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Designing Process Guidance Systems

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Abstract

Process knowledge is a vital prerequisite for employees to execute organizational processes successfully in the course of their daily work. However, the lack of process knowledge, especially concerning novice users, and the need for support pose a challenge to employers. Inspired by research on spatial knowledge and navigation, we conceptualize three process knowledge types addressing the needs of employees during their process execution. On the basis of these process knowledge types, we derive three theoretically grounded design principles for process guidance systems to support employees' process execution. We instantiate the design principles and evaluate the resulting artifacts in a laboratory experiment and in a subsequent field study. The results demonstrate the positive effects of process guidance systems on users' process knowledge and process execution performance. Our study contributes to research and practice by proposing a new conceptualization of process knowledge and a nascent design theory for process guidance systems that builds on theories of spatial knowledge and navigation, as well as decision support research.

Keywords: Guidance, Process Knowledge, Process Execution, Spatial Knowledge, Design Theory

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1 Introduction

Organizations specify the processes that need to be followed in order to standardize employees' work and improve their process execution (Davenport & Short, 1990). To profit from the benefits of such a process standardization, employees need to conform with predefined process specifications (Hadasch, Maedche, & Gregor, 2016; Schaefer, Fettke, & Loos, 2013). Thus, employees' process knowledge is a necessary prerequisite for proper process execution and a critical factor for achieving successful process standardization, improvement, and ultimately process performance (Amaravadi & Lee, 2005; Münstermann, Eckhardt, & Weitzel, 2010; Seethamraju & Marjanovic, 2009). In this sense, particularly novice users require support because their knowledge of the processes is often limited. Because of insufficient process knowledge, these users are likely to choose less demanding strategies, like workarounds (Alter, 2014), to carry out their daily work and execute processes without considering the specifications, which may lead to a loss of accuracy (Singh, 1998). More importantly, deviating from or even violating process specifications can lead to serious consequences: For example, a critical accident that occurred at a nuclear fuel processing facility in Japan in 1999 can be traced back to a change in the operating process that had neither been approved nor communicated (Bhanot, 2000). Deviations from the process can also result in lower organizational performance and decreased customer satisfaction (Frei, Kalakota, Leone, & Marx, 1999). Thus, proper process execution is critical to organizations' success, and it is therefore important for organizations to support their employees by providing them with the required process knowledge (Amaravadi & Lee, 2005; Münstermann et al., 2010).

From an organizational research perspective, Feldman and Pentland (2003) introduce organizational routines with an ostensive and a performative view. The ostensive view refers to the routine's generalized ideal or schematic form that can be codified in a procedure (Feldman & Pentland, 2003), such as process specifications. The performative view refers to the "specific actions taken by specific people at specific times when they are engaged in an organizational routine" (Feldman & Pentland, 2003, pp. 101-102). Pentland and Feldman (2005) propose that the ostensive view of routines (e.g., in the form of process specifications) should be used to guide users' performances of routines (e.g., the execution of processes by the user). Traditional organizational-support structures, such as handbooks or training, are known to be less successful at supporting users' performances of routines (Sykes, 2015), whereas embedded guidance concepts have proven to be successful at increasing users' knowledge and helping them make proper decisions (Limayem & DeSanctis, 2000). In the context of processes, guidance promises to be a valuable concept to address users' lack of process knowledge. In particular, novice users with a limited understanding of existing process specifications are expected to benefit from guidance (Dhaliwal & Benbasat, 1996; Gregor & Benbasat, 1999).

Process guidance is comparable to car navigation, which provides car drivers with spatial information. When moving from location A to B, individuals require information on the upcoming route and how to follow this route to reach the desired destination. More generally, users benefit from an overview of the overall route (e.g., in the form of a map) and detailed information on how to navigate the route (Thorndyke & Hayes-Roth, 1982).

Since business processes can be very complex and highly branched, users require support when trying to find their way during process execution. In line with Pentland and Feldman (2005), we argue that during the execution of actual processes (the performative view of organizational routines), users benefit from receiving information on the processes (ostensive view of organizational routines). The manifestation of the ostensive view in the form of artifacts can support the users' performance of these routines (Pentland & Feldman, 2005). Especially novice users can use these artifacts "prospectively, as a guide to what actions ought to be taken" (Feldman & Pentland, 2003, p. 105). The concept of guiding users in process execution has been investigated in the information systems (IS) context for approximately two decades, and the first evaluation results provide evidence for the usefulness of process guidance (Burkhart, Krumeich, Werth, & Loos, 2012; Dorn, Burkhart, Werth, & Dustdar, 2010; Reimer, Margelisch, Novotny, & Vetterli, 1998). However, existing research primarily focuses on the concept's evaluation by implementing prototypes or systems. Their underlying design and its theoretical justification are underreported. Thus, we address this gap by providing design knowledge for process guidance systems (PGSs).

In the context of decision support, there is a long tradition of research investigating the support that individuals receive in the form of decisional guidance (Silver, 1991) and explanations (Gregor & Benbasat, 1999), which can be considered for the theoretical justification of the PGS design. Building on research on spatial knowledge and navigation, as well as research on decisional guidance and explanations, we propose design principles for PGS. The resulting PGS artifact guides or navigates users through their process execution by providing the required process information (Pentland & Feldman, 2005) and enabling them to build the required process knowledge (Amaravadi & Lee, 2005). Existing research on learning from maps and learning through navigation (Thorndyke & Hayes-Roth, 1982; Thorndyke & Stasz, 1980) provides a solid basis to support users with appropriate process information during process execution. In addition, research in decisional guidance and explanations (Limayem & DeSanctis, 2000; Parikh, Fazlollahi, & Verma, 2001) postulates supportive theoretical grounding for the design of PGS. We argue that users require (1) general information on the process, such as an overview of all the steps and their sequence, (2) specific information on how to execute the steps to navigate through the process, and (3) the possibility to identify their current position within the process. In our research project, we extend the theoretical base of research on decision support in the context of process guidance by considering research on spatial knowledge and navigation. In this way, we adapt and extend our PGS design (Morana, Schacht, Scherp, & Maedche, 2014) following the design science research (DSR) approach (Hevner, March, Park, & Ram, 2004). We address the following research questions:

- *How can a process guidance system be designed to increase users' process knowledge and improve process execution performance?*
- *What are the key design principles for such a process guidance system?*

Our research contributes to theory and practice in three ways. First, we address an important real-world issue, namely proper process execution, by providing users with the required process information during process execution. Consequently, we support them in process execution and increase their process knowledge. In so doing, we conceptualize process knowledge on the basis of findings from spatial knowledge and navigation by applying an innovative theoretical lens to process knowledge. Second, we derive and discuss three theoretically grounded design principles for PGSs by applying this theoretical lens. Going by the proposed design principles, we instantiated two PGS artifacts and evaluated them in a laboratory experiment and a subsequent field study. We evaluated the functional aspects of two instantiations of our design in two related settings. We summarize our results and contributions in the form of a nascent design theory (Gregor & Hevner, 2013) that represents an initial step toward a comprehensive design theory (Gregor & Jones, 2007) for process guidance systems. The proposed nascent design theory, including design principles, testable propositions, and actual design instantiations, extends the body of knowledge for researchers and practitioners. Researchers can apply the provided design knowledge to their research contexts of users' process execution and process knowledge. Practitioners can use the derived design knowledge to build PGSs that support users in their process execution. Third, by following the framework for evaluation in design science (FEDS) (Venable, Pries-Heje, & Baskerville, 2016), we conduct a comprehensive and rigorous evaluation of the design in a laboratory experiment with high internal validity, as well as in a field study with high external validity (Venable et al., 2016). The research presented in this paper balances relevance and rigor (Bhattacherjee, 2012; Hevner, 2007) by following the DSR approach, considering theoretical knowledge from various research areas, and applying the FEDS framework evaluating the resulting artifact in both a laboratory and a real-world field setting (Peffers, Rothenberger, Tuunanen, & Vaezi, 2012; Venable et al., 2016). Thereby, we demonstrate how DSR can address a real-world issue, derive a theoretically grounded design, and prove the validity of the design through a systematic and comprehensive evaluation.

2 Theoretical Foundations and Related Work

In this section, we present and discuss the theoretical foundation of our PGS design—namely, research on decisional guidance and explanations, process knowledge, and spatial knowledge and navigation. Subsequently, we conceptualize process guidance, provide an overview of existing research addressing the process guidance concept, and outline our research objective.

2.1 Theoretical Foundations

2.1.1 Decisional Guidance and Explanations

In the context of decision support systems, the concept of (decisional) guidance has been intensively investigated in the IS community (for an overview, see Morana, Schacht, Scherp, and Maedche, 2017). In particular, decisional guidance (Silver, 1991) and explanations (Gregor & Benbasat, 1999) mainly aim at supporting the human decision-making process and have been applied to various contexts and empirically evaluated on many occasions. In these studies, researchers examine key factors that need to be considered when providing guidance. Because the goal of guidance is to support users' understanding of the task or context, users' active participation is one relevant factor. When actively participating in the task execution, users will learn the task's underlying concepts (Glover, Prawitt, & Spilker, 1997) or contexts more effectively, which in turn will result in, higher decision quality, performance, and satisfaction (Dhaliwal & Benbasat, 1996). Many positive effects of decisional guidance have been shown in laboratory settings (Limayem & DeSanctis, 2000; Parikh et al., 2001; Shen, Carswell, Santhanam, & Bailey, 2012). For instance, novice users particularly benefit from guidance enhanced by explanations when compared to expert users. For this reason, the expertise of the audience (novice vs. experts) should be incorporated into the design of guidance (Arnold, Clark, Collier, Leech, & Sutton, 2006).

2.1.2 Process Knowledge

Processes in organizations can be defined as a set of logically related tasks that will be performed to achieve a defined business outcome. They have a beginning, an end, and an overall structure for action (Amaravadi & Lee, 2005; Davenport & Short, 1990). Process knowledge is defined as "*contextual, experiential, value laden and insightful information about a process, including how it is configured, how it is coordinated, how it is executed, what outputs are desirable and what impacts it has on the organization*" (Amaravadi & Lee, 2005, p. 69). In the research community, many studies address the role of process knowledge, such as for process improvement (Seethamraju & Marjanovic, 2009) or process-oriented knowledge management (Kwan & Balasubramanian, 2003). In so doing, most research examines the provision of process information in isolation from actual process execution—e.g., providing support in the form of training and handbooks (Sykes, 2015; Venkatesh, Zhang, & Sykes, 2011). However, we argue that these forms do not provide users with sufficient support—in the form of required process information—during the actual process performance. Therefore, there is an opportunity for researchers to investigate the provision of the required process knowledge (process information) during the actual process execution.

2.1.3 Spatial Knowledge and Navigation

For decades, researchers in cognitive psychology on human behavior in navigation and wayfinding have examined various forms of spatial knowledge and the ways in which the human brain acquires and processes it (Ishikawa & Montello, 2006; Richardson, Montello, & Hegarty, 1999; Thorndyke & Hayes-Roth, 1982). In the following, we introduce three types of spatial knowledge that humans require for navigation and wayfinding.

Humans can acquire spatial knowledge from various sources, such as maps, navigation experiences, pictures, and descriptions (Richardson et al., 1999). Spatial knowledge can be divided into two different types: procedural and survey knowledge (Thorndyke & Hayes-Roth, 1982). Thorndyke and Hayes-Roth (1982) define *survey knowledge* as spatial knowledge about an environment's topographic properties and as the two-dimensional relationships between locations. This type of spatial knowledge is similar to a map because the relationship between two locations on a map can be identified without additional information about the route (Goldin & Thorndyke, 1982). Users can build up survey knowledge in various ways, such as navigating in a certain environment, which is also referred to as a "primary" experience (Ishikawa & Montello, 2006; Presson & Hazelrigg, 1984). Another possibility to gain survey knowledge is studying a map or an image, which is referred to as a "secondary" experience (Goldin & Thorndyke, 1982; Richardson et al., 1999). Users transform the gained survey knowledge into mental images, which can be used as a physical map to navigate inside a particular environment (Thorndyke & Hayes-Roth, 1982). Researchers have found that gaining survey knowledge through active participation is superior to survey knowledge gained by secondary sources (Presson & Hazelrigg, 1984).

In contrast to survey knowledge, *procedural knowledge* is defined as knowledge about specific routes navigated in the environment. The procedural knowledge is organized in a sequential memory structure, and users can retrieve their procedural knowledge to mentally navigate in the environment (Goldin & Thorndyke, 1982). It comprises four components: (1) a sequence of actions performed at particular locations, (2) a series of perceptual features encountered along the route, (3) distances between locations, and (4) angles or bearings changes at turning points along the route (Goldin & Thorndyke, 1982). Thus, the existence of procedural knowledge does not guarantee the existence of complementary survey knowledge (Moeser, 1988). However, because the primary source of survey knowledge is the active experience of navigating in the environment (Presson & Hazelrigg, 1984), it is most likely that users also have survey knowledge when they have procedural knowledge. Procedural knowledge is important to conduct the daily navigation from the apartment to the office, for example.

For successful navigation in an environment, users require both types of spatial knowledge—for example, to navigate inside buildings (Carlson, Hölscher, Shipley, & Dalton, 2010). Moreover, a dedicated form of spatial knowledge is necessary when an exception occurs and the individual needs to identify an alternate route. In such a situation, it is important to have information on the current spatial position and orientation (Klatzky, Loomis, Beall, Chance, & Golledge, 1998). Such *orientation knowledge* can be instantiated in the form of a "you are here" pointer (Kuipers, 1978) and enables users to follow the route according to their procedural knowledge and reach their intended destination. With this knowledge, users are able to change their daily route to the office when they discover an obstacle, as described in the example above.

2.2 Process Guidance

The guidance concept is well-established in the IS community and defined as "supporting users with their decision-making, problem solving, and task execution during system use by providing suggestions and information" (Morana et al., 2017, p. 33). This concept can be adapted to the process context. Processes (or the related concept of organizational routines) comprise two aspects: the specification or definition of the process (the ostensive view of the routine) and the actual execution of the process (the performative view of the routine) (Feldman & Pentland, 2003). Pentland and Feldman (2005) propose instantiating or codifying routines' ostensive aspects in artifacts that guide the execution of the process (performative view of the routine). Accordingly, we refer to this ostensive view of routines when addressing the ideal of the process according to the organization's process specification. Process guidance supports users with their task execution by providing information about the process. PGS artifacts capture and provide organizationally defined process specifications. In this way, PGS artifacts guide users in their execution of the process in accordance with their specification.

Processes can be classified along a continuum ranging from human-centric to system-centric, as well as unframed to tightly framed processes (van der Aalst, 2013). We assume the process guidance concept is especially useful for processes that involve human activities and are at least loosely framed in accordance with an underlying process model (van der Aalst, 2013).

2.3 Related Work

Existing research on the process guidance concept primarily focuses on the sole implementation of the concept in corresponding software artifacts, which results in a variety of PGS research prototypes. This paper focuses on supporting employees in an organizational context; process guidance or similar concepts in nonorganizational contexts, such as private life, are not considered. In the following, we provide an overview of existing research on the process guidance concept. We selected the business process management (BPM) context because of our studies' context. In addition, we provide an overview of process guidance in software engineering because of the dependence on processes in this domain and the existing research on how to support software developers in their daily work.

2.3.1 Process Guidance in Business Process Management

Researchers have applied the process guidance concept to support users in the execution of processes in organizations and thereby address a more general BPM approach. Often, employees in an organization are required to deal with various kinds of tasks that need to be performed properly because of laws and regulations (Reimer et al., 1998). Owing to the large variety of tasks, regulations, and laws, the employees need support by receiving the information they require. To support employees with the required knowledge, Reimer et al. (1998) propose a knowledge-based system named EULE to provide process guidance to users who have to perform tasks they "may not be familiar with" (Reimer et al., 1998, p. 56). EULE visualizes the process and provides information on how to execute the specific process steps. The researchers evaluated the system within a field study by interviewing seven employees of an insurance company. On the basis of this evaluation, Reimer, Margelisch, and Staudt (2000) concluded that EULE users extended their expertise and required less support from colleagues. Moreover, EULE helped them "to avoid incorrectly executed tasks" (Reimer et al., 2000, p. 67).

Flexible or ad hoc processes are another example in which organizations have to cope with process-related issues to dynamically adapt to changing environments (Dorn et al., 2010). Because many processes or tasks are initiated by email, Dorn et al. (2010) apply the process guidance concept to support users of ad hoc and email-based processes. They developed an email client called COPA that analyzes the email traffic and proposes recommendations on a suitable process for the identified email context. The proposed process guidance concept was evaluated in a laboratory experiment by Burkhart et al. (2012) and Krumeich, Werth, and Loos (2012), who evaluated the effects of COPA within a controlled experiment in a laboratory setting with 32 students. The participants had to execute workflows with and without the process guidance. After analyzing the experiment's data, Burkhart et al. (2012) concluded that the participants were significantly faster at workflow execution and more satisfied with the processing when using COPA.

Focusing on supporting users with relevant information and knowledge in the task at hand, Maus, Schwarz, Haas, and Dengel (2011) propose a system named CONTASK. Similar to COPA, CONTASK provides context-sensitive process guidance for knowledge-intensive tasks (Maus et al., 2011). The development of CONTASK was motivated by the observation that knowledge tasks or knowledge-intensive processes are highly fragmented and thus that users require support when executing them (Maus et al., 2011). CONTASK tracks a user's activities within the system and predicts the user's next tasks. In so doing, the system is able to support the user with proactive information delivery on the task and to provide context-specific, task-relevant information to the user, thus ensuring the reuse of valuable task expertise. Moreover, the system allows the user to provide feedback and supports learning (Maus et al., 2011).

AssistantPro also focuses on providing context-sensitive process guidance on the basis of the current process context and the integration of the process guidance into the required target system (Tekinerdoğan, Bozbey, Mester, Turançiftci, & Alkışlar, 2011). The system has been evaluated by calculating a cost model and assessing the overall costs for factors such as implementation and learning aspects. According to Tekinerdoğan et al. (2011), the evaluation was "very positive", but no further empirical details were provided.

2.3.2 Process Guidance in Software Engineering

The software development process is complex and users require support in order to increase process knowledge and to handle infrequently performed tasks (Becker-Kornstaedt et al., 1999). Becker-Kornstaedt et al. (1999) developed an electronic process guide that "gives guidance to the user, that is, it provides the Process Performer with information about the actual state, history, context, and future steps of the process to make informed decisions" (Becker-Kornstaedt et al., 1999, p. 127). Holz, Maus, Bernardi, and Rostanin (2005) also apply the process guidance concept in their artifact named PRIME. The system gives software developers access to relevant information about their current tasks. PRIME enables users to store the information they perceive as useful, to categorize and distribute it among the software development teams. However, Holz et al. (2005) do not report any evaluation of the PRIME system and therefore fail to demonstrate the effects of the provided process guidance. Similarly, Grambow, Oberhauser, and Reichert (2011) provide process guidance to software developers by collecting and aggregating contextual information. They argue that process guidance is especially useful in the software engineering context to address issues such as specialized refactoring, fixing bugs, and customer support (Grambow et al., 2011). Their implementation of process guidance builds on a set of sensors to gather contextual information automatically and determine the current process. The information serves to suggest a dynamic set of process candidates (e.g., how to resolve a bug in the software) to support users' process execution. To evaluate their artifact, the researchers conducted a "synthetic, but concrete practical scenario generated in a lab environment" (Grambow et al., 2011, p. 13). However, an evaluation of the system in the form of an experiment or field study evaluation has been postponed for future research.

2.4 Research Objective

Reflecting the presented theoretical foundations and related work on process guidance, we can conclude that there is already some research on the concept of process guidance in general. However, to the best of our knowledge, there are only a few insights on the underlying design of the whole class of PGSs. We summarize the current brief design knowledge in this section but argue that there is still a research opportunity to derive theoretically grounded design knowledge for PGSs. Moreover, a systematic and rigorous evaluation of this design can further contribute to the body of knowledge. Thus, our research pursues the following two objectives:

(1) Deriving theoretically grounded design principles that can be used for the entire class of PGSs summarized in the form of a nascent design theory.

(2) Instantiating theoretically grounded design principles in the form of artifacts and the systematic evaluation of these artifacts in a laboratory and a real-world context in accordance with established evaluation guidelines.

3 The Design Science Research Project Setting

Our research project follows the DSR approach (Hevner et al., 2004) and addresses the question of how to support individuals to build up the required process knowledge and support their process execution. To demonstrate the effects of a PGS that delivers process information at the right time, we cooperated with an industry partner that is also the research project's case company. By applying the DSR approach, implementing our PGS artifact in a case company (Hevner et al., 2004), and evaluating the artifact following the FEDS, we balance the rigor with the relevance of our research (Hevner, 2007).

The case company is a global supplier, developer, and service partner for customers in various sectors—including automotive, civil aviation, and mechanical engineering. At the end of 2015, the case company employed 15,146 employees at over 45 sites worldwide and had sales of more than €2.27 billion.

We conducted our DSR project in three cycles. In the *first design cycle*, we explored issues related to process knowledge and process execution by executing an explorative literature review and conducting a series of expert interviews. The expert interviews revealed that the employees experience difficulties in properly executing processes due to a lack of process knowledge. In particular, one of the interviewees requested some "guidance, claiming the system which needs to be used in a particular business process step" (Morana, Schacht, Scherp, & Maedche, 2013, p. 497). Such guidance should support users in their process execution. Next, we conducted a systematic literature review on the guidance concept in IS research (Morana et al., 2017). Building on the findings of the interviews and reviews, we identified a set of meta-requirements and proposed the concept of process guidance to support users in increasing their process knowledge and improving their process execution. These meta-requirements describe the goals of the artifact (Gregor & Hevner, 2013; Walls, Widmeyer, & El Sawy, 1992); for example, the meta-requirement describing the need to provide process guidance while executing a particular process (Morana et al., 2014). On the basis of the meta-requirements and current research on guidance, we derived three theoretically grounded design principles (DPs) for PGSs. We considered the concepts of decisional guidance (Silver, 1991) and explanations (Gregor & Benbasat, 1999)—in particular, because they form the foundation of the body of knowledge on guidance. We instantiated the design in the form of an artifact for the case company's procurement department that focuses on structured, document-centric business processes specified by the department. Subsequently, we qualitatively evaluated the instantiated artifact and the DPs in a workshop series with employees from the case company. The workshops' positive results show that the proposed and instantiated functionalities described in the DPs have some validity, which indicates the usefulness of the PGS artifact (Morana et al., 2014).

We started the *second design cycle* with further reading on spatial and navigational theory to enrich our design's theoretical basis. Although the existing design is theoretically grounded in decision support literature, an additional theoretical lens enriches the design as presented below. Therefore, we updated the existing DPs to the new theoretical lens taken from spatial navigation and knowledge. In so doing, we aimed to increase the validity of our design. The evaluation of the adapted design is based on the FEDS—a framework for evaluating DSR artifacts (Venable et al., 2016). In a laboratory experiment, we evaluated the functionality described in the DPs in isolation from each other by instantiating three different artifacts with varying implementations of the DPs' functionality. For the experiment's context, we selected the IT service ticketing process of our case company to apply the concept of process guidance to a quasi-real-case scenario. These IT management processes are adapted from the IT infrastructure library (ITIL) framework (Tan, Cater-Steel, & Toleman, 2009) and can be classified as human-centric and loosely coupled processes (van der Aalst, 2013).

In the third design cycle, we replicated our results of the second cycle in a real-world context. Responding to the call by Peffers et al. (2012) and the suggestions in the FEDS (Venable et al., 2016) for more real-world evaluations of DSR artifacts, we evaluated the functionality of all three DPs by instantiating them in a PGS artifact deployed in the case company and balancing the rigor and relevance of our research. Thus, we evaluated the effects of the design instantiation in our case company by applying a survey-based approach with real users and real problems. To be able to compare the results of the second with those of the third design cycle (laboratory experiment vs. real-world evaluation), we observed the effects of the PGS artifact in the same context—the IT service ticketing process—as done in the experiment. Following Bhattacherjee (2001), we designed the survey-based evaluation as a longitudinal field study. In addition to the quantitative evaluation, we conducted a qualitative evaluation in the form of expert interviews and focus groups (Morana, Schacht, & Maedche, 2016). Figure 1 depicts the three consecutive design cycles and their research activities. A more detailed description can be found on the public project page on mydesignprocess.com[1] (vom Brocke et al., 2017).

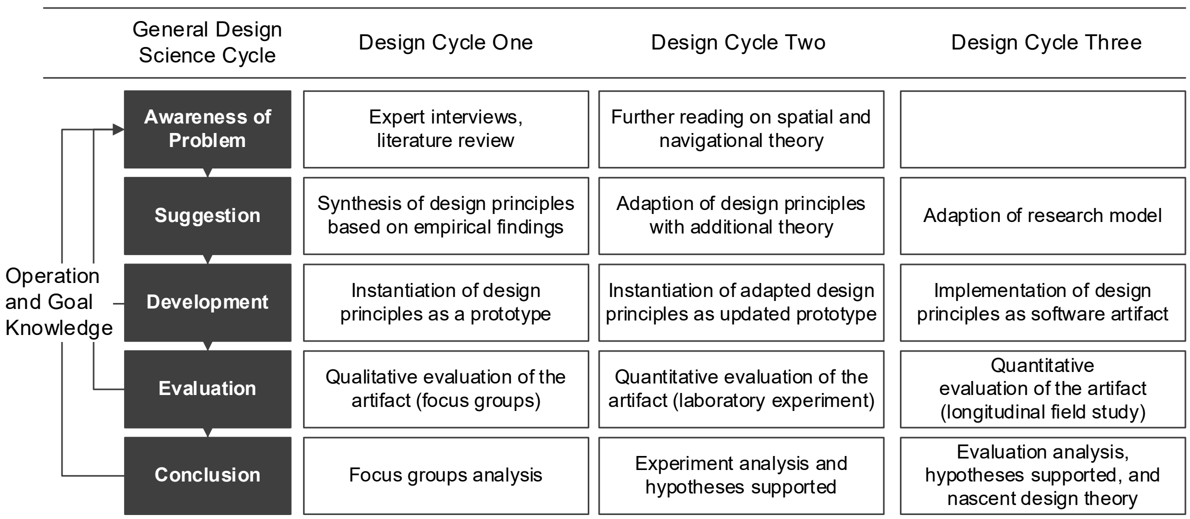


Figure 1: Three Consecutive Design Cycles and Research Activities

In this paper, we discuss the results of our research activities and address in detail the two quantitative evaluations that we performed in the second and third design cycle. First, we discuss the adaptation of the first cycle's PGS design by applying the theoretical lens of spatial knowledge and navigation as well as the derivation of testable propositions to evaluate the PGS design. Subsequently, we present the evaluation strategy and the results of our laboratory experiment and the survey-based real-world field evaluation in the case company.

4 Designing Process Guidance Systems

In the first design cycle, we identified three theoretically grounded DPs (Morana et al., 2014). In the following, we discuss how the three types of spatial and navigational knowledge are mapped to process knowledge and how we adapted the three DPs accordingly in the second design cycle. Subsequently, we propose testable propositions for the evaluation of the design.

4.1 Design Adaptation

Process knowledge is important for users to execute their daily work (Amaravadi & Lee, 2005;

[1] https://mydesignprocess.com/public/191/.

Münstermann et al., 2010). Similar to our discussion on spatial knowledge, we propose that three different forms of process knowledge are required to navigate and support users in their process execution. We argue that a PGS can only provide process information to the users, which they, in turn, digest and turn into process knowledge. In the following, we discuss how we adapted the three existing DPs by using the spatial knowledge and navigation theories introduced in the theoretical foundation section.

Orientation knowledge enables users to locate themselves with respect to their existing survey and procedural knowledge. Combining survey and procedural knowledge enables the user to navigate from one location to another by using an alternate route and circumventing an obstacle on the original route (Klatzky et al., 1998)—see Figure 2 (A). Thus, orientation knowledge is a prerequisite for users to navigate and move in an environment. Similarly, a PGS should enable users to locate themselves within the process by providing process orientation information as a prerequisite to executing a process. In so doing, users will be aware of the current process step in which they find themselves, the activities required next, and the activities within the process that have already been carried out, as illustrated in Figure 2 (A1). In general, providing process guidance should be done only when users request it, since automatically providing it "might irritate more than it guides" (Silver, 2006, p. 110). Moreover, we argue that a PGS needs to monitor user behavior and context in the current process execution to provide the appropriate process orientation information and process guidance in general (Gregor & Benbasat, 1999). Thus, we adapt our first DP as follows:

DP1: Provide process guidance, including process orientation information, on the basis of the monitoring of the users' process execution context and on users' request in order to enable users to gain process orientation knowledge.

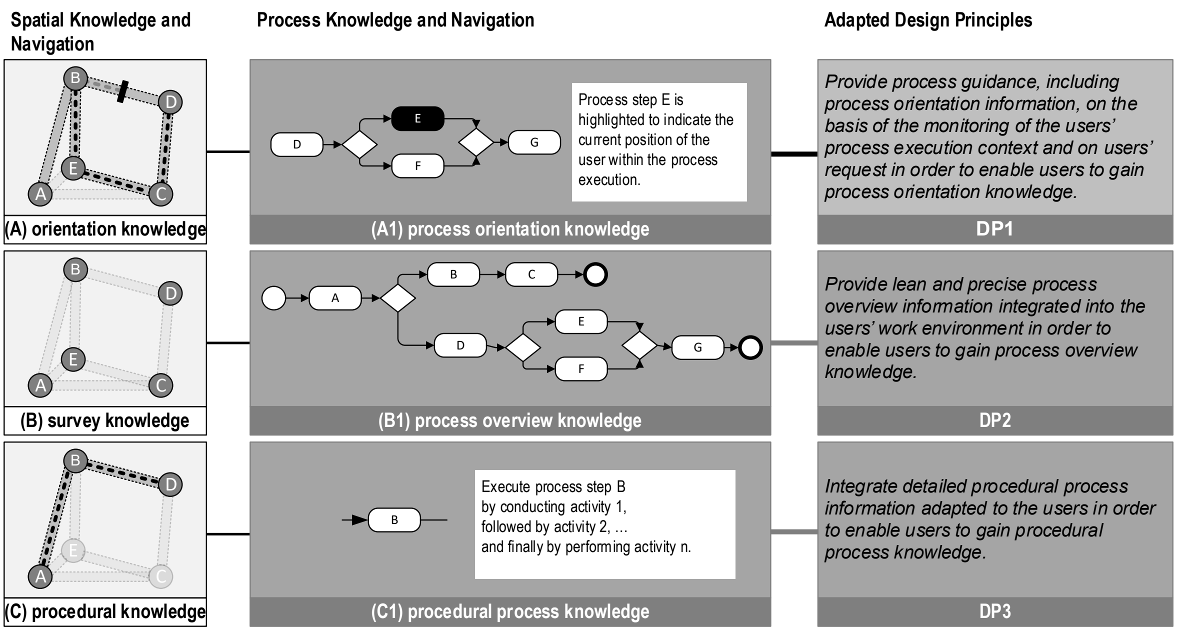


Figure 2: Spatial Knowledge Theories for Process Knowledge and Adapted DPs

Spatial knowledge theory states that users require an overview of the map (survey knowledge) to be aware of the location and the orientation of specific points on a map (Thorndyke & Hayes-Roth, 1982)—see Figure 2 (B). In the process context, users similarly require an overview of the various process steps and their sequence within the process. We refer to such knowledge as "process overview knowledge". To support users in process navigation, a PGS should visualize the various process steps and their relationship, as illustrated in Figure 2 (B1). Similarly, to survey knowledge in spatial navigation (Goldin & Thorndyke, 1982), we argue that by providing such process overview knowledge users can form mental maps of processes. Moreover, researchers show that it can be useful to externalize (process) information for cognitive tasks (van Nimwegen, Burgos, van Oostendorp, & Schijf, 2006), ease problem solving (Zhang & Norman, 1994), and support users to learn through task experience (Glover et al., 1997). In addition, process overview knowledge is required during users' current process execution and in their work environment to prevent media disruptions (Heinrich & Paech, 2010). Thus, a PGS needs to visualize processes to foster process overview knowledge. Consequently, we adapt the need for process overview knowledge to arrive at our second DP:

DP2: Provide lean and precise process overview information integrated into the users' work environment in order to enable users to gain process overview knowledge.

In addition to survey knowledge, users also require procedural knowledge (Goldin & Thorndyke, 1982) for spatial navigation (see Figure 2). Adapted to the process context, we propose that users require procedural process knowledge to execute specific process steps within the entire process. Thus, the PGS should offer procedural process information on how to execute a particular process step in addition to process orientation and process overview knowledge. As illustrated in Figure 2 (C1), procedural process knowledge addresses information on what to do in the current process step. Such "how to do it" instructions assist users in their task execution (Carroll & Aaronson, 1988). Novice users, in particular, benefit from "what to do next" instructions when they are uncertain or afraid to make mistakes (Good, Whiteside, Wixon, & Jones, 1984). By contrast, more experienced users or experts require more specific information to solve a specific problem or exception within the process (Gönül, Önkal, & Lawrence, 2006). It is important to consider the expertise of the user when providing the adequate form of guidance (Gregor & Benbasat, 1999; Ye & Johnson, 1995). Thus, we argue that the provided procedural process information should be adapted to the user and his/her expertise. We address this with procedural process knowledge in our adapted third DP for PGSs:

DP3: Integrate detailed procedural process information adapted to the users in order to enable users to gain procedural process knowledge.

In summary, the theory on spatial knowledge and navigation serves as a valuable theoretic foundation for adapting the existing DPs. In Figure 2, we map the proposed three types of process knowledge to the three adapted DPs for PGS.

Process guidance and the instantiated PGS artifacts provide process information that the user translates into process knowledge. We propose a total of three types of process information that a PGS can provide to the user—namely, process orientation information, process overview information, and procedural process information. Ideally, all three types are provided to the user and we refer to this superset as process information.

4.2 Derivation of Testable Propositions and Constructs

Following the suggestions by Gregor and Jones (2007) and Walls et al. (1992), we derive testable propositions as truth statements to assess our proposed design. These propositions take a more general form and can be tested by instantiating the design in the form of a specific PGS artifact (Gregor & Jones, 2007). In the following, we outline a total of three propositions for the evaluation of the PGS design with respect to the proposed effects on the constructs users' process knowledge, process execution effectiveness, and process execution efficiency. We use the already discussed research from the theoretical foundation and the design adaptation as the baseline for deriving the propositions.

Process guidance proposes to increase users' process knowledge. We define process knowledge as "information about a process, including how it is configured, how it is coordinated, how it is executed, what outputs are desirable and what impacts it has on the organization" (Amaravadi & Lee, 2005, p. 69). By providing the required process information during the process execution, process guidance can "beneficially impact users' learning through task experience" (Glover et al., 1997, p. 251). Thereby, the use of a PGS enables users to internalize the provided process information as process knowledge and supports the users' process execution. The internalization takes place when explicit knowledge is converted into tacit knowledge and results in new mental models and working routines (Nonaka et al. 2000). This assumption is supported by Dhaliwal and Benbasat (1996), who propose that the use of explanations (a form of guidance) results in an improved user understanding and the gain of knowledge (Dhaliwal & Benbasat, 1996). A similar effect is observable in spatial navigation, as users increase their spatial knowledge when navigating in an environment (Ishikawa & Montello, 2006; Presson & Hazelrigg, 1984). Researchers find that maps and active navigation have a positive effect on the users' knowledge acquisition (Richardson et al., 1999). For the process guidance context, we propose that providing required process information in the form of a PGS artifact during the process execution can result in a form of learning that increases users' process knowledge. Some researchers already demonstrate the positive effect of guidance in general on users' knowledge. Limayem and DeSanctis (2000), for example, studied the effects of guidance on users' decision-making processes. They observed an increased understanding of underlying decision models when participants received guidance. Similarly, Parikh et al. (2001) examined increased learning effects due to guidance received during the task execution. With regard to the accompanying task context, Parikh et al. (2001) realize that users receiving guidance will learn more than users who do not. We include this aspect in our first proposition:

Proposition 1: Process information in a process guidance system leads to users having increased process knowledge.

In addition to the proposed effect of process guidance on users' process knowledge, we argue that process guidance increases users' process execution performance. Researchers discuss the concepts of effectiveness and efficiency and their relationship with each in relation to performance. There seems to be a consensus about defining effectiveness as the quality of an activity's outcome and/or the number of completed tasks and efficiency as the ratio between the outcome and the expended resources (Dennis, Haley, & Vandenberg, 1996). Dhaliwal and Benbasat (1996) also apply the constructs of effectiveness and efficiency to their framework. Thus, we define process execution effectiveness as the number of times the user correctly executes a process instance (i.e., the process was executed, and the intended outcome/quality was achieved). In addition, we define process execution efficiency as the ratio between the correctly executed process instances and the time spent to execute the process instances.

Guidance can be a valuable support to execute a process properly—especially for novice users who have little process knowledge (Good et al., 1984; Jensen, Lowry, Burgoon, & Nunamaker, 2010). In this case, the literature also reports a positive impact of guidance on users' task execution accuracy or effectiveness because of the provided guidance (Wilson & Zigurs, 1999). In the context of decision-making tasks, Shen et al. (2012) observe better decision-making results (selection of the correct display format) for those experiment participants who received guidance. Similar results on increased guidance-based effectiveness are demonstrated by Huguenard and Frolick (2001), Singh (1998), and Lankton, Speier, and Wilson (2012), among others. In particular for complex tasks, guidance can improve users' effectiveness (Lankton et al., 2012). Limayem and DeSanctis (2000) also show that guidance has a positive effect on users' decision quality on the basis of the conceptual model by Dhaliwal and Benbasat (1996). Summarizing the theoretical and empirical findings, we propose that providing process information in the form of a PGS improves users' process execution effectiveness:

Proposition 2: Process information in a process guidance system leads to users having increased process execution effectiveness.

Efficiency is defined as the ratio between effectiveness of the performance and the time spent for the performance (Dennis et al., 1996). Generally, users tend to "trade-off quality to increase speed (i.e., reduce time), as a mechanism for reducing effort associated with decision making" (Lankton et al., 2012, p. 63). In addition to increasing effectiveness, the guidance also supports users in their task execution efficiency. Therefore, guidance is proposed to address this trade-off between effort and accuracy (Lankton et al., 2012). In particular, Shen et al. (2012) demonstrate the positive effect of guidance on participants' task execution speed. In the context of decision support, Parikh et al. (2001) also observe a reduction in the time spent on decision-making due to guidance. Similar to the results of providing guidance on the users' effectiveness, Limayem and DeSanctis (2000) find a positive effect of guidance on the users' efficiency. In line with the argumentation on the effect of process guidance on the process execution effectiveness, we suppose a direct effect on the users' process execution efficiency. Thus, we propose that providing process information in the form of a PGS improves users' process execution efficiency:

Proposition 3: Process information in a process guidance system leads to users having increased process execution efficiency.

Although some researchers posit mediation between guidance, knowledge, and performance (Dhaliwal & Benbasat, 1996; Limayem & DeSanctis, 2000), other researchers argue against such a mediation because performance and learning (knowledge) are linked and therefore potentially confounded (Gregor & Benbasat, 1999). We therefore decided on only direct propositions for our research project. The investigation of potential mediating or moderating effects is subject to future research.

4.3 Evaluation

In this section, we outline our evaluation strategy, present the underlying methodologies of the two evaluation episodes, and discuss the results in detail.

4.4 Evaluation Strategy

To evaluate the functionality described in our DPs, we followed the FEDS strategy, which suggests planning out an evaluation in four steps (Venable et al., 2016). The purpose of our evaluation was to provide evidence that the proposed design could be instantiated in the form of an artifact that addresses the outlined problems and achieves the expected environmental utility—e.g., the increase in users' process knowledge and process execution performance. For the evaluation strategy, we decided to follow the technical risk & efficacy strategy, which should be adapted "if it is prohibitively expensive to evaluate with real users and real systems in the real setting" and "if a critical goal of the evaluation is to rigorously establish that the utility/benefit is due to the artefact, not something else" (Venable et al., 2016, p. 82). When following the technical risk & efficacy strategy, Venable et al. (2016) recommend "start[ing] with a laboratory experiment to clarify the boundaries of the technology" (p. 83). Thus, we evaluated the PGS design in a laboratory experiment in the second design cycle. An experimental research design also ensures high internal validity and moderate external validity (Bhattacherjee, 2012) and therefore enables us to demonstrate that the observed effects are due to the PGS artifact rather than other factors that cannot be influenced. The laboratory experiment assesses the functionality described in the DPs and the effects of their instantiation in isolation from each other and thus can be categorized as a formative evaluation episode (Venable et al., 2016). Armed with a more detailed understanding of the effects of process guidance, we then decided to evaluate the PGS design and the effects of its instantiation (all three DPs together in an artifact) in a field study to increase the generalizability (Bhattacherjee, 2012). This naturalistic evaluation episode in the form of a survey-based field study is conducted in our case company with real users who have real problems (Venable et al., 2016). With respect to the evaluation properties, we focus on the validity of our overall design and the effects of its instantiation on users' process knowledge and process execution performance. Figure 3 depicts the two complementary evaluation episodes. In the following sections, we outline the evaluation approach in detail.

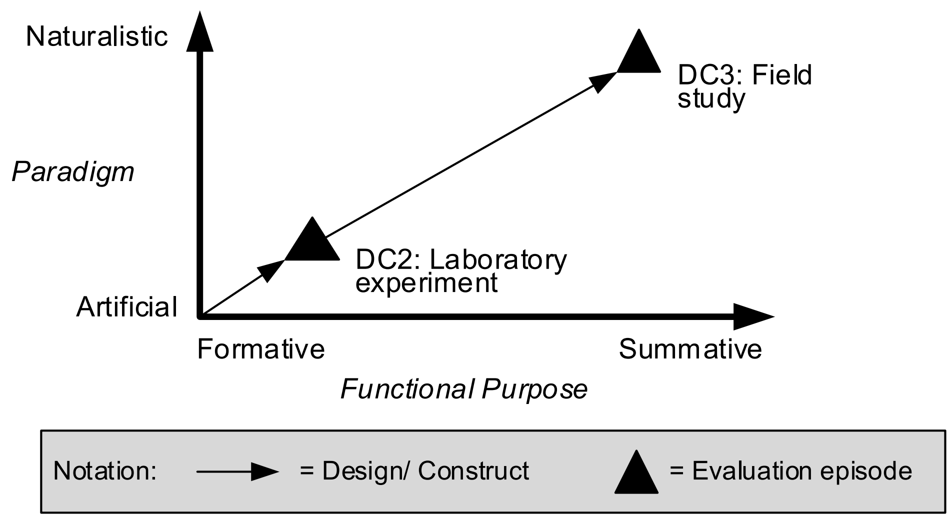


Figure 3: Evaluation Strategy (Venable et al., 2016)

4.5 Laboratory Experiment

4.5.1 Hypotheses Derivation of the Laboratory Experiment

In the first formative and artificial evaluation episode, we assessed the functionality of the proposed DPs and the effects of the resulting instantiated artifacts independently in a controlled laboratory setting. Before we derive the hypotheses, we have to briefly discuss the interdependencies among the three DPs with regard to their technical instantiation in a PGS artifact and the constraints for the experiment. The first DP describes the provision of process guidance in a PGS based on the users' process context requested by the users as well as the specific provision of process orientation information. In order to observe the effects of process guidance provided by a PGS in a controlled laboratory setting, we decided to ensure that all participants should receive the same process guidance as intended according to the experimental setting. Therefore, we decided to have the PGS artifact already running at the beginning of the experiment and did not implement the manual invocation by the user. Based on this decision, we instantiated DP1 in the laboratory experiment only partially—namely, by providing process guidance in the form of a PGS. The assessment of the entire functionality described in DP1 including the manual invocation of the PGS and provision of dedicated process orientation information will be done in the subsequent field study.

The functionalities described in the second and third DP depend on each other. To provide procedural process information for each process step (as described in DP3), it is required to visualize the process guidance and thereby provide process overview information (as described in DP2).

Table 1. Experiment's Configuration Modes

Configuration mode of the PGS artifact / group	Design principle instantiation in the PGS artifact	Provided process information by the PGS artifact
No process guidance (NPG)	DP1 not instantiated DP2 not instantiated DP3 not instantiated	None
Basic process guidance (BPG)	DP1 not instantiated DP2 instantiated DP3 not instantiated	Process overview information
Extended process guidance (EPG)	DP1 not instantiated DP2 instantiated DP3 instantiated	Process overview information and procedural process information

Note: The PGS artifact for the NPG group did not display any process information (see Table 2).

The visualization covers two aspects: on the one hand, the process needs to be technically visualized in the form of a graphical user interface embedded into the users' work environment (as described in DP2); on the other hand, the process needs to be graphically visualized by expressing the single process steps in a format that the user can understand (e.g., the sequence of the process steps in a list). Because of the interrelationship between the instantiation of DP2 and DP3, we considered three configuration modes for the evaluation of the PGS artifacts' effects in the laboratory experiment (see Table 1).

In order to test the proposed functionality described in the second and third DP instantiated (or not instantiated) in the three configuration modes, we derive three hypotheses on the basis of the already introduced testable propositions. As such, each hypothesis assesses if a PGS configuration mode (the instantiation of a DP and the provision of the respective type of process information by the PGS artifact) leads to an increased effect on the users' process knowledge, process execution effectiveness, and process execution effectivity compared to another PGS configuration mode.

We hypothesize that the provision of process information (including process overview information [DP2] and procedural process information [DP3]) in a PGS will increase users' process knowledge, execution effectiveness, and execution efficiency. An overview of the environment in the form of survey knowledge is a necessary prerequisite to allow a successful navigation (Goldin & Thorndyke, 1982). Adapted to the process context, we suppose that users require process overview knowledge to execute the process properly. Therefore, providing process overview information in a PGS is assumed to positively support their process execution and increases process knowledge. Moreover, users require both procedural and survey knowledge to navigate successfully in an environment (Thorndyke & Hayes-Roth, 1982). Thus, we suppose that users require procedural process knowledge to execute a process properly. The provision of procedural process information on how to execute the process steps (Good et al., 1984) is assumed to increase their process knowledge and improve their process execution performance. Thus, we formulated the following hypothesis to assess the functionalities proposed in DP2 and DP3:

H1: Providing process overview information and procedural process information in a process guidance system leads to users having increased **(a)** process knowledge; **(b)** process execution effectiveness; and **(c)** process execution efficiency when compared with a process guidance system providing no process information.

In addition to testing the combined effect of the functionalities described in DP2 and DP3 with respect to the three testable propositions, we also examine the distinct effects of both DPs. Therefore, we propose the following hypothesis assessing the effect of the functionality described in DP2:

H2: Providing process overview information in a process guidance system leads to users having increased **(a)** process knowledge; **(b)** process execution effectiveness; and **(c)** process execution efficiency when compared with a process guidance system providing no process overview information.

Accordingly, we propose the following hypothesis to assess the effect of the functionality described in DP3:

H3: Providing procedural process information in a process guidance system leads to users having increased **(a)** process knowledge; **(b)** process execution effectiveness; **(c)** process execution efficiency when compared with a process guidance system providing no procedural process information.

4.5.2 Research Design and Artifact of the Laboratory Experiment

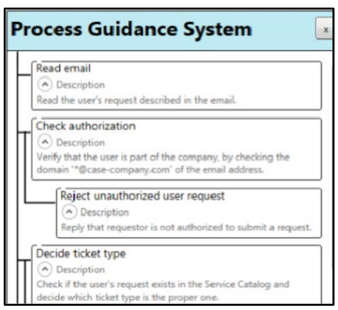
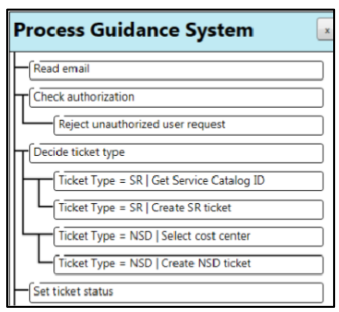
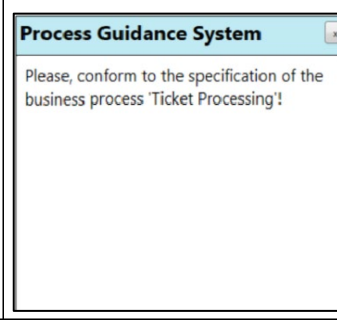
For testing the proposed hypotheses, we instantiated three PGS artifacts that either implemented the functionality described in a DP or explicitly did not implement the described functionality. As outlined in the hypotheses derivation section, we postponed the evaluation of the first DP to the field study and focus on the second as well as third DP in the laboratory experiment.

The following Figure 4 depicts the instantiation of the functionality described in the two DPs in the experiment's PGS for the EPG mode. The lean and precise process overview information (DP2) is implemented as a vertical list with a box for each process step, including the name of the process step. In addition, the PGS artifact is integrated into the experiment's work environment (see Figure 6), and each of the process step boxes contains detailed procedural process information (DP3). This procedural process information supports the users in executing this specific process step. In contrast, the PGS artifact for the NPG mode does not provide any type of process information and, thus, no process guidance to the participant. The difference between the three instantiations of PGS is depicted in Table 2.

This instantiation of the design focusing on a textual explanation is based on the expertise of the researchers and reflects their decisions made for their research context. Instantiations by other researchers or designers might result in different artifacts.

In summary, the laboratory experiment assesses the functionality described in the DPs and tests hypotheses H1, H2, and H3 by evaluating three PGS instantiations. Figure 5 depicts the research model for the experiment with the hypotheses and Table 6 in Appendix C provides the definition of the experiment's constructs.

Table 2. Process Guidance Systems Instantiations

Extended process guidance (EPG)	Basic process guidance (BPG)	No process guidance (NPG)
		

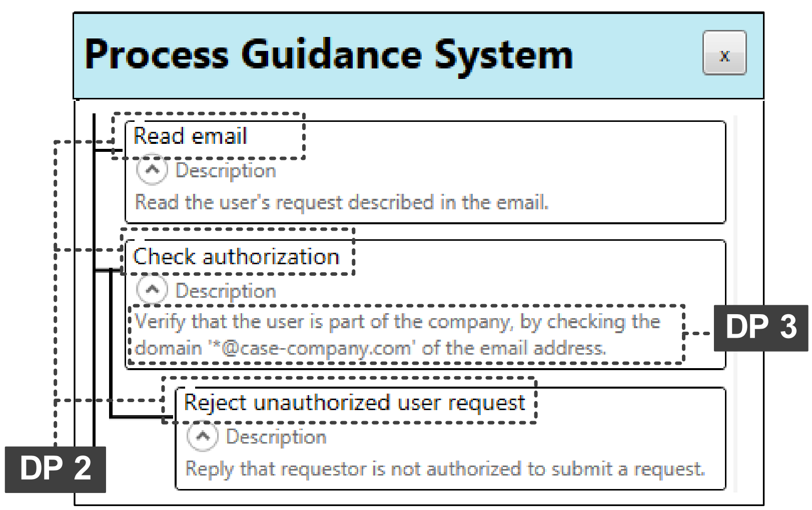


Figure 4: PGS Artifact for the Laboratory Evaluation

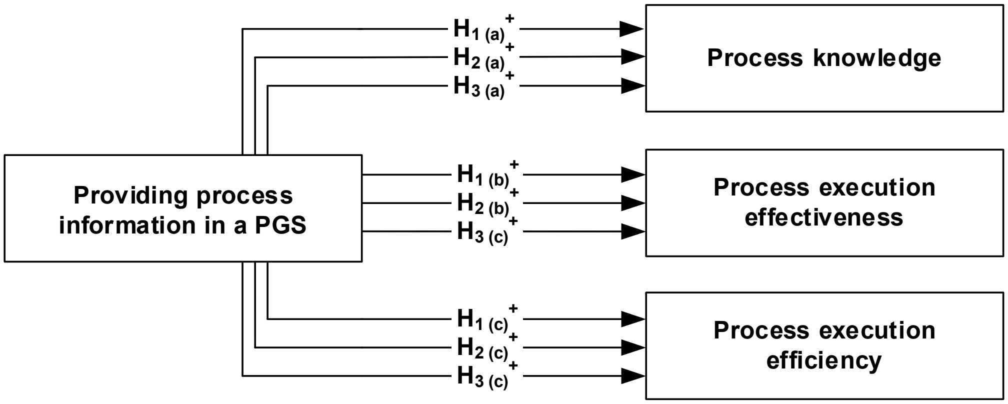


Figure 5: Laboratory Experiment's Research Model and Hypotheses

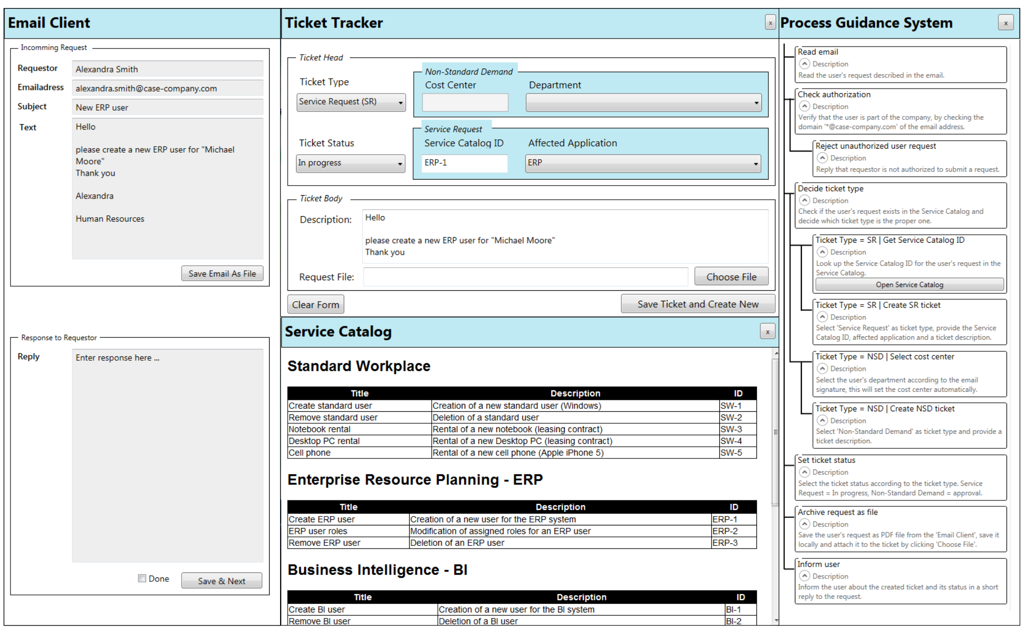


Figure 6: Experiment Applications

4.5.3 Methodology of the Laboratory Experiment

The experiment followed a five-step approach to test the proposed hypotheses. *First*, this evaluation episode focused on novice users to evaluate the effects of PGS on process knowledge and process execution performance. As already outlined, novices in particular require immediate support during the execution of the process to increase their process knowledge and to execute the processes according to their specifications. Consequently, we argue that students were appropriate participants in the experiment, since—similarly to novice users—they have little or no prior knowledge of the underlying experiment's process. Thus, students can be considered an adequate and representative sample in the experimental setup (Burton-Jones & Meso, 2009). In total, we recruited 118 undergraduate (management information systems) and graduate (management information systems and business administration) students from a public university in Germany. As an incentive, all students received extra credit for the final exam based on their participation and experiment performance. After the selection and invitation of the participants, we presented the experiment context to the participants. For the experiment, we selected a real process from the case company to simulate a real-world situation: the case company's IT ticketing process and involved systems according to the ITIL process. We simplified the case company's IT ticketing process by reducing the required process steps to ensure that the process can be executed in the experiment. To execute the IT ticketing process, the participants had to process requests targeting several IT services, such as creating a user account or purchasing IT equipment. An email client provided the requests to the participants.

The participants then had to extract the information, create an accompanying ticket in the ticketing application, and reply to the requestor by writing an email. For the ticket creation, the participants had to gather the required information from the service catalog application (see Appendix A for details). Figure 6 is a screenshot depicting the position of the PGS (here the EPG mode) on the right-hand side, as well as the applications used in the experiment—namely, the email client, ticketing application ("Ticket Tracker"), and service catalog.

In a mandatory introductory session one week before the experiment, we presented the process details and the involved applications to all participants and informed them that there would be a PGS supporting their process execution. On purpose, we did not show the actual PGS instantiation in advance but only introduced the PGS concept. We provided all training material to the participants and instructed them to study the material carefully in preparation for the task.

Second, we randomized the assignment of all participants into one of the three experiment groups corresponding to the configuration modes. We did not inform the participants about their assignment or about differences in the provided PGS. The randomized assignment of participants to the experiment groups had three purposes: (1) distributing participants' idiosyncratic characteristics to prevent a sample selection bias, (2) enabling the computation of an unbiased estimate of error effects, and (3) ensuring that the error effects were statistically independent (Kirk, 2003, p. 24).

Third, we asked the participants to complete a multiple-choice test to assess their process knowledge one week after the introductory session and immediately before the actual experiment session. For the multiple-choice test, we formulated 13 questions on the experiment's ticketing process (see Appendix B for more details on the multiple-choice test). For the procedure of the multiple-choice test, we refer to Morgan, Cleave-Hogg, McIlroy, and Devitt (2002) and Scherer, Bruce, and Runkawatt (2007) who used a multiple-choice test in order to test for learning increases in student groups.

Fourth, we conducted the actual experiment sessions. Thus, all participants received access to the same experiment applications (email, ticketing, and service catalog) as depicted in Figure 6. Depending on their group assignment, the participants received different PGS instantiations. Table 2 depicts the three PGS instantiations used in the experiment.

In total, we asked the participants to execute eight different instances of the ticketing process with varying complexity. For six instances, the participants had to process the ticketing requests, create a ticket, and write a success email. For the remaining two instances, participants had to reject the ticketing request, create no ticket, and send a rejection notice to the requestor. We measured process execution effectiveness by assessing the email reply accuracy in combination with the correct (non)creation of the tickets. A correct ticket was created when the participant included all required information without providing the nonrequired information in the ticketing application. In addition, we measured the time needed for each instance and the overall time required to process all instances to compute participant's process execution efficiency as the ratio between the process execution effectiveness and the required time. Table 6 in Appendix C summarizes the experiment's constructs, as well as their operationalization and measurement.

Fifth, immediately after the actual experiment we asked the participants to answer the multiple-choice test again (according to the described procedure in the third step). The delta between both tests (post and pre) assessed the increase in process knowledge based on the experiment accomplishment.

4.5.4 Results of the Laboratory Experiment

To test the proposed hypotheses, we applied a nonparametric approach. This approach is justified by the non-normal character of the data (see Table 7 in Appendix D for the descriptive results) that we tested beforehand (Corder & Foreman, 2009).

In testing the hypotheses, we examined differences in the mean values between the three configuration modes. Therefore, we tested each group against the other two groups, which resulted in three group-wise comparisons using Mann-Whitney U tests (Mann & Whitney, 1947). In so doing, we assessed the functionality described in DP2 and DP3 as well as the effects of their instantiations in the PGS artifacts. To test hypothesis H1, we compared the results of the EPG mode (DP2 and DP3 instantiated) with the NPG mode (no DP instantiated). To test hypothesis H2, we compared the BPG mode (DP2 instantiated) with the NPG mode (no DP instantiated). Finally, to test hypothesis H3, we compared the results of the EPG mode with those of the BPG mode. Because of the direct hypotheses, we performed one-tailed tests for all group comparisons. Table 3 summarizes the results of the group comparisons providing the p-values and the effect sizes (Pearson correlation coefficient r) in brackets (Cohen, 1992).

Table 3: P-Values and Effect Sizes of Pairwise Comparison Tests

Between-group analysis	Process knowledge		Process execution effectiveness	Process execution efficiency	Tested hypothesis
(1) EPG vs. NPG	0.216 (0.139)	0.037 (0.200)	0.013 (0.247)	0.033 (0.206)	H1
(2) BPG vs. NPG	0.405 (0.094)	0.067 (0.169)	0.390 (0.032)	0.491 (0.003)	H2
(3) EPG vs. BPG	0.760 (0.035)	0.353 (0.044)	0.036 (0.206)	0.043 (0.196)	H3

Note:
NPG: No process guidance | BPG: Basic process guidance | EPG: Extended process guidance
H1: Provide process overview information and procedural process information in a PGS (DP2 and DP3)
H2: Provide process overview information in a PGS (DP2)
H3: Provide procedural process information in a PGS (DP3)

The results of the first group comparison (EPG vs NPG mode) to test hypotheses H1 indicate that process guidance has a direct significant, positive, and small to medium-sized effect on the increase of users' process knowledge (measured by process knowledge delta), process execution effectiveness, and process execution efficiency. We therefore assume hypotheses H1(a), H1(b), and H1(c) are supported.

The second comparison (BPG vs. NPG mode) tests hypothesis H2. We cannot identify a significant effect of providing process overview information in a PGS on the users' process knowledge, process execution effectiveness, and process execution efficiency compared with the PGS not providing process overview information. Thus, we assume that hypotheses H2(a), H2(b), and H2(c) are not supported. However, the test of the increase of process knowledge is close to significance (p-value = 0.067), and there might be a potential to show a significant effect by increasing the sample size.

To test hypothesis H3, we conducted the third comparison (EPG vs. BPG mode). We cannot identify a significant effect of providing procedural process information in a PGS on the increase of users' process knowledge compared with the PGS that does not provide procedural process information. By contrast, we find a direct, significant, positive, and small- to medium-sized effect on the users' process execution effectiveness and efficiency. In summary, we assume that hypothesis H3(a) is not supported and that hypotheses H3(b) and H3(c) are supported.

Table 4 summarizes the testing of hypotheses for the laboratory experiment:

4.6 Field Study

4.6.1 Hypotheses Derivation of the Field Study

After performing the laboratory experiment, we conducted a longitudinal field study to increase the generalizability of our research results. This second summative and naturalistic evaluation episode assesses the validity of the overall PGS design and the effects of the PGS artifact instantiating all three DPs. The field study enabled us to assess the functionality described in DP1 fully instantiated in the PGS artifact, which was not tested in the laboratory experiment, and to test the effects of process guidance in a real-world setting.

With respect to our theoretical lens, Klatzky et al. (1998) found that orientation knowledge is required for users to locate themselves in the environment and for successful navigation. Therefore, we suppose that process orientation knowledge is required to allow users to identify the current process step of the process instance that they are executing. Providing process orientation information in the form of a "you are here pointer" (Kuipers, 1978) supports users in their process execution.

Because of legal restrictions in Germany and the case company's data protection regulations, it was not possible to gather individual-related usage data (e.g., using log files). Therefore, we decided to apply a survey-based approach with anonymized, subjective, and perceptual measurements complementing the data collected in the laboratory experiment. For testing the effect of the PGS instantiating all three DPs in the field study, we adapted the three testable propositions and derived a new hypothesis for the field study. Since the usage of the PGS artifact is voluntary for the case company's employees and because we were not able to collect PGS usage data (e.g., using log files), we adapted our independent construct to reflect the perceived usage of the PGS-providing process information. Thus, we hypothesized that the perceived usage of the PGS-providing process information (including process orientation information, process overview information, and procedural process information) increases the users' perceived process knowledge, perceived execution effectiveness, and perceived execution efficiency in accordance with our three propositions:

H4: The perceived usage of a process guidance system providing process information leads to users having increased **(a)** perceived process knowledge; **(b)** perceived process execution effectiveness; **(c)** perceived process execution efficiency.

Figure 7 depicts the research model for the field study.

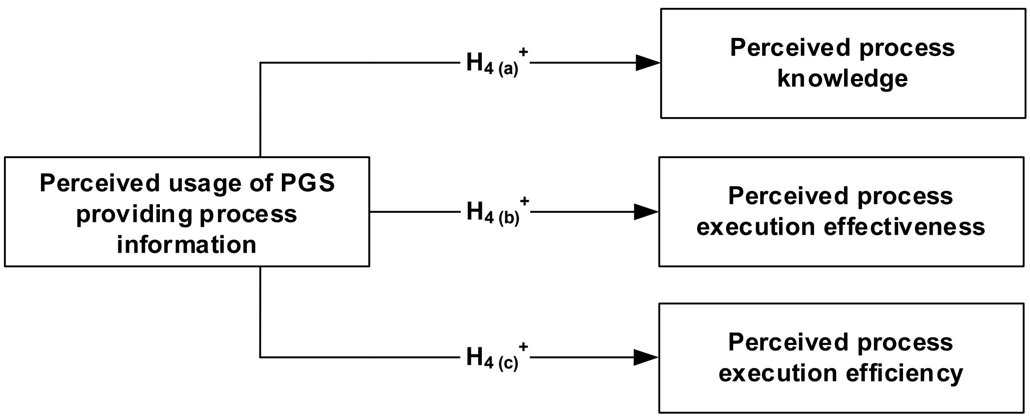


Figure 7. Adapted Research Model for the Field Study

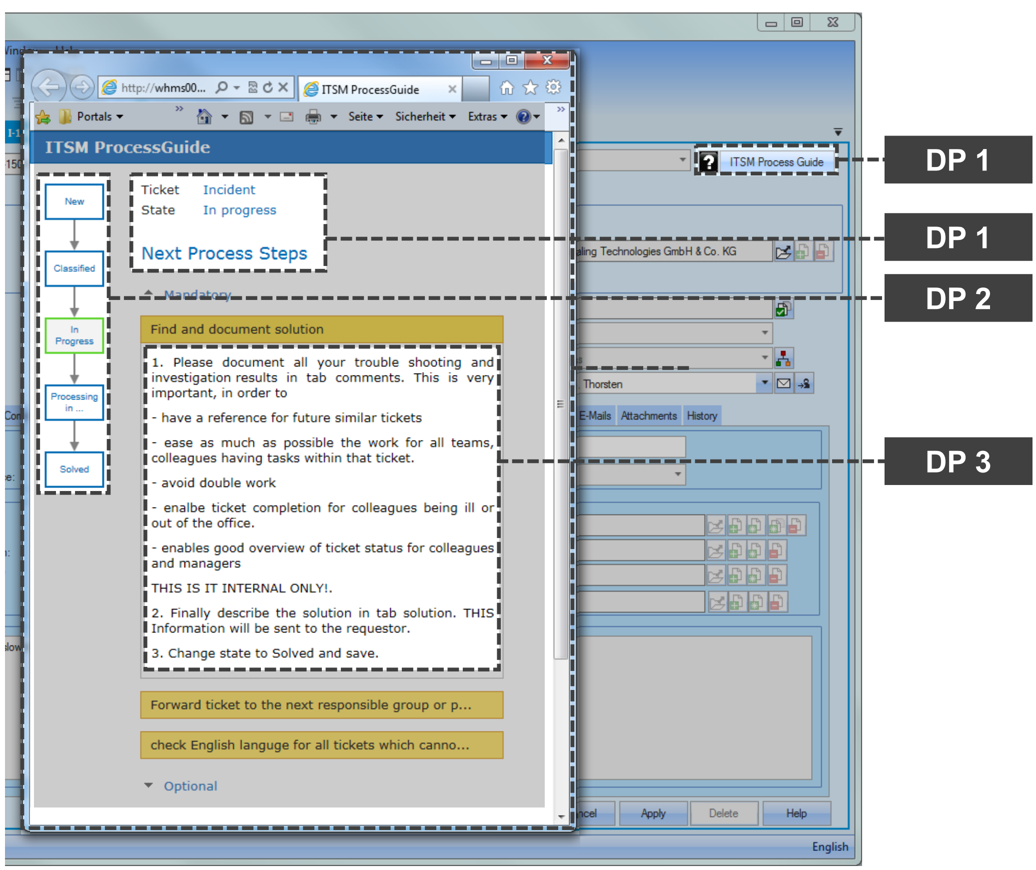


Figure 8. ITSM ProcessGuide and the Design Principles

4.6.2 Research Design and Artifact of the Field Study

For the field study, we developed a new PGS artifact named ITSM ProcessGuide (Morana, Gerards, & Maedche, 2015), which instantiates the functionalities described in all three DPs. Figure 8 depicts the PGS and highlights the instantiation of the three DPs. We integrated the PGS into the case company's ticketing system (background). Users could request process guidance by clicking on the button in the upper-right corner (DP1). The PGS provides process orientation information on request to users by stating the current position within the process (as described in DP1) and process overview information by depicting the overall process (as described in DP2) and the users' current process step. In addition, users received procedural process information in the form of explanations on what to do in the distinct process steps (as described in DP3).

4.6.3 Methodology of the Field Study

Next, we identified items that would be appropriate to conduct the longitudinal, survey-based field study. As a starting point, we consulted existing literature and searched for items for each construct that fit our research interest and goal. Through discussions involving three academics and a master's degree student, we selected what we perceived to be the best-suited items for the constructs of our research model. In so doing, we ensured a high discriminant validity of the applied items (Hair, Hult, Ringle, & Sarstedt, 2014). Because the case company is a multinational organization based in Germany, we sought to avoid any misunderstandings resulting from language difficulties. Thus, for German survey participants, we translated the survey items into German. In this way, all four researchers independently executed a forward and backward translation (Harkness, 2010). In a subsequent discussion round, we formulated the final translations to ensure the validity and a common meaning of the items. We modeled all items of the survey reflectively and measured them by using a seven-point Likert-type scale. Table 8 in Appendix E contains the survey constructs, as well as the items and their sources.

4.6.4 Results of the Field Study

We conducted the survey three months after introducing and implementing the ITSM ProcessGuide. The PGS was made available to all employees of the IT departments, and they had sufficient time and ample opportunity to get to know and test the PGS. In total, 78 employees (response rate 29.8%) completed the survey. We conducted a confirmatory factor analysis to test all the items' unidimensionality (Urbach & Ahlemann, 2010). The analysis revealed that all the survey's items load more to the proposed latent variable than to another one. Consequently, the criterion of unidimensionality is fulfilled (see Table 9 in Appendix F for details). To assess the measurement model, we determined internal consistency reliability, convergent, and discriminant validity (Hair et al., 2014; Urbach & Ahlemann, 2010). On the basis of our analysis and because all items are well-established in the literature, all items fulfill the criterion of consistency reliability. To assess the model's convergent validity, we considered the average variance extracted (AVE). All constructs have an AVE of greater than 0.80. Thus, the constructs have high levels of convergent validity. Finally, all of our constructs meet the Fornell-Larcker criterion (Hair et al., 2014) (see Table 10 in Appendix F for details) and we analyzed the correlation between the survey's items (see Table 11 in Appendix F). On the basis of the results, the proposed constructs and items support the reliability and validity of our measurement model. Thus, the adapted research model can be used to test the effects of PGS on the users' perceived process knowledge and perceived process execution performance.

We used SmartPLS (Ringle, Wende, & Becker, 2015) to analyze the survey data. The analysis shows the explanatory power for perceived process knowledge ($R^2 = 12\%$), perceived process execution effectiveness ($R^2 = 13\%$), and perceived process execution efficiency ($R^2 = 10\%$) can be considered weak effects (Urbach & Ahlemann, 2010). Next, we applied the bootstrapping resampling technique to test for path significance (Hair et al., 2014; Urbach & Ahlemann, 2010). We applied a one-tailed t-test, since the proposed hypotheses are unidirectional, and found all three paths to be significant (p-values < 0.001). In addition, we estimated the effect sizes of the model and found that all paths have a medium effect (Urbach & Ahlemann, 2010). Figure 9 depicts the model with the t-statistics and standard errors highlighting that all paths are at a 0.001 level significant with a small effect size, and thus, we consider hypotheses H4(a), H4(b), and H4(c) to be supported.

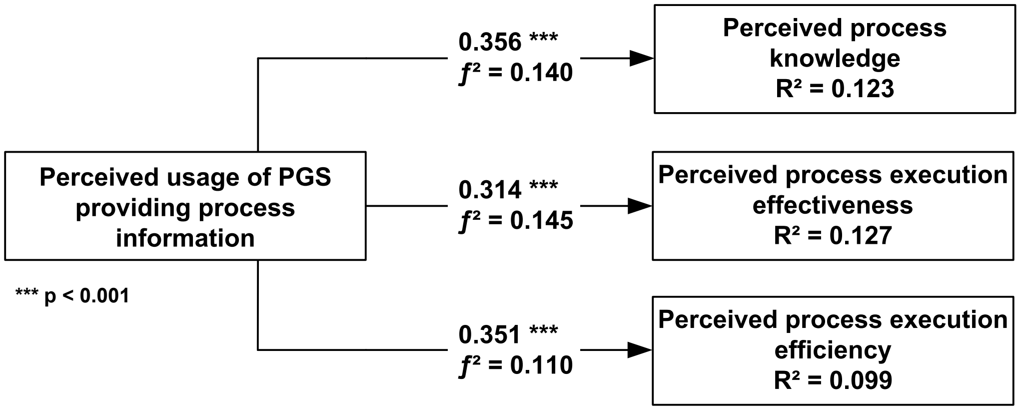


Figure 9. Effects of PGS Based on Field Study

In summary, the results of the field study support the proposed PGS design and confirm the intended effects of process guidance described in the three DPs.

5 Discussion

The results of both evaluation episodes confirm the validity of the proposed PGS design and provide significant indications of the positive effects of process guidance on process knowledge and process execution performance. Below, we discuss our findings and their implications.

5.1 Summary and Findings

In the first evaluation episode, we evaluated the proposed PGS design in a laboratory experiment by comparing the increases in process knowledge and process execution performance among the three experimental groups. Based on our analysis, we consider the proposed effects of process guidance systems that provide process overview information and procedural process information (Hypotheses H1(a), H1(b), and H1(c) of the laboratory experiment) as confirmed in our first evaluation episode. In the second evaluation episode, we instantiated the DPs in a fully functional PGS for the case company's IT ticketing process and integrated the PGS into their ticketing system. An analysis of the survey-based evaluation confirmed the experiment's findings. We consider the proposed functionality of PGS-providing process orientation information, process overview information, and procedural process information (hypotheses H4(a), H4(b), and H4(c) of the field study) to be confirmed by the field study.

Both evaluation episodes show the validity of the instantiations of the proposed PGS design. However, because the field study collected perceived data in contrast to the data gathered in the laboratory experiment and as we were not able to assess the functionality described in the first DP in the laboratory experiment, our findings should be discussed and not simply compared with each other. The findings from the laboratory experiment indicate that the provisioning of process information (namely, process overview information and procedural process information) to novice users has a positive effect on the increase of process knowledge and process execution performance. The controlled setting in the lab experiment enabled us to investigate the proposed effects in isolation from other potential influencing factors and ensure a high internal validity. In the field study, we were not able to control for influencing factors, but could investigate the effect of a PGS providing all three types of process information in a real-world scenario with a high external validity. In both evaluation episodes, the process context was the case company's ticketing process. However, the processes within the field study are more complex than the experiment's simplified process. Accordingly, it is more difficult to codify the ostensive aspects of these ticketing processes in the form of process information provided by the field study's PGS than with the experiment's process. Moreover, assessing the performative aspects of the ticketing processes is more complex than the performance of the experiment's process (Pentland & Feldman, 2005). All these facts need to be considered when reflecting the significant and positive results in both evaluation episodes. Considering the internal and external validity of both evaluation approaches, we consider the proposed effects of process guidance can be confirmed.

In addition to evaluating the effect of a PGS providing two (laboratory experiment) and three (field study) types of process information at once, we assessed the isolated effects of providing process overview information and procedural process information in a PGS artifact. This analysis of the experiment's data reveals mixed results. We found no support for hypotheses H2(a), H2(b), H2(c), and H3(a), but we found support for hypotheses H3(b) and H3(c). The analysis of H3(a) is close to being significant, and eventually a large sample size would have resulted in a significant effect. In addition, finding no effect by the sole provision of process overview information (DP2) on the users' process execution performance and process knowledge can be explained with the need for procedural process information (DP3). In the laboratory experiment, we measured the number of accurately executed process instances and the time needed for the execution. In case the participants had no prior process knowledge (because of studying the provided material prior to the experiment), they were not able to execute the process accurately with process overview information alone, we assume they required procedural process information as well. Although we were not able to identify a significant effect by instantiating DP2 alone, we argue DP2 is required in our nascent design theory. DP2 describes the functionality of providing process guidance into the users working environment and is therefore necessary to implement a PGS artifact.

5.2 Theoretical Implications

According to the DSR contribution framework by Gregor and Hevner (2013), we argue our research can be classified as an improvement. In our research project, we developed a new solution to a known problem based on existing research. Our findings are in line with the results reported in research on guidance and decision support. For example, Shen et al. (2012) find a positive effect of providing guidance to novice users to increase their decision accuracy and decision speed (Shen et al., 2012). Similar positive effects of providing guidance on the users' performance are found in other research on decision support (Lankton et al., 2012; Mahoney, Roush, & Bandy, 2003; Parikh et al., 2001; Wilson & Zigurs, 1999). Our findings also resonate with the few findings of PGS evaluations reported in the literature. Krumeich et al. (2012) find a significant effect on the users' execution efficiency by using their PGS artifact, COPA. Moreover, in another study, researchers show that COPA provides an overview of the underlying workflow (Burkhart et al., 2012). The significantly increased process knowledge of the users with the PGS providing process information in our experiment indicates the usefulness of the concept to support novice user learning. Using the PGS, the user participates more actively in the underlying task, which results in increased learning (Glover et al., 1997), as shown by other researchers in the guidance context (Arnold et al., 2006; Parikh et al., 2001). Limayem and DeSanctis (2000) also find a significant effect of guidance on the users' model understanding (knowledge), decision quality (effectiveness), and decision time (efficiency).

5.3 A Nascent Design Theory for Process Guidance Systems

To date, research on PGS in the BPM domain (Burkhart et al., 2012; Krumeich et al., 2012; Maus et al., 2011; Tekinerdoğan et al., 2011) and software development (Becker-Kornstaedt et al., 1999; Grambow et al., 2011; Holz et al., 2005) has focused on the development of artifacts for a specific context and their evaluation but offered few insights into the underlying design of their PGS. We addressed this shortcoming in our research project by systematically deriving three theoretically grounded DPs.

We instantiate the functionality described in the three DPs in two related PGS artifacts reported in this paper. Our design extends the existing body of process guidance research (Becker-Kornstaedt et al., 1999; Burkhart et al., 2012), which predominantly provides process guidance within one distinct application system. With respect to existing research, the combination of a visual and a textual format for providing process guidance, the monitoring and extraction of the users' process context, and the potential to provide process guidance for multiple application systems are all new. We decided to develop the PGS as a stand-alone application because of the resulting flexibility, and, in most cases, it is not possible to modify the application systems required to perform the processes. One approach to guiding a user in the execution of a process could be to restrict the systems and their user interface. System restrictiveness refers to a system's ability to "limit the users' decision-making processes to a subset of all possible processes" (Silver, 1990, p. 52). Despite the positive effects of applying system restrictiveness for certain use cases to enforce consistency and completeness (Mălăescu & Sutton, 2015), it requires strictly specified processes and the resulting implementation in the application system. Especially for commercial application systems or information systems, it is not possible to modify and restrict the user interface explicitly for the execution of one process step. Moreover, as we intend to propose a PGS design that supports various types of processes and multiple application systems at the same time, we consider system restrictiveness as outside the scope of our process guidance context.

In summary, by presenting a situated instantiation (Level 1) in the form of two PGS artifacts and by formulating "more general artifacts (Level 2) in the form of constructs, methods, models, and design principles" (Gregor & Hevner, 2013, p. 346), our research contributes to improving current solutions. Table 5 summarizes our findings in the form of a nascent design theory (Gregor & Hevner, 2013; Gregor & Jones, 2007).

Table 5. A Nascent Design Theory for Process Guidance Systems

Component	Description
Purpose and scope	Process guidance increases users' process knowledge and process execution performance. We propose three theoretically grounded design principles for process guidance systems.
Constructs	We defined the following constructs below: process knowledge in general, three distinct types of process knowledge grounded in spatial knowledge and navigation, and process execution effectiveness and efficiency. **Process knowledge** (in general): information about a process, including how it is configured, how it is coordinated, how it is executed, what outputs are desirable, and what impacts it has on the organization (Amaravadi & Lee, 2005). **Process orientation knowledge**: information enabling users to locate themselves within the entire process. **Process overview knowledge**: information about the various process steps and their sequence within the entire process. **Procedural process knowledge**: information on how to execute a specific process step within the entire process. **Process execution effectiveness**: the number of times the user correctly executes a process instance (i.e., the process was executed, and the intended outcome/quality was achieved) (Dennis et al., 1996). **Process execution efficiency**: the ratio between the correctly executed process instances and the time spent to execute the process instances (Dennis et al., 1996).
Principle of form and function	On the basis of existing literature, we derived three theoretically grounded design principles for process guidance systems and evaluated the proposed design quantitatively in a laboratory experiment and through a field study. **DP1**: Provide process guidance, including process orientation information, on the basis of the monitoring of the users' process execution context and on users' request in order to enable users to gain process orientation knowledge. **DP2**: Provide lean and precise process overview information integrated into the users' work environment in order to enable users to gain process overview knowledge. **DP3**: Integrate detailed procedural process information adapted to the users in order to enable users to gain procedural process knowledge.
Justificatory knowledge	The PGS design is grounded in research on decision support, as well as research on spatial knowledge and navigation.
Testable propositions	We derived three testable propositions to evaluate the PGS design: **Proposition 1**: Process information in a process guidance system leads to users having increased process knowledge. **Proposition 2**: Process information in a process guidance system leads to users having increased process execution effectiveness. **Proposition 3**: Process information in a process guidance system leads to users having increased process execution efficiency.
Artifact mutability	We discuss the mutability of the provided process guidance information, as well as the actual instantiation of the design in two different artifacts in this paper.
Principles of implementation	We provide examples of how to instantiate the proposed design in the form of the two artifacts. Especially, the ITSM ProcessGuide can serve as a baseline for further process guidance systems.
Expository instantiation	We develop a distinct process guidance system for each evaluation episode. One of the artifacts, the ITSM ProcessGuide, is used productively in the case company.

5.4 Limitations

Although we conducted the DSR project and the two evaluation episodes reported in this paper according to established guidelines, there are some potential limitations.

First, both evaluation episodes address only one specific process. Addressing more than one process within the evaluations episodes could result in different outcomes. Moreover, the addressed process (the case company's ITIL process) is IT-related. The evaluation in the field study was conducted with the case company's IT departments; therefore, the users' possible IT affinity could have affected the results. Future research should provide process guidance for other, non-IT-related process contexts and confirm the effects of process guidance.

Second, the field study needs to be discussed with respect to the research model. Our research model has a relatively low explained variance for the three latent variables ranging from 10% to 13%. A reason for this rather low explained variance could be the complexity of the ticket processes and the irregular performance of the ticketing processes by the employees. In addition, the functionality instantiated in the PGS was new to IT departments, and the employees might need more time to explore the functionality and recognize the benefits. Moreover, our research model includes only one explanatory construct, and the inclusion of additional constructs could increase the explained variance (Bhattacherjee, 2012). Potential candidates could be adapted from, for example, IS adoption research, and might include the employees' IT affinity, job position, and job experience (Venkatesh, Morris, Davis, & Davis, 2003), personality (Rammstedt & John, 2007), or the degree to which they feel informed about the processes (Smith, Johnston, & Howard, 2011), among other things. We did not include such constructs in our survey as we focused on the validation of the proposed PGS design and therefore decided to apply a minimal survey design. Moreover, because of data privacy regulations of the case company and in Germany, it was not possible to collect such individual-related data.

Third, these regulations also affected the decision to conduct a survey-based evaluation rather than collecting objective data by measuring the employees' PGS usage and the subsequent process performance. Therefore, the potential implications of perceived data and related biases need to be considered. The participants in the survey may have had a tendency to report a higher usage of the PGS or its effects than they actually had. To avoid such a socially desirable bias (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003), we framed the survey as a university study and explicitly stated that the data was not distributed to the case company. Thereby, we intended to provide participants with the safety to report their actual perception of the PGS and its effects. Another potential common method bias could be related to the scales that were used. As we used similar seven-point Likert scales for all our items, a potential common scale bias (Podsakoff et al., 2003) could be introduced by this decision. Nevertheless, we adapted all scales and items from existing literature, and since our model fulfills all quality criteria suggested in research (Hair et al., 2014; Urbach & Ahlemann, 2010), we regard the survey data and the implications that were drawn as reliable. In addition, the data was gathered from the employees of the case company that used a fully functional PGS in their daily work. Thus, because of the perceived nature of the data, the high relevance and the high external validity of the evaluation episode should counterbalance the possible bias. Nevertheless, we invite researchers to conduct future research and further evaluations to confirm this paper's findings.

Fourth, we did not evaluate the effect of providing process orientation information in a PGS artifact within a controlled setting. Providing process orientation information is only included in the ITSM ProcessGuide used in the field study and not in the PGS artifacts evaluated in the laboratory experiment. This was necessary because of the technical dependencies in the implementation of the different DPs. Existing research on spatial knowledge and navigation (Klatzky et al., 1998) supports the proposed effects of providing orientation information. Future research in the context of process guidance systems could investigate under which conditions the provisioning of process orientation information positively influences users' process knowledge and process execution performance.

Fifth, another important aspect that needs to be discussed is our instantiation of the proposed DPs and the resulting artifacts. We decided on a combination of visual and textual elements to depict process guidance with a focus on the textual elements. This design decision is based on our interpretation of the functionality described in the DPs, existing PGS prototypes (Becker-Kornstaedt et al., 1999; Burkhart et al., 2012), and the specific process context in our case company. These design decisions potentially affect the evaluations' results and their implications. Another interpretation and the different PGS artifact that results from it—for example, a sole focus on the visual depiction of the process—could have produced diverse results or even unconfirmed hypotheses. Therefore, when reflecting on the evaluation results, it is important to consider both the proposed DPs and our instantiation of the PGS.

5.5 Avenues for Future Research

The concept of process guidance and the presented nascent design theory for PGSs can form a baseline for future research.

First, the presented implementations of the PGS provide only a basic visualization of the processes. Future research should focus on improving the process visualization in a PGS. In addition, there is a need to investigate how more complex processes with multiple branches and decisions could be adapted and visualized in the PGS—for example, by using standard process modeling notations. However, users with a lack of experience with such modeling notations might be overstrained with the graphical representation. Furthermore, the more complex and larger the process is, the more complex the depiction of the process in the PGS will be. Users with little experience with the process and modeling notations could be overburdened. Thus, a simplification or abstraction of complex process models as process depiction in the PGS could be beneficial for such users.

Second, the involvement of end users in the process adaptation and thus the maintenance of PGS constitute another field of potential future research. For the field study, we stored the process specifications provided by the IT department in the PGS. End users were not involved in this activity, and the stored process specifications might not reflect their actual daily work. Thus, there is an opportunity to involve end users. At the moment, we consider only the path from ostensive aspects to performative aspects by providing process information in the PGS artifacts (Pentland & Feldman, 2005). Nevertheless, it could be valuable to consider the path from performative to ostensive aspects as well (Pentland & Feldman, 2005). We argue that an assistance system (Maedche, Morana, Schacht, Werth, & Krumeich, 2016) in the form of a PGS can support the specification and the improvement of processes by enabling end users to identify weaknesses or suggest improvements to the current process specification. The PGS could provide functionalities to gather feedback by the end user or—even better—enable end users to modify the process specification within the PGS directly as process variants of the current process specification. The process owner can then discuss these process variants and improve the process. In addition, the PGS could be used to communicate changes in the process. Such an involvement by the end user could be used to exploit their experience and knowledge and enable a continuous process improvement in the organization. Moreover, such a PGS could positively affect the postimplementation phase of IS by providing the information required to use the IS and thereby foster user learning.

Third, our paper focuses on the direct effects of process guidance on the users' process knowledge and process execution performance. There are many other factors that could be investigated in future research. Factors often addressed in related decision support research include trust (Wang & Benbasat, 2009) and mental workload (Shen et al., 2012), among others. Future studies could also investigate how to drive the adoption and use of PGS within organizations. The effect of the PGS on users' mental workload could be investigated in laboratory experiments, which would provide a reliable and controlled research setting. Finally, future research should investigate how trust in the provided process guidance could be increased.

Fourth, we derived and tested a research model that includes only direct effects. Some researchers in the guidance context (Dhaliwal & Benbasat, 1996; Limayem & DeSanctis, 2000) have included a mediating effect of knowledge on the individuals' performance on the basis of the provided guidance. In our paper, we focused on the derivation of the design and its validation in the form of PGS artifacts. Future research could conduct evaluations focusing on investigating potential mediating or moderating effects between the provision of process guidance, the users' process knowledge, process execution performance, and other constructs of interest. In addition, future research could conduct a field study and collect actual data on the users' process knowledge and process execution performance to confirm the findings of our field study that relied on perceived measurements.

Fifth, we proposed three types of process knowledge adapted from spatial knowledge and navigation theory. This conceptualization fits well with our research context. However, more research into the conceptualization and implications of different types of process knowledge is required. In addition, future research might address how novice users could be supported in learning these different types of process knowledge—for example, by using the process guidance concept.

6 Conclusion

Our research is motivated by employees' lack of process knowledge and the support required for their actual process execution. This paper pursues the objective of deriving theoretically grounded DPs for PGSs and evaluating their instantiation as PGS artifacts. We presented two interrelated evaluation episodes, a formative and artificial laboratory experiment and a summative and naturalistic longitudinal field study. Our research can be classified as an improvement because we provide a new solution to an already known problem. Our findings contribute to both theory and practice.

From a *theoretical perspective,* we address an important real-world challenge and propose a theoretically grounded and evaluated design supporting users with process execution by adequately providing the required process information. We evaluate the design with two interrelated and comprehensive evaluation episodes. We present the resulting design in the form of a nascent design theory for PGSs. In this way, we demonstrate how to apply the DSR methodology to address a real-world challenge, use existing theories and design knowledge, and derive new design knowledge. In addition, we propose several opportunities for future research on the proposed process guidance concept. The presented nascent design theory can serve as the baseline for future research on the design and effects of PGSs.

From a *practical perspective,* our research contributes by proposing a design for PGSs to support employees in their process execution. The results from our field study confirm that PGSs can have a positive impact on employees' process knowledge and process execution performance. By formulating general DPs rather than specific design features, the proposed design can serve as a baseline or a blueprint that can be adapted to fit multiple contexts in various organizations. Practitioners can build their own PGS instantiations to increase their employees' process knowledge and enable them to execute their processes in a way that complies with the organizational specifications.

We invite researchers and practitioners to apply, instantiate, evaluate, and extend the proposed nascent design theory for PGSs to advance the presented design knowledge to a full design theory for the whole class of PGSs in the future.

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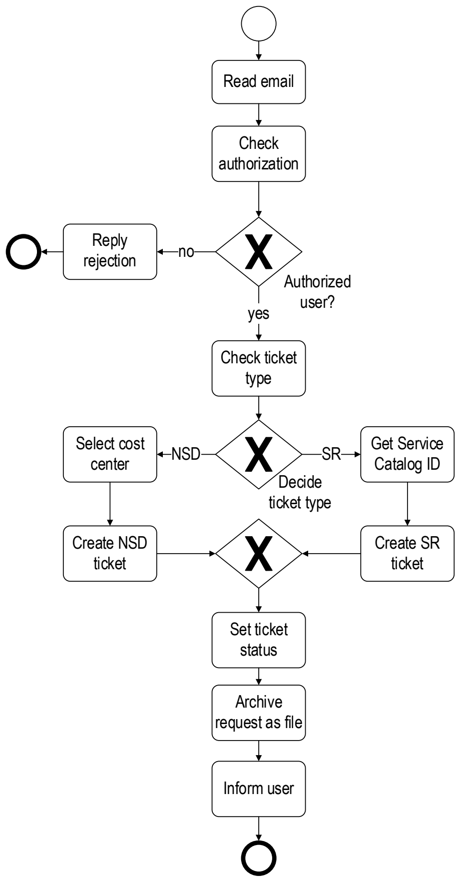
Appendix A

The experiment's ticketing process specifies how incoming requests via email should be handled. Figure 10 depicts the process in BPMN notation (the process is aligned vertically to ease the reading) and the explanations of each process step:



Process step	Explanation
Read email	Read the user's request described in the email.
Check authorization	Verify that the user is part of the company by checking the domain "*@case-company.com" of the email address.
User authorized	If the domain of the email conforms to "case-company.com", the user is authorized.
Reply rejection	If the user is not authorized, reply that requestor is not authorized to submit a request.
Check ticket type	Check whether the user's request is in the Service Catalog.
Decide ticket type	Decide which ticket type is the proper one for the user's request.
Get Service Catalog ID	Look up the Service Catalog ID for the user's request in the Service Catalog.
Create SR ticket	Select "Service Request" as ticket type, provide the Service Catalog ID, affected application, and ticket description.
Select cost center	Select the user's department according to the email signature; this will set the cost center automatically.
Create NSD ticket	If the request is not part of the Service Catalog, select "Non-Standard Demand" as ticket type and provide a description for the ticket.
Set ticket status	Select the ticket status according to the ticket type. Service Request = in progress; Non-Standard Demand = approval.
Archive request as file	Save the user's request as a PDF file from the "Email Client", save it locally, and attach it to the ticket by clicking "Choose File".
Inform user	Inform the user about the created ticket and its status in a short reply to the request.

Figure A1: Experiment's Ticketing Process and Description

In the experiment, the participants had to process eight email requests. Depending on the actual process instance, there were three possible process outcomes: (1) the rejection of the request, (2) the creation of a Service Request, or (3) the creation of a Non-Standard Demand. For three out of the eight requests, the participants had to create Service Request tickets and send a reply regarding the creation of these tickets to the requestor. Similarly, for another three out of the eight email requests, the participants had to create Non-Standard Demand tickets and send a reply regarding the creation of these tickets. Finally, for two out of the eight requests, the participant had to reject the request by sending a replying regarding the refusal to the requestor. In these two cases, the participant did not have to create a ticket.

Appendix B

To ensure the validity of the questions for the multiple-choice test, we created the questionnaire according to the guidelines of Haladyna (2004) following a two-step procedure that includes a content review (Popham, 1992) and a pretest for validity, using two groups consisting of students and research assistants. Thus, three experts familiar with the ticketing process discussed 20 test items according to their relevance to the process (Popham, 1992). Finally, we selected 13 out of 20 items for the pretest and randomly selected a total of 16 students and research assistants, who were divided into two groups. The treatment group (n=8) received the same introduction as planned for the experiment, including a printout of the process and descriptions of the process steps. In the experiment, this information was also provided for the EPG group and in parts for the BPG. The control group (n=8) received none of the above-mentioned materials and had to answer the multiple-choice test unprepared. On average, the control group scored five out of 13 answers correctly (SD 2.139). By contrast, the treatment group with the process information scored on average 12 out of 13 answers correctly (SD 1.808). The results of a Mann-Whitney U test (Mann & Whitney, 1947) show that the differences between the two groups are significant ($p < 0.001$, $r = 0.869$). Thus, we concluded that the multiple-choice test assessed the participants' process knowledge adequately. With respect to the test procedure in the experiment, we followed the procedure described by Gosselin and Macklem-Hurst (2002), Morgan et al. (2002), and Scherer et al. (2007) who tested for learning and knowledge increases by applying a similar structured knowledge test before and after a phase of active learning.

Appendix C

Below, Table C1 includes the definition, operationalization, and measurement of the laboratory experiment's constructs.

Table C1. Laboratory Experiment Constructs

Construct	Definition	Operationalization & measurement
Providing process information in a PGS		Assignment of the participants to one of the three experiment groups with the particular PGS instantiation.
Process knowledge	Information about a process, including how it is configured, how it is coordinated, how it is executed, what outputs are desirable and what impacts it has on the organization. (Amaravadi & Lee, 2005, p. 69).	The users' knowledge of the experiment's process, including the sequence of process steps and how the process steps are performed. Measured at two points in time, before the experiment and directly after the experiment, as the participants score in the multiple-choice questionnaire with 13 questions.
Process execution effectiveness	Effectiveness is defined as the quality of an activity's outcome and/or the amount of completed tasks (Dennis et al., 1996).	Users' ability to execute the experiment's process accurately according to its specification. Measured as the assessment of the participant's email reply accuracy in combination with the correct (non)creation of the tickets. As such, a correct ticket is created, when the participant includes all required information without providing the nonrequired information in the ticketing application.
Process execution efficiency	Efficiency is defined as the ratio between the outcome (effectiveness) and the expended resources (time required) (Dennis et al., 1996).	Users' ability to execute the experiment's ticketing process in the ratio of accuracy and time. Measured as the ratio between the participants' overall time required to process all eight instances and the participant's process execution effectiveness.

Appendix D

Below, Table D1 provides the mean values for the experiment measurements and the standard deviations in brackets.

Table D1. Descriptive Results

Groups	n	Process knowledge[a]			Process execution effectiveness[b]	Process execution time[c]
		Pre-	Post-	Delta		
All	118	9.780 (2.578)	10.356 (2.061)	0.576 (1.968)	4.814 (2.620)	11.954 (4.442)
EPG	39	10.205 (2.114)	10.949 (1.679)	0.744 (1.644)	5.641 (2.259)	11.932 (4.748)
BPG	38	9.711 (2.910)	10.447 (2.086)	0.737 (1.983)	4.500 (2.770)	12.557 (5.122)
NPG	41	9.439 (2.595)	9.707 (2.178)	0.268 (2.187)	4.317 (2.608)	11.416 (3.223)

Note: NPG: No process guidance | BPG: Basic process guidance | EPG: Extended process guidance
[a] measured on a scale from 1 to 13 | [b] measured on a scale from 0 to 8 | [c] measured in minutes

Appendix E

Table E1 lists the items in the survey.

Table E1: Measures of Survey Constructs

Construct	Item	Question	Source
Perceived usage of ITSM ProcessGuide	USAGE1	My current usage of the ITSM ProcessGuide is (very infrequent…very frequent).	(Bajaj & Nidumolu, 1998)
	USAGE2	I currently use the ITSM ProcessGuide…(not at all, less than once a week, about once a week, 2 or 3 times a week, 4-6 times a week, about once a day, more than once a day).	
	USAGE3	Regarding the use of the ITSM ProcessGuide in the past four months, I have…(never tried it at all, tried it once but not since then, used it earlier but stopped now, used it for about 10% of the time I use the ticketing system, used it for between 10 and 50% of the time I use the ticketing system, used it more than 50% of the time I use the ticketing system).	
Perceived process knowledge	PK1	To what extent does the ITSM ProcessGuide help you to comprehend the ticket processes represented in the ticketing system?	(Bera, Burton-Jones, & Wand, 2011)
	PK2	To what extent does the ITSM ProcessGuide help you to understand the ticket processes represented in the ticketing system?	
	PK3	Overall, the ITSM ProcessGuide helps me to grasp information about the ticket processes represented in the ticketing system.	
Perceived process execution efficiency	PEFFI1	Using the ITSM ProcessGuide in the ticketing system helps me to spend less time on my ticket process execution.	(Bhattacherjee & Premkumar, 2004; Compeau, Higgins, & Huff, 1999)
	PEFFI2	Using the ITSM ProcessGuide in the ticketing system increases my quantity of ticket process execution outputs for the same amount of effort.	
	PEFFI3	Overall, using the ITSM ProcessGuide in the ticketing system enhances my efficiency in executing ticket processes.	
Perceived process execution effectiveness	PEFFECT1	Using the ITSM ProcessGuide in the ticketing system helps me to execute the ticket processes more accurately.	(Bhattacherjee & Premkumar, 2004; Compeau et al., 1999)
	PEFFECT2	Using the ITSM ProcessGuide in the ticketing system increases the quality of my ticket process execution output.	
	PEFFECT3	Overall, using the ITSM ProcessGuide in the ticketing system enhances my effectiveness in executing ticket processes.	

Note: For reasons of anonymity, we substituted the name of the company's ticketing system with #Ticketing System#.

Appendix F

Table F1 and Table F2 list the results of the confirmatory factor analysis and the assessment of the reflective measurement model of the survey.

Table F1. Results of Confirmatory Factor Analysis

	PK	PEFFI	PEFFECT	USAGE
PK1	**0.842**	0.339	0.352	0.147
PK2	**0.836**	0.364	0.344	0.155
PK3	**0.824**	0.360	0.301	0.184
PEFFI1	0.417	**0.763**	0.363	0.117
PEFFI2	0.362	**0.854**	0.209	0.183
PEFFI3	0.285	**0.828**	0.402	0.072
PEFFECT1	0.460	0.297	**0.748**	0.176
PEFFECT2	0.345	0.300	**0.829**	0.183
PEFFECT3	0.314	0.510	**0.757**	0.105
USAGE1	0.189	0.018	0.041	**0.890**
USAGE 2	0.143	0.089	0.054	**0.909**
USAGE 3	0.006	0.181	0.239	**0.840**

Note: PK = Perceived Process Knowledge | PEFFI = Perceived Process Execution Efficiency | PEFFECT = Perceived Process Execution Effectiveness | USAGE = Perceived Process Guidance Usage

Table F2. Assessment of Reflective Measurement Model

				Fornell-Larcker Criterion			
Construct	**Item**	**Mean**	**SD**	**PK**	**PEFFI**	**PEFFECT**	**USAGE**
Perceived process knowledge (CR=0.988; α=0.981; AVE=0.964)	PK1	4.462	1.278	**.982**			
	PK2	4.449	1.307				
	PK3	4.692	1.264				
Perceived process execution efficiency (CR=0.970; α=0.953; AVE=0.914)	PEFFI1	4.192	1.350	.756	**.956**		
	PEFFI2	4.192	1.261				
	PEFFI3	4.295	1.360				
Perceived process execution effectiveness (CR=0.968; α=0.950; AVE=0.909)	PEFFECT1	4.705	1.134	.770	.776	**.953**	
	PEFFECT2	4.526	1.163				
	PEFFECT3	4.526	1.227				
Perceived process guidance usage (CR=0.926; α=0.881; AVE=0.807)	USE1	2.295	1.477	.351	.314	.356	**.899**
	USE2	2.385	1.222				
	USE3	2.987	1.286				

Note: CR = Composite reliability | α = Cronbach's alpha | AVE = Average variance extracted | SD = Standard derivation

Table F3. Item Correlations

	PEFFECT1	PEFFECT2	PEFFECT3	PEFFI1	PEFFI2	PEFFI3	PK1	PK2	PK3	USAGE1	USAGE2	USAGE3
PEFFECT1	1.000											
PEFFECT2	0.847	1.000										
PEFFECT3	0.849	0.894	1.000									
PEFFI1	0.733	0.703	0.775	1.000								
PEFFI2	0.622	0.604	0.730	0.874	1.000							
PEFFI3	0.680	0.680	0.829	0.870	0.871	1.000						
PK1	0.758	0.708	0.728	0.736	0.693	0.682	1.000					
PK2	0.756	0.714	0.724	0.765	0.702	0.697	0.989	1.000				
PK3	0.742	0.668	0.691	0.741	0.696	0.672	0.921	0.929	1.000			
USAGE1	0.297	0.283	0.197	0.242	0.265	0.148	0.288	0.290	0.323	1.000		
USAGE2	0.295	0.300	0.241	0.235	0.318	0.202	0.304	0.309	0.317	0.768	1.000	
USAGE3	0.358	0.373	0.346	0.312	0.326	0.317	0.300	0.316	0.329	0.657	0.713	1.000

Note: PK = Perceived Process Knowledge | PEFFI = Perceived Process Execution Efficiency | PEFFECT = Perceived Process Execution Effectiveness | USAGE = Perceived Process Guidance Usage

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