in ways that pertain to the task at hand. The existence of informal methods of documenting material alongside 'official' versions is, of course, well known. In the context of ERP processes, however, their integration is both necessary and problematic. These ways of storing knowledge might compete with formal means, such as emails, and thus create unintended extra work [15]. They need to be integrated and contextualised to specific ERP objects (masks, customers, etc.) or ERP processes. For example, certain email or chat conversations should be included in such a documentation system via carbon copy (Cc) or chatbot and be processed to relate to other contents for reuse.

Combining general and individual documentation could reduce complexity, as users could refer to their documents and notes in subsequent meetings occurring weeks or even months later. This would constitute an adaptation of the generificated standard software [61]. This way of storing information would disperse information and knowledge throughout the ERP system. Such a novel documentation system could thus provide a means to export templates such as process- or department-oriented requirements specifications.

These formal and informal documents could also become important in the post-implementation phase for all (future) users, customer service and (future) consultants to understand customers' issues or when preparing system updates or upgrades, contributing to the reusability of knowledge [33].

5.2.5 (Re-) Contextualisation of Documentation. As shown before, handbooks provided by technology providers, here represented by the consultants, are mostly of little use to users (EF5.2, 5.5 to 5.8). Users prefer to create practice-oriented documentation per individual task but often use it only for themselves (EF 5.3), drawing on technical documentation and individualising it (EF 5.3). This implicates a clear need for documentation structured around tasks to be completed in a language appropriate to user needs and indexed accordingly [63].

The added need, however, is to link or embed the material into the respective resources and tools to support seamless context-related information within a given situation [78]. How-to manuals and

workflows can be designed to interact with the system and shared amongst users to disseminate practices (e.g. to train new employees). They could also be used to store meeting outcomes as procedures within the system and reused later. One such task at an early implementation stage is having key users or end users enter master data into the new ERP system.

However, from our observations, users did not know the fine details of this task, or they were quickly forgotten (EF4.4). This sometimes led to significant project delays because users tended to procrastinate over these rather under-specified tasks [71]. If such tasks emerge from any project meetings, there is a clear need to record them in something like a how-to manual. Nevertheless, not all documentation can be contextualised directly inside the ERP system in this way. The systems are mostly not used at the beginning of ERP implementation projects, but current and future processes are discussed. Based on the decisions made in such meetings, the ERP system is configured accordingly at a later stage.

Our findings clearly showed the users' desire for context-related, practice-oriented documentation (EF5.3). This requires that it is related to the systems or process context from which it emerged. With this and the aforementioned suggestions regarding consistent documentation in mind, the information generated at this phase should be closely related to the emergent ERP system and closely tied to the point of action. Documentation from the early phases, however, cannot be contextualised this way. Hence, it could be (semi-) automatically contextualised afterwards (e.g. according to the content or specific markers such as hashtags like those used in social media). This is important so that users can later access the documentation where it is needed.

The storage location of user-created documentation is particularly important because, as our empirical evidence shows, users will later refer to the documentation created during training or introduction when they need to find their way around the ERP system and solve potential problems (EF5.4). To avoid making the users dependent on other actors, such as the internal IT department or the consultancies' hotline, the knowledge should be stored in a place where they can easily find and reuse it again. An appropriate place for this might be areas in the ERP system such as interface objects or processes. For example, this could be in tutorials the user creates directly within the ERP system. The tutorials could guide the user through a process and show him which actions she has to perform. They could be in a form that allows the user to execute the process simultaneously; thus, no significant extra time is required in the day-to-day business.

5.2.6 Maintaining User's Notes. Documentation has a life [29]. Its relevance shifts depending on who is using it and when it is being used. The emergent and dynamic nature of tasks to be performed has implications for the status of documents. In our case, documentation is prone to losing validity over time (EF5.5), raising the issue of maintenance [15]. During the implementation phase, processes and tasks often undergo changes and reach a first stable version around 'go live'. To keep documentation connected to the ERP system and its user interface elements up to date [15], there is a clear need for information about changes to be propagated, especially to authors.

Additionally, users of potentially outdated manuals should be informed as and when necessary. Documentation, then, needs to be updated in a timely fashion. In the context of the ERP implementation life-cycle, this turns out to be problematic in the post-implementation phase. If processes change or new release updates are installed, the validity of such step-by-step documentation can be compromised (EF5.5). This will affect the training of new employees, temporary replacements or rare processes such as annual inventory (EF5.4.).

5.2.7 Joining the Path of Least Resistance. Although a lot of emphasis is placed on appropriate and useful documentation throughout our study, our findings indicate that personal contact is preferred over other methods of obtaining information for reasons of timeliness (EF5.6), situational inappropriateness (EF5.7) or little expectation of success when searching through documentation,

for example (EF5.8). This phenomenon is also well known in the literature, since Randall and colleagues [63] started discussing what they termed the Mavis phenomenon regarding organisational memory and the issue of remembering. There, the emphasis was placed on the fact that working environments are usually fragmented, time-pressured or interrupted. Such a phenomenon made evident the tendency for sharing expertise within communities of practice and, in our case, amongst colleagues in the same department or organisation. This was preferred to using artefact-centred knowledge [1], although such knowledge repositories were regarded as important and desirable.

De Carvalho et.al [15] suggest addressing the issue of time pressure in working environments by designing for timeliness (e.g. providing contingent information as and when required). However, the literature does not provide specific measures for addressing these requirements in the context of cooperative work through ERP systems. KES needs to reflect the situated, context-related, time-sensitive nature of information use and, moreover, indicate the actors involved. The capacity to store information during the task at hand and reduce overhead work for knowledge creation is critical [15].

To further support context-relatedness, we suggest that KES should be supported directly within the ERP system. For example, it should be attached to a mask, tab, field, field content or process by a community of practice such as a department or company to foster context-relatedness, following the concepts of CHIC [86] or Answer Garden [3, 4]. The aim here is not to create a comprehensive knowledge repository but rather a collection of knowledge artefacts created by users in specific use contexts, sharing excerpts of information or experience so others can transfer this to their situated task [57].

5.2.8 Facilitating Proportionate and Situated Training. User training on the ERP system is central to all ERP implementation frameworks (see e.g., Leyh [42]). However, our findings show some problems regarding its effectiveness. One major concern was the time between training and application in daily practice (EF4.4), which sometimes occurred in reverse when users started their job, but training was only provided weeks later (EF4.5). Learning the job by doing during post-implementation also occurred, because companies rarely provide training for new employees (EF4.6) or knowledgeable colleagues are not available (anymore) (EF4.8). Our participants also stated that training was skipped entirely due to delays during implementation (EF2.2), leaving training of the end users solely to the rather unprepared key users (EF3.8, EF3.9).

Due to the complexity of business processes (EF4.1) and their implementation in the ERP system (EF4.2), this poses a significant challenge for key users to take on alone. Consultancies typically provide full-day training dedicated to specific themes with as many participants as possible, an approach which cannot easily be aligned with individual users' contextual needs (EF4.4). Alternatives lie in synchronous or asynchronous learning measures that can be embedded into users' everyday work, as suggested by Robey et al. [67]. Here, the concepts of e-learning in organisations [16] or blended learning [45, 51] could be applied, equalling training elements in both time (daily routine) and space (workplace, ERP system). These concepts are also well known in CSCW [31, 75].

5.3 Interplay of Measures

The measures we have described in the previous sections are intended to have a sustainable impact on the level of knowledge in the companies. The interaction of these measures is illustrated in the following graphic. As we have shown, building a stable knowledge base in the form of usable documentation is important to compensate for the loss of knowledge resources after the end of the implementation phase and to be able to store knowledge sustainably and independently of employees. At the beginning of the documentation process, key users must be equipped, and the scope of the measures must be adapted to the work environment to form a solid basis for the

subsequent documentation efforts. Using this, knowledge can be maintained and kept current during implementation and beyond by attempting to follow the path of least resistance in the documentation. Training sessions appropriate to the time and situation will then be used to regularly improve the level of knowledge during the use phase.

As indicated in Figure 3, the level of knowledge cannot be maintained stably and consistently because the SME environment is too changeable. This and factors such as employee turnover are too disruptive to the level of knowledge. However, the goal must be to achieve a consistently higher level of knowledge than we currently observe in our empirical study without the measures we have proposed.

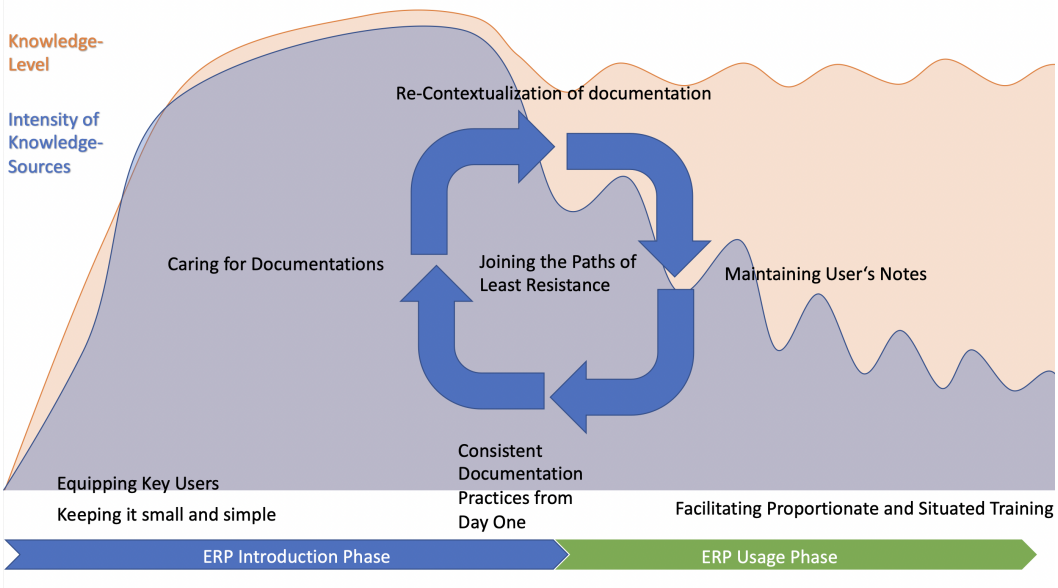

Fig. 3. Illustration of interplay of the proposed measures

5.4 Limitations

Many of the measures we have discussed require additional effort regarding methodological rigour and additional time and costs for the organisation. These aspects, however, are already critical, especially in SMEs, as our empirical findings suggest. Overcoming this contradiction might not be possible by applying the suggestions made in the discussion, but may also require organisational preparation, such as at the chartering phase of an ERP project. Customers and vendors must be aware and should acknowledge the effort such a project will take one way or another. We suggest that the measures described imply additional effort but aim to reduce additional, unplanned effort such as double work due to factors such as undocumented decisions that might need to be re-discussed or delays due to uncertain task descriptions, such as entering master data into the new ERP system.

One of the most important factors here might be the customer or vendor's capable and consistent project leadership. When implementing the methods proposed in this paper companies should first assess which of them would be the most critical and sensible for the success of their projects after the 'go live' moment. The implementation difficulty and appropriateness of a measure needs to be evaluated individually for each case in which companies want to use it. This should be done

in order to get the desirable results and build up trust to tackle measures which are harder to implement. Following this divide and conquer mentality companies should be able to succeed in implementing the ERP system in an sustainable way.

6 CONCLUSION

In this paper, we have discussed issues of KES concerning the deployment and maintenance of ERP systems in SMEs. Findings from our empirical study demonstrate how this is an intensive, knowledge-dependent and collaborative process, which demands strategies and tools to help the involved actors deal with the different layers of complexity involved. In some ways, readers will be aware of the parallels with issues in software engineering, especially when considered as a socio-technical issue [80].

Nevertheless, our work shows some unique features to consider in ERP implementation, especially for SMEs. These features can be summed up as 1) recognising the critical but problematic role of key users; 2) understanding the importance of the often-overlooked post-implementation phase; and 3) understanding the added complexity of coordination when consultants and clients work together in an evolving context. Our contribution lies in what we might term the 'paradox of configurability'.

ERP systems are designed to be configured in customisable ways, but the processes by which this might be done have hitherto remained opaque. Very little work thus far has dealt with how customisation or configuration is done after consultants leave the room. As discussed throughout the paper, the canonical ERP implementation literature does not address key issues identified in our study, for example, the issue of sustainable and practice-oriented documentation. We therefore have contributed to this literature from a CSCW perspective. In particular, we suggest a series of socio-technical measures to support knowledge transfer-oriented ERP implementation in SMEs.

In search of an answer to our first research question, 'To what extent are ERP implementation processes adequate in SMEs?', we have demonstrated the layers of complexity involved in ERP implementation in SMEs with a focus on the role of the key user. We presented the challenges key users often face in a German SME environment and the issues that emerge from these conditions.

With regard to our second research question, 'What role does KES, or its absence, play in the ERP implementation process?', we have shown the relevance of KES in ERP implementations in theory and practice and the discrepancies that can be found in current practice. We have demonstrated how documentation can be a key for learning and sharing knowledge about ERP systems but that official documentation is rarely used in practice. This is based on our findings because this type of system-oriented handbook does not fit the users' daily business and is therefore replaced by users' self-created and process-oriented documentation. These personal documents are difficult to maintain but are nonetheless being used frequently to teach the ERP system to new employees.

Concerning our third research question, 'How can sustainable KES be supported in ERP implementation projects?' - both organisationally and technologically - we suggested, based on our empirical findings, a series of implications for the design of ERP systems which can potentially lead to a more practice-oriented, sustainable and knowledge-oriented ERP implementation in SMEs. We concentrated on measures to support the key users in their role by proposing methods to better align the ERP implementation to their day-to-day business. We suggested which could be used to better organise the documentation process, starting at the beginning of the implementation project and lasting throughout the ERP.

While we are confident that our recommendations are sensible and potentially relevant, it is still necessary to investigate the extent to which they are effective and used in practice. This falls within the scope of our future work.

ACKNOWLEDGMENTS

The research project 'ExpertERP' is funded by the German Federal Ministry for Education and Research (No. 02L20C021).

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A TABULAR OVERVIEW EMPIRICAL FINDINGS

A.1 Empirical Findings - Jack of all trades

ID	Empirical Finding	Design Challenge
EF1.1	Staff in SMEs usually work in several roles at the same time.	A measure that is to support the introduction in SMEs must respond to this specificity in SMEs and be flexible accordingly.
EF1.2	Staff in SMEs work in roles that they are not trained for.	Systems that should support them should consider this and help them to earn lacking knowledge.
EF1.3	Key users in SMEs are often heavily involved in the day-to-day business due to their many roles and cannot be relieved by their colleagues due to their personal specialisation.	Introductory measures should be planned in such a way that they do not place an additional burden on the key users, but in the best case lead to relief.

A.2 Empirical Findings - Overwork, overtime

ID	Empirical Finding	Design Challenge
EF2.1	Due to the circumstances described in EF1.1, staff in SMEs are usually heavily involved in day-to-day business.	Measures to improve implementation activities such as training must adapt to these circumstances and be compatible with day-to-day business.
EF2.2	Due to time constraints, sufficient training is often not provided.	ERP trainings should be designed in a way in which they fit to the praxis and the daily business of the users.
EF2.3	Frustration due to difficulties in balancing day-to-day business and key user role.	When preparing users for the ERP implementation project all parties involved should be transparent about the amount of time that is needed by the users for a succesful implementation.
EF2.4	The only department that is strengthened in the course of an ERP implementation is IT.	Other departments should also be evaluated if more workforce is needed. If that is not an option, measures should be designed in a way to support the users with combining daily business and ERP implementation project.

A.3 Empirical Findings - Key user by circumstances

ID	Empirical Finding	Design Challenge
EF3.1	Key users should be selected based on their characteristics to fit the key user role. However, in SMEs there is often no selection, so it is not really a decision based on characteristics who becomes a key user.	Key users should be supported with measures that help them to compensate for deficits in certain areas that are needed for their key user activity. (e.g. guidelines for the training of colleagues).
EF3.2	Key user role is not being defined at the beginning of the implementation project.	Key user role should be defined at the beginning of the implementation project.
EF3.3	Key users are not given sufficient freedom to perform their key user tasks.	Measures should be designed to fit to the key users tight schedule
EF3.4	ERP implementation project must have priority over day-to-day business	Measures should be applied that help key users to priorities the implementation project
EF3.5	Key users will not be given formal or informal formats in which to share and support each other.	Key users should get the possibility to share knowledge and support each other. This should be enabled by technical as well as organisational measures.
EF3.6	Key users are not given enough freedom to learn the ERP system, which can prevent them from transferring the knowledge into the company.	Formats in which key users are being trained need to be designed to fit their daily business.
EF3.7	Key users are expected to have the necessary skills to pass on knowledge.	Systems and measures should enable the key users to gain the skills necessary to pass on their knowledge.
EF3.8	Key users do not receive methodical training in which they are taught how to share the ERP knowledge with colleagues in the company.	Measures should be designed in a way to assist key user sharing knwoledge and expertise
EF3.9	Key user role is formulated too utopian to be implemented in the SME context	The key user role should be re-designed for the SME context to fit the praxis and the constraints.

A.4 Empirical Findings - Expected versus effective ways of learning the ERP system

ID	Empirical Finding	Design Challenge
EF4.1	Learning ERP usage is difficult, because often a deeper understanding of business processes is necessary.	Training needs to be designed in a way that users can see the 'bigger picture' and understand the connection between ERP and business processes.
EF4.2	Learning ERP usage is difficult, because users need to know how to handle business processes inside their ERP system.	Systems should be designed in a way that they help the users to translate their processes into the ERP schematics.
EF4.3	(Key-)Users learn ERP usage along the way during the implementation phase.	Measures should be designed to support (key-)users learning the ERP system along the way
EF4.4	There are often too long a gap between training and practical application by users.	Training should be scheduled close to the practical application of the users.
EF4.5	Companies do their own internal training in the use phase, but at regular intervals and not depending on the situation, which means that much of the knowledge has already been acquired through learning by doing.	New users should be getting appropriate training immediately when they begin working.
EF4.6	Companies make little use of training during the use phase.	Training should be designed in a way that it also fits the use phase.
EF4.7	New employees usually turn to experienced colleagues to learn their jobs.	Measures should be in place to ensure that such a person is clearly defined after the introduction (but also later in the utilisation phase) from whom the colleagues can get help.
EF4.8	Employees are often 'thrown in at the deep end' because they cannot be trained by colleagues.	There need to be systems that can compensate in these situations.
EF4.9	It is partly expected that new employees educate themselves autodidactically about their new workplace.	Systems should be designed in a way that they support the users in learning about their new workplace.

A.5 Empirical Findings - Documentation

ID	Empirical Finding	Design Challenge
EF5.1	Handbooks by ERP providers are mostly system-oriented and generic to fit all customers in order to keep efforts and costs low.	Systems should enable the users to customise the handbooks and appropriate them according to their individual processes.
EF5.2	Users who feel deterred by system-oriented handbooks rarely make use of it.	Documentations should be designed in a way that invites users to use them.
EF5.3	Users usually create process-oriented documentations for themselves instead of using the provider handbooks	Users should be supported in creating these.
EF5.4	User handbooks are helpful in the long run for rare or infrequent processes such as annual inventory or temporary replacement.	Documentations for rarely used processes need to be kept up to date so that users can rely on them if they are needed.
EF5.5	User-created documentation is often outdated when given to new colleagues.	User-created documentation should be designed so that it helps the users to keep it up to date
EF5.6	Users often prefer personal contact over documentation, especially in time-critical situations.	Documentation needs to be designed in a way that it can support users in time-critical situations.
EF5.7	Client-created handbooks are usually not used because they are not appropriate for the situations in which they are needed.	There should be an system for users to create their own documentations in a way in which they are appropriated for the situations in which they are needed (e.g. context related documentation)
EF5.8	Handbooks are so broad and difficult to search that users avoid trying to find solutions in them because they think that they would not find one.	Documentation needs to be structured in way in which the user do not have to search long for a solution to their problem (e.g. context related documentation)

Received January 2023; revised April 2023; accepted July 2023