Enterprise Systems Knowledge, Beliefs, and Attitude: A Model of Informed Technology Acceptance

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Abstract

Fostering positive attitudes and increasing knowledge are key success factors for enterprise systems. Training can improve knowledge, but little research has investigated the effects of domain-relevant knowledge on salient cognitive beliefs and attitude in technology acceptance. We highlight the critical role of domain-relevant knowledge in the formation of beliefs and the shaping of attitude by developing a model of informed technology acceptance. We hypothesize the positive effects of multi-dimensional enterprise resource planning (ERP) knowledge on salient cognitive beliefs (i.e., ERP self-efficacy, perceived ease of use, and perceived usefulness) and general affective attitude toward an ERP system. Using survey data from gamified ERP training of 248 professionals from three different organizations, results support the proposed model, suggesting that ERP knowledge is an important antecedent of ERP self-efficacy, perceived ease of use, perceived usefulness, and attitude. We find that ERP knowledge exhibits both direct and indirect effects on attitude. Moreover, we find that gamified training is an effective means of improving ERP knowledge.

Keywords: knowledge, enterprise resource planning, technology acceptance, gamification, serious games

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1. Introduction

Organizations continue to struggle with enterprise system (ES) implementations, spending more than $400 billion USD annually (Gartner, 2018) and facing challenges with ROI and overall satisfaction (Computer Economics, 2019). Enterprise resource planning (ERP) systems, the most complex and expensive type of ES, can improve firm performance (Hitt et al., 2002) but are renowned for failed implementations (Ali & Miller, 2017). Despite more than two decades of research on critical success factors for ERP projects (Chatzoglou et al., 2016; Finney & Corbett, 2007), education and training continue to present significant roadblocks for ERP success (Loonam et al., 2018), and they are among the most important and most controllable success factors (Baykasoğlu & Gölcük, 2017). Improving employees' knowledge, beliefs, and attitudes regarding ERP systems through training is critical to success, but has received insufficient attention in both research (Esteves, 2014) and practice (Panorama, 2015).

Knowledge, of course, is the primary objective of education and training activities. Domain-relevant knowledge is central to the formation and strengthening of attitudes (Petty & Brinol, 2014). Learning (i.e., the acquisition of knowledge) creates or updates a set of beliefs about an object. The mechanisms through which knowledge influences beliefs have been studied in contexts such as entrepreneurship (Roy et al., 2017), eco-friendly purchasing (Waris & Ahmed, 2020), and personal finance (Xiao et al., 2011). Those beliefs, in turn, contribute to the formation of an overall attitude toward that object, and ultimately to intentions and behaviors relating to that object (Ajzen, 1991). Stated differently, training leads to knowledge, knowledge to beliefs, beliefs to attitude, attitude to intention, and intention to behavior.

In the domain of technology acceptance, prior literature has deeply explored salient beliefs (i.e., ease of use, usefulness) and attitudes (Davis, 1989), including in the specific context of

ERP (e.g., Amoako-Gyampah & Salam, 2004). It has also highlighted the importance of training to develop information technology (IT) knowledge and competencies (e.g., Sharma & Yetton, 2007), striving to address the challenges of IT-induced organizational change such as those experienced in ERP implementations. Given that knowledge plays a critical role in some theories of technology adoption (e.g., Rogers, 2010), specifically, domain-relevant knowledge, it has received relatively less consideration in the mature domain of technology acceptance (Davis, 1989; Venkatesh & Bala, 2008).

Reviewing the above flow from training to knowledge to beliefs (and eventually to behavior), we note a research gap in the technology acceptance literature between knowledge and beliefs in general, and for ERP systems more specifically. Prior literature has considered numerous antecedents to technology acceptance beliefs (Venkatesh & Bala, 2008); however, knowledge *per se (*specifically, domain-relevant knowledge) has been largely absent from this literature. Thus, given the sustained importance of the ERP context, and the importance of domain-relevant knowledge in establishing and strengthening beliefs and attitudes, our primary research objective is *to develop and test a model of informed technology acceptance*. The purpose of this paper is to determine the effects of domain-relevant knowledge on beliefs and attitude.

We develop our model based on the theory of planned behavior (TPB; Ajzen, 1991). We acknowledge the substantial body of literature related to the technology acceptance model and situate it as it was originally developed, as a specific case of the theory of reasoned action, TPB's predecessor (Davis et al., 1989). Our model contributes to theory by extending the nomological network of technology acceptance in the specific context of ERP (in this study), but with implications for the broader domain of information systems, by incorporating perceived ERP domain knowledge[1] as an antecedent to salient cognitive beliefs and affective attitude toward ERP systems. In adopting a contextualized and multi-dimensional view of knowledge,

[1] For brevity, we use the term ERP knowledge henceforth to refer to perceived ERP domain knowledge.

we offer a richer understanding of the mechanisms through which ERP knowledge influences beliefs and attitude, and suggest that future research can incorporate similar domain-relevant knowledge constructs. We contribute to practice by offering actionable guidance for specific types of knowledge to target with ERP training, going beyond general guidance to improve perceptions of usefulness and ease of use.

We test the model in the context of gamified ERP training, based on the assumption that the predictive power of knowledge will increase with its domain specificity, and recognizing that education and training are critical to the success of ERP systems. Accordingly, we also investigate the effectiveness of gamified ERP training for improving training as an exploratory objective of the paper. Gamification involves the use of game design elements in non-game contexts (Deterding et al., 2011), and offers great potential for improving ERP implementation outcomes (El-Telbany & Elragal, 2017). The outcomes of gamification can vary greatly depending on the organizational context and need (Landers et al., 2018). The use of serious games (Dörner et al., 2016) is closely related to gamification, as the "aspects of serious games that game designers change in order to improve learning form the toolkit of gamified learning" (Landers, 2014, p. 754). Thus, "gamifying" ERP training can help achieve desirable outcomes as, based on our proposed model of informed technology acceptance, knowledge gained during gamified training is instrumental in enhancing beliefs and attitude toward ERP systems.

2. Theoretical Development

2.1. Reasoned Action, Planned Behavior, and Technology Acceptance

We adopt the perspective that technology acceptance decisions are based on principles of reasoned action, such that behavior and intention are motivated by an overall affective evaluation (i.e., attitude) toward a system, and that this attitude forms based on a set of salient cognitive beliefs about the system (Fishbein & Ajzen, 1975). While attitude toward an object is a generalizable concept, the theory of reasoned action suggests that salient cognitive beliefs will vary across contexts and should be tailored to the relevant domain. This view of reasoned action has evolved in two important directions since its inception. First, the general theory was extended to incorporate aspects of behavioral control, leading to the development of TPB (Ajzen, 1991). Second, many social science disciplines have developed contextualized models based on reasoned action and TPB, seeking to leverage TPB as a powerful, parsimonious, and extendible foundation for explaining attitudes and behaviors in various contexts. One of the more well-known and enduring adaptations of this theory is the technology acceptance model (Davis, 1989).

The technology acceptance model posits two salient cognitive beliefs that are generalizable across technologies to explain attitude and intention: the expected utility of the technology – perceived usefulness (PU); and the anticipated difficulty of using the technology – perceived ease of use (PEOU). Additionally, PEOU influences PU (Davis, 1989). While many studies position behavioral intention to use a technology as the primary dependent variable, in a mandatory-use context such as ERP, attitude is a more appropriate target outcome for technology acceptance (Brown et al., 2002). Moreover, prior literature suggests that attitude is an important determinant of intention in both hedonic (Lin & Bhattacherjee, 2010) and learning (Cheng, 2011) contexts, both of which are relevant to a gamified training approach.

Context-specific extensions of the technology acceptance model typically include additional antecedents of PEOU and PU (e.g., Cheung & Vogel, 2013; Gefen & Straub, 1997). Several studies extend the model in the context of ERP acceptance (e.g., Al-Jabri & Roztocki, 2015; Bagchi et al., 2003; Chen et al., 2011). One extension focuses on the effects of extent of training (i.e., number of hours) and reactions to training on acceptance beliefs, finding that training reactions were significant predictors of PEOU and PU (Marler et al., 2006). Another extension incorporates shared beliefs in system benefits as an antecedent of perceived usefulness and perceived ease of use, with communication and training influencing this shared belief (Amoako-Gyampah & Salam, 2004), providing indirect support for the importance of knowledge acquired via training on beliefs about ERP systems.

Despite other adaptations of TPB incorporating domain-relevant knowledge as a key antecedent to salient cognitive beliefs (e.g., Croy et al., 2010; Moores et al., 2009; Roy et al., 2017; Waris & Ahmed, 2020; Xiao et al., 2011; Yadav & Pathak, 2016), we found little such work in the domain of technology acceptance. Thus, this study investigates how domain-relevant knowledge contributes to individuals' beliefs and attitudes toward ERP systems.

2.2. ERP Knowledge

We adopt the definition of knowledge as "justified belief that increases an entity's capacity for effective action" (Alavi & Leidner, 2001, p. 109). Based on this definition, salient cognitive beliefs in technology acceptance represent knowledge about properties of that system, i.e., an individual's knowledge about the system's ease of use (PEOU) and usefulness (PU). We suggest that these two beliefs are of a higher order, and that they result from more fundamental knowledge about a system. Knowledge about an object (an ERP system in this case) thus *informs* cognitive beliefs and affective attitude toward that object.

We focus here on individual knowledge, and note that prior literature has considered organizational ERP knowledge as critical to ERP system success (Sharma & Yetton, 2007; Stratman & Roth, 2002). Consistent with organizational knowledge literature, we also suggest that organizational knowledge is rooted in individual knowledge (Grant, 1996; Nonaka, 1994). Individual knowledge is, therefore, of significant practical and theoretical interest.

In the information systems literature, knowledge has traditionally taken the form of "user competence" with IT (Bassellier et al., 2003; Marcolin et al., 2000; Santhanam & Sein, 1994). User competence with IT is a rich multi-dimensional concept, but represents a broad cross-section of IT-related knowledge (Marcolin et al., 2000). While this is helpful for studying broader IT phenomena such as project management and business-IT communication (Bassellier et al., 2003), the general nature of this knowledge limits its utility in studying specific IT such as ERP systems. While a few studies have developed richer domain-relevant knowledge constructs relating to individual technology acceptance (e.g., smart phone usage; Koo et al., 2015), most employ a simpler unidimensional concept of self-perceived knowledge (e.g., Aggarwal et al., 2015; Darban et al., 2016; Kwak & McDaniel, 2011). Of these, only one considers ERP knowledge specifically, with knowledge change during training as a predictor of intention to continue learning about ERP systems (Darban et al., 2016).

Given the complexity of ERP systems, and the critical importance of training to promote knowledge about the application, business context, and collaborative tasks supported by an ERP system (Sharma & Yetton, 2007), we suggest that a unidimensional concept of self-perceived knowledge is insufficient for studying salient beliefs and attitudes toward ERP systems. To effectively use such systems, users must have knowledge of business processes and task interdependencies in addition to technical proficiency (Orlikowski & Gash, 1994; Sein et al., 2001). As tasks become standardized and complex systems enforce business rules and manage interdependencies, users require deeper and broader knowledge to effectively utilize the system. To account for these deeper knowledge requirements, Sein et al. (2001) propose a hierarchical model of knowledge by considering tool-procedural knowledge at the individual level, business-procedural knowledge at the team level, and tool-conceptual knowledge at the department level – each resting on a common foundation of business-motivational knowledge (e.g., understanding the interdependence of tasks).

Extending this model to the context of collaborative applications, Kang and Santhanam (2003) propose that good work processes result from three primary types of knowledge that are appropriated and refined through information system use: application knowledge (tool concepts and procedures), business context knowledge (business procedures and motivations), and collaborative task knowledge (interdependencies and collaborative problem solving). This conceptual division of knowledge dimensions lends itself well to the domain of ERP, which entails application knowledge using an often-complex interface, multiple business processes, and task and process interdependencies. Cronan and Douglas (2013) contextualize collaborative application knowledge by developing a conception of ERP knowledge with three related dimensions: transaction skill knowledge, business process knowledge, and ES management knowledge.

Transaction skill knowledge represents the extent to which a user can use the system to perform discrete functions related to business operation and the setup and use of master data in an ERP system. Moving beyond transaction skill proficiency, business process knowledge is the extent to which a user understands and can differentiate between operational processes and business terminology within and between functional areas of a business. ES management knowledge is the extent to which a user understands the importance of interdependent business processes and integrated information in an organization, and how ERP supports these needs (e.g., organizational structures, controls, decision making) (Cronan & Douglas, 2013). Prior literature has tested these knowledge dimensions in the context of traditional classroom training with undergraduate students (Cronan & Douglas, 2012; Seethamraju, 2011), online classroom training with MBA students (Hwang & Cruthirds, 2017), and training with working professionals (Deranek et al., 2019). Further, this self-assessed knowledge construct correlates strongly with objective assessments of knowledge (Cronan et al., 2012) and with generalized attitudes toward ERP systems (Deranek et al., 2019).

Despite the importance of knowledge in the formulation of beliefs and attitude, we found few studies assessing the impact of domain-relevant knowledge on technology acceptance. One study highlights the importance of self-perceived knowledge on likelihood of acceptance, but does not explicitly consider mediating mechanisms through which this phenomenon occurs (Aggarwal et al., 2015). A study in the fantasy sports context shows a positive impact of perceived subject-matter knowledge on general attitude and intention (Kwak & McDaniel, 2011), but does not account for the effect of knowledge on specific technology acceptance beliefs. Another study shows a positive impact of understanding (via two general questions about understanding a new system and its organizational impact) on excitement and confidence about a system-induced change (Washington & Hacker, 2005), but not on specific beliefs about the system itself. Overall, we note inconsistencies in knowledge measures and the need for a richer conceptualization of self-assessed knowledge. We thus adopt a more integrative perspective of ERP knowledge (comprised of three related dimensions) based on Cronan and Douglas (2013) and situate this construct as an antecedent of technology acceptance beliefs and attitude.

2.3. Self-efficacy

Self-efficacy refers to an individual's belief that she can accomplish a task, and may be conceptualized at a level of broad generalizations about any task (Bandura, 1982), a group of similar tasks – e.g., computer self-efficacy (Compeau & Higgins, 1995), or a specific task – e.g., application-specific computer self-efficacy (Agarwal et al., 2000). As it relates to TPB, Ajzen (1991, p. 184) referred to perceived behavioral control (a core generalizable belief in TPB) as being "most compatible with Bandura's… concept of perceived self-efficacy".

Factors that influence the formation of self-efficacy include enactive performance, vicarious experience, verbal persuasion, and emotional arousal (Bandura, 1977). Prior literature suggests that enactive performance, or hands-on experience with a task, is the strongest mechanism through which self-efficacy forms, and this view is supported in the literature (Gist & Mitchell, 1992). The influences of these factors and the formation of self-efficacy are dynamic, changing over time and through phases of self-efficacy development (Gist & Mitchell, 1992).

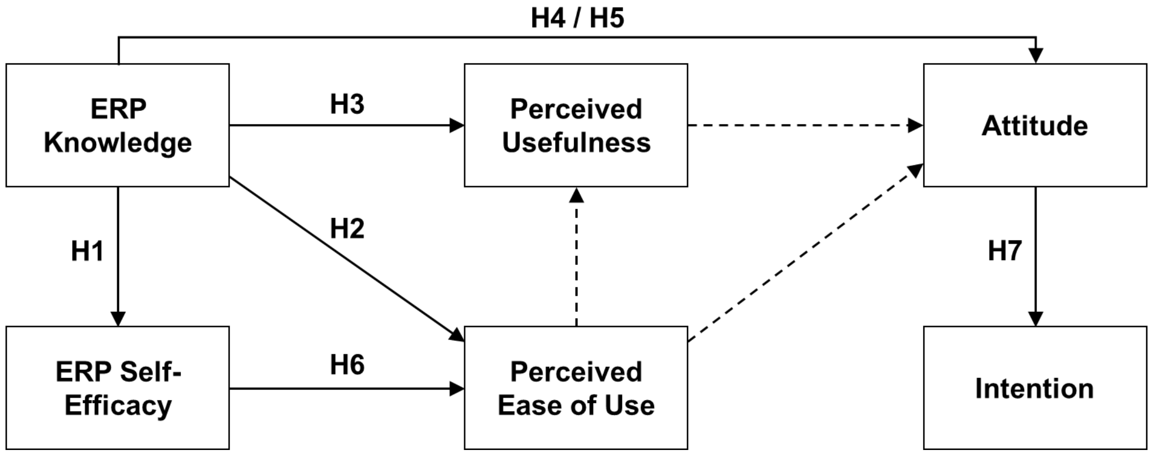
Bandura (1982) suggests that the study of self-efficacy be tailored to the domain and task under investigation. While general self-efficacy is an established phenomenon which influences more specific self-efficacy beliefs, the most accurate predictors of attitude and behavior should be those beliefs that are more germane to the behavior itself. Accordingly, computer self-efficacy (CSE) represents a more specific belief in one's ability to use computers and software successfully (Compeau & Higgins, 1995). As it relates to technology acceptance, CSE is an established antecedent of PEOU, but not PU (Venkatesh & Bala, 2008). Application-specific CSE (AS-CSE) is a stronger predictor of relevant beliefs than general CSE (Agarwal et al., 2000; Yi & Hwang, 2003), so we consider ERP self-efficacy, or one's belief in the ability to successfully use the ERP system to accomplish business and task outcomes, as the most appropriate level of construal to study beliefs and attitude toward ERP systems.

In the following section we present our research model and develop hypotheses describing the relationships between knowledge, self-efficacy, technology acceptance beliefs, and attitude toward ERP systems.

2.4 Hypotheses

Based on TPB (Ajzen, 1991), collaborative application knowledge (Cronan & Douglas, 2013; Kang & Santhanam, 2003), and attitude literature (e.g., Petty & Krosnick, 1995), we propose that ERP knowledge is an important antecedent of ERP self-efficacy, technology acceptance beliefs, and attitude toward ERP systems. **Figure 1** illustrates the proposed model of informed technology acceptance. Established relationships in the nomological network of technology acceptance are modeled but not hypothesized. These relationships include the effects of PEOU and PU on attitude and the effect of PEOU on PU. Consistent with prior literature, we expect that these relationships will remain strong and significant (King & He, 2006). The proposed model focuses on ERP knowledge (domain-relevant) and its influence on salient cognitive beliefs and general affect (i.e., attitude) toward ERP systems. Consistent with prior literature, we posit ERP self-efficacy as an antecedent of PEOU. Recognizing the central role of attitude in explaining intention and behavior (Dwivedi et al., 2019), and acknowledging that even mandated use may be circumvented or socially negotiated (Tsai et al., 2017), we also include behavioral intention as an outcome of attitude toward ERP systems.

Figure 1. A Model of Informed Technology Acceptance



2.4.1. ERP Knowledge and Self-Efficacy Beliefs

Based on learning experiences, individuals assess their own knowledge (Bandura, 1982), and that self-assessment affects subsequent cognitive development and functioning (Bandura, 1993). Self-assessed knowledge is a correlate and antecedent of self-efficacy in multiple contexts (Ineson et al., 2013; Sitzmann et al., 2010; Zhao et al., 2005). Consistent with the original conceptualization of self-efficacy (Bandura, 1977), we suggest three mechanisms through which knowledge may contribute to the formation of ERP self-efficacy: performance accomplishments, vicarious observation, and verbal persuasion.

Hands-on experience (i.e., *performance accomplishments*) gained with ERP systems should reinforce the self-perception that an individual is able to successfully use the system to achieve positive results, particularly in terms of transaction skill knowledge. When learning about the system, shared experiences afford *vicarious observation* as individuals observe how others navigate and use the system (i.e., transaction skill knowledge) and how the system supports integrated processes (i.e., ES management knowledge). Observing others' successful use of the system helps create confidence that one can successfully use the ERP system to achieve desired outcomes. *Verbal persuasion* (e.g., through training) fosters knowledge through discussions focused on understanding business processes. Such knowledge enhances both self-efficacy and outcome expectations by developing a holistic perspective of the value of an ERP system (i.e., ES management knowledge).

In other contexts, knowledge is found to affect self-efficacy (e.g., Ineson et al., 2013). Knowledge also affects confidence (a concept very similar to self-efficacy) in decisions such as purchasing a home PC (Tang et al., 2011). In the context of technological pedagogical content knowledge (a multi-dimensional knowledge construct similar to the ERP knowledge construct), knowledge affects teacher self-efficacy beliefs (Abbitt, 2011). Thus, we expect similar effects of knowledge on self-efficacy in the specific context of ERP systems.

H1: Higher levels of ERP knowledge are associated with improved ERP self-efficacy.

2.4.2. ERP Knowledge and Beliefs (PEOU and PU)

If a user perceives a system as complex and unfamiliar, then PEOU will be lower. Knowledge of ERP transaction skills, particularly through hands-on experience, can increase a user's comfort level with a complex system interface such as those in typical ERP systems, and support more efficient routines for system use (Ferratt et al., 2018). Also, knowledge about how an ES supports integrated business processes should improve PEOU by instilling an understanding of how the management of the overall business process will require less effort, even if certain steps in the process are more difficult to accomplish with the ERP system. For example, requiring the use of the ERP system to record inventory withdrawals for production or fulfillment processes may introduce a new step that slows down the execution of a process, but the value gained from having accurate inventory levels for decision making reflects an overall efficiency in managing the process. This logic is congruent with the business-motivational knowledge in the hierarchy proposed by Sein et al. (2001). Knowledge in other domains has been shown to support both controllability (a similar concept to PEOU) as well as self-efficacy (Xiao et al., 2011).

H2: Higher levels of ERP knowledge are associated with improved PEOU.

Technology acceptance literature suggests that four cognitive factors affect PU: PEOU, output quality, job relevance, and result demonstrability (Venkatesh & Davis, 2000). As ERP knowledge increases, the user learns how to use an ERP system to support integrated business processes. Higher levels of transaction knowledge (e.g., how to read and customize ERP screens and reports) will increase perceived output quality through transaction use. By learning the ERP system's functional capabilities, the user better understands the outcomes associated with its use (Ferratt et al., 2018). Higher levels of business process and ES knowledge allow an individual to see how her job is relevant in the context of the larger integrated enterprise, thereby increasing perceptions of job relevance. Further, higher levels of knowledge about how ERP supports integrated business processes (ES management knowledge) will increase the perception of demonstrable results, as "knowing that IT can support an organization's strategy leads one to believe in the usefulness of IT" (Bassellier et al., 2001).

H3: Higher levels of ERP knowledge are associated with improved PU.

2.4.3. ERP Knowledge and System Attitude

Attitude occupies a central role in social science research, and we adopt its definition here as the extent to which one has a favorable or unfavorable evaluation of an object or behavior (Ajzen, 1991). Attitude-relevant knowledge is among the most influential predictors of attitude strength (i.e., the extent of favorable or unfavorable evaluation) (Krosnick et al., 1993; Petty & Krosnick, 1995). The fundamental relationship between knowledge and attitude manifests through the formation of stronger (i.e., more polarized) attitudes as knowledge about a topic increases (Tesser & Leone, 1977). That is, for those with lower levels of knowledge about a topic, other factors such as social influence are likely to have a stronger effect on attitude (e.g., Galletta et al., 1995), with less attitude-relevant knowledge on which to anchor an attitudinal disposition. Knowledge influences attitude in other technology-related contexts, such as when purchasing a home computer (Tang et al., 2011). Taking the form of cognitively developed "change schema," knowledge also influences attitudes toward a specific change such as that brought about by ERP systems (Lau & Woodman, 1995). ES management knowledge reflects an appreciation of the complexity and interdependence of business processes, and how ERP systems support an enterprise. We suggest that understanding of the "big picture" of ERP is an important component in the formation of attitudes toward ERP, above and beyond the influences of perceived usefulness and ease of use.

H4: Higher levels of ERP knowledge are associated with improved attitude toward ERP.

We expect ERP knowledge to also contribute indirectly to attitude through PEOU and PU. While the original technology acceptance model suggested that PEOU and PU fully mediate the effects of external variables, with some studies supporting this assertion (e.g., Gursoy et al., 2019), other work has highlighted cases of partial mediation (e.g., Burton-Jones & Hubona, 2006; Ooi & Tan, 2016). As discussed above, knowledge about a system enhances beliefs about that system's ease of use and usefulness. For example, as a user learns to navigate a new ERP system, she may identify "shortcuts" for executing common tasks and develop a better understanding of how the ERP system presents information to support decision making. The user's ability to navigate the system (i.e., PEOU) improves, as does her ability to act on information provided by the system (i.e., PU). These beliefs, anchored by knowledge, subsequently influence the user's overall evaluation of a system. Knowing how to use a system with minimal effort, and understanding how that system can provide value through its use, contribute to overall positive affect (i.e., attitude) toward the system.

H5: PEOU and PU partially mediate the effect of ERP knowledge on attitude toward ERP.

2.4.4. Self-efficacy and PEOU

As users' beliefs about their ability to successfully complete tasks using an ERP system increase (i.e., ERP self-efficacy), they will perceive the system as being easier to use. Venkatesh and Bala (2008) confirm CSE as an important anchor on which PEOU is formed, and other studies have found AS-CSE to be an antecedent of PEOU (e.g., Agarwal et al., 2000). Consistent with prior literature, we expect ERP self-efficacy to exhibit similar effects on perceptions that the ERP system is easy to use.

H6: Higher levels of ERP self-efficacy are associated with improved PEOU.

2.4.5. Attitude and Intention

Consistent with the original technology acceptance model (Davis et al., 1989) and TPB literature (Ajzen, 1991), we posit that behavioral intention is strongly influenced by an individual's attitude toward using the system. Attitude plays a central role in acceptance and use of a system by mediating the effects of PEOU and PU on intention, and through its direct influence on behavior (Dwivedi et al., 2019). Simply put, favorable appraisals (i.e., attitude) about an ERP system should lead to increased use intention (and, ultimately, use behavior) because individuals are more likely to pursue activities that they perceive as good and worthwhile. Prior TPB research has shown that attitude can significantly affect intention to use new systems in contexts such as e-commerce (Pavlou & Fygenson, 2006) and e-government (Rana et al., 2017). We therefore expect similar effects in the ERP context.

H7: Higher levels of attitude are associated with improved behavioral intention.

3. Methods

3.1. Gamified Training

For the exploratory component of the study, we used gamified ERP training for improving domain-relevant knowledge. Games and play are essential tools for acquiring knowledge (Gee, 2003; Spinka et al., 2001), and the increasing convergence of work and play calls for greater study of how people develop knowledge and skills for the collaborative workplace (Petter, 2017). One meta-analysis indicates that a particular type of serious game, computer-based simulation, is superior to classroom instruction in terms of both affective and cognitive learning (Sitzmann, 2011). Similarly, problem-based learning (an approach typically used in serious games) leads to more positive attitudes (Vernon & Blake, 1993) and more effective learning of advanced concepts (Gijbels et al., 2005) than traditional training. Increasingly, organizations draw inspiration from games to promote learning (Koivisto & Hamari, 2019), motivate behavior (e.g., Suh et al., 2017), and improve engagement and problem-solving outcomes (e.g., Li et al., 2014). Intrinsic and hedonic motivations (i.e., inclination toward pleasurable activities) such as those fulfilled by games are central to the study of technology acceptance, evaluation and continued use (Hwang, 2005; Köse et al., 2019; Lowry et al., 2013).

The quality of education and training is an important predictor of ERP implementation success and post-implementation performance (Ram et al., 2013). Education and training should also instill confidence in the project and in users' ability to successfully navigate the change (Armenakis et al., 1993), as well as a positive attitude about the change and its impact on the organization (Piderit, 2000). Confidence and attitudes subsequently impact proactive, extended use of the system and willingness to recommend the system to others (Dennis et al., 2017; Yen et al., 2015). Exploratory use of a system during training also influences extended system use, particularly in a climate that encourages innovative behavior and embraces higher risk (Liang et al., 2015), such as that experienced during gamified training.

We suggest that serious games offer an effective training method to help reduce psychological barriers while promoting deeper levels of relevant knowledge. Serious games offer a fun and engaging way to achieve instrumental goals (e.g., learning) (Dörner et al., 2016), and team-based collaborative learning is an area of growing theoretical and practical interest (Hull et al., 2019). To determine the effectiveness of gamified ERP training (the exploratory component of this research), we evaluate learning based on pre- and post-training measures of ERP knowledge and compare effect sizes to results from a meta-analysis of organizational training interventions.

3.2 Study Context

We conducted this study with groups of working professionals in a behavioral research laboratory at a large Midwestern U.S. university. The study consisted of a series of twelve-hour workshops (conducted over two partial days each) in which groups of participants learned about ERP systems and competed in a simulation game using SAP ERP[2]. After dividing participants into teams of three or four participants each, the facilitator (first author) presented core ERP concepts and provided information about the shared market environment of the game.

The first part of the workshop experience focuses on an introductory version of ERPsim (Léger et al., 2007)[3], a serious game designed to teach ERP concepts, in which teams use SAP to manage fulfillment, manufacturing, and procurement processes for a muesli manufacturing firm in Germany. The introductory game consists of three rounds, with each round adding additional responsibility for one of the processes: fulfillment in the first round, production in the second round, and planning and procurement in the third round. Prior to each round, the facilitator presented key concepts and demonstrated transactions necessary to support each process. Teams then spent ten minutes prior to each round to discuss strategy and tactics, practice transactions, and prepare their companies for the upcoming round. Each round consists of thirty virtual days, with each virtual day lasting approximately one minute in clock time. During this time, a market simulator records business transactions for that day in the ERP system. Throughout each round, teams use the data available in the ERP system to guide decision making and manage operational activities. At the end of each round, a leaderboard displays summarized financial results for all teams, ranked by cumulative net income (i.e., profit). In the introductory version of the game, all teams sell the same six products and have a limited number of decisions through which they can differentiate their firms (i.e., pricing,

[2] SAP ERP is the market-leading ERP system and is used in all organizations participating in this study.
[3] We used the most recent available version of ERPsim for each training workshop. During the span of the study (2010-2015), core aspects of the game remained unchanged.

marketing, forecasting and scheduling). The introductory game focuses on operational integration of the processes and development of transaction skills to support those operations.

The second part of the workshop experience involves an extended version of ERPsim which incorporates additional options for strategic decision making using SAP. Teams must continue to operate their firms using the knowledge gained during the introductory game, but can now make strategic decisions to change their product designs (to reach new markets and/or to develop premium recipes) and to reinvest cash into loan repayment, lean manufacturing, or improved production capacity. Teams experiment with these new decisions in a new environment with one additional practice round and are then dismissed for the day. On the second day, the workshop culminates in a competitive four-round simulation in which teams put into practice all that they learned on the previous day, and concludes with a debriefing.

3.3. Participants and Data Collection

The sampling frame consists of 12 workshops conducted over a 6-year time frame with a total of 258 participants from 3 different organizations. Prior to the workshop, participants completed a pre-survey questionnaire. After the completion of the final game, but prior to debriefing, participants completed a post-survey questionnaire. Of the 258 participants, we received matched pre- and post- survey responses from 248, for a response rate of 96.1%. Of the 248 respondents, 177 were male (71.4%). Average age of respondents was 25.9 years (SD = 8.3), with average work experience of 4.1 years (SD = 8.7).

3.4. Measures

Questionnaires used previously validated items for all constructs in the model. All items used seven-point Likert-type scales, with 7 at the positive end of the scale (very high for knowledge items, very good for attitude items, strongly agree for all others) and 1 at the negative end of the scale (very low for knowledge items, very bad for attitude items, strongly disagree for all others). For perceived usefulness, perceived ease of use, and attitude, we adapted items from Venkatesh et al. (2003). For ERP self-efficacy, we selected and adapted items from Compeau and Higgins (1995) consistent with other technology acceptance literature (Venkatesh & Bala, 2008). For ERP knowledge, we adapted items from Cronan and Douglas (2013). During measurement model assessment, we removed items that did not meet generally accepted cutoff criteria for construct validity, retaining three items for perceived usefulness and attitude (we dropped one item from each original scale due to low factor loadings) and four items each for ERP self-efficacy and perceived ease of use. We used single-item measures for three control variables: age, gender, and ERP experience in years. We used multi-item measures for one control variable (pre-training attitude; three items) and for behavioral intention (two items). **Appendix A** provides the measurement instrument used.

To represent and evaluate the concept of multi-dimensional ERP knowledge, we operationalize ERP knowledge as a second-order construct with three first-order formative dimensions (with reflective indicators): ES management knowledge (three items), transaction skill knowledge (four items), and business process knowledge (five items). Reflective indicators for first-order dimensions allow for adequate assessment of the validity and reliability of each component of ERP knowledge, and the formative second-order dimension allows for model parsimony while accounting for the influence of each dimension on an overall representation of ERP knowledge (Petter et al., 2007).

Table 1 presents descriptive statistics and correlations. Means and standard deviations are based on unstandardized latent variable estimates calculated in the measurement model described below.

Table 1. Descriptive Statistics and Correlations

Constructs	Mean	SD	α	CR	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Age	25.92	8.26	1	1	1												
2. Gender	0.71	0.45	1	1	-0.07	1											
3. ERP Years	1.46	3.61	1	1	0.72	-0.15	1										
4. Pre-Attitude	4.66	1.15	0.92	0.95	0.21	-0.10	0.25	0.93									
5. Intention	5.60	1.23	0.91	0.96	0.21	-0.17	0.25	0.36	0.96								
6. Attitude	5.38	1.07	0.92	0.95	0.14	-0.06	0.16	0.49	0.55	0.93							
7. Perceived Usefulness	5.77	0.93	0.90	0.94	0.03	-0.09	0.14	0.40	0.66	0.61	0.91						
8. Perceived Ease of Use	5.41	0.97	0.89	0.93	0.07	-0.04	0.15	0.39	0.39	0.60	0.52	0.90					
9. ERP Self-Efficacy	5.80	0.83	0.79	0.88	-0.06	0.10	0.03	0.02	0.11	0.18	0.27	0.30	0.84				
10. ERP Knowledge (ERPK)	5.01	0.87	0.94	0.95	-0.16	0.00	0.00	0.19	0.22	0.36	0.39	0.42	0.27	0.77			
11. ERPK - Business Process	4.89	0.91	0.90	0.92	-0.14	0.01	0.00	0.21	0.17	0.36	0.34	0.37	0.21	0.93	0.84		
12. ERPK - ES Management	5.37	0.99	0.90	0.94	-0.17	-0.03	-0.06	0.12	0.15	0.30	0.34	0.36	0.24	0.82	0.70	0.92	
13. ERPK - Transaction Skill	4.88	1.09	0.90	0.93	-0.12	0.02	0.03	0.15	0.26	0.28	0.34	0.38	0.28	0.87	0.71	0.55	0.88

Notes: SD: standard deviation. CR: composite reliability. Diagonal elements for multi-item constructs are the square root of average variance extracted (AVE). All correlations > |.13| are significant at $p < 0.05$.

4. Analyses and Results

Prior to evaluating the theoretical model, we assess the impact of the gamified training intervention on all theorized constructs. As expected based on prior studies (e.g., Cronan & Douglas, 2012; Deranek et al., 2019), we observed significant improvements ($p < 0.01$) in all model constructs as a result of the gamified training intervention (**Appendix B** presents pre-post construct difference results). We address our exploratory research objective, to assess the effectiveness of gamified ERP training for improving ERP knowledge, by comparing the effect size of the learning outcomes (ERP knowledge) to effect sizes found in a meta-analysis of organizational training (Arthur et al., 2003)[4]. The effect sizes for ERP learning outcomes (reported in Appendix B) suggest that this gamified training intervention is more effective than average organizational training interventions.

Next, we evaluate the theoretical model based on the results from the post-survey and incorporate control variables captured in the pre-survey for reported years of ERP experience, age, gender, and pre-simulation attitude. As previously noted, all model constructs increased as a result of the gamified training intervention, so we test the model on the foundation of newly acquired knowledge and enhanced perceptions (i.e., post-training). We use partial least squares (PLS), a component-based structural equation modeling (SEM) technique, to analyze the data using the SmartPLS 3 statistical package (Ringle et al., 2015). PLS is robust to underlying distributional assumptions and sample size, effective for testing newly developed theories, and maximizes predictive accuracy (Chin, 1998a). PLS is also well-suited to analyze structural models including both reflective and formative constructs (e.g., Bala et al., 2017).

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[4] We calculate effect sizes using a measure based on Cohen's (1988) *d* that accounts for the correlation of intra-individual measures (i.e., pre- and post-measures per individual) and uses the standard deviation of the pre-test since it is not influenced by the intervention (Morris, 2008). The effect size for change in ERP knowledge (composite), is 1.38, which is very large (Sawilowsky, 2009). By comparison, the average sample-weighted mean of learning effect sizes in a meta-analysis is 0.63 (Arthur et al., 2003) – a medium to large effect (Cohen, 1988). Effect sizes for all ERP knowledge dimensions exceed 1.0, and their 95% confidence intervals do not include 0.63, suggesting that this gamified training is more effective than average organizational training. While salient beliefs and attitude improve with the training, their effect sizes are consistent with those found in the meta-analysis (Arthur et al., 2003).

PLS provides simultaneous analysis of the measurement model and structural model. To evaluate a model containing a second-order formative construct, we follow the repeated indicator approach recommended by Becker et al. (2012)[5]. Because the ERP knowledge construct is exogenous in our model, this is an appropriate method for estimation. In this approach, indicators of first-order reflective constructs are also used as indicators of the second-order formative construct. As a result, the coefficient of determination for the second-order formative construct is 1.0. We estimate structural model parameters using a bootstrapping method with 500 iterations which selected random subsamples of the data to test the model.

4.1. Measurement Model

We assess convergent and discriminant validity using standard guidelines. Cronbach's α values for all constructs exceed the generally accepted threshold of 0.7, suggesting adequate scale reliability (Nunnally, 1978). Additionally, composite reliability scores for each construct exceed 0.85, above the threshold of 0.7 suggested by Werts et al. (1974). The average variance extracted (AVE) for each construct exceeds 0.65, above the 0.5 level recommended by Fornell and Larcker (1981). We report α, reliability, and AVE values in Table 1. All items exhibit primary loadings greater than 0.7 on the expected construct, supporting adequate convergent validity. For reflective constructs, all cross-loadings are smaller than primary loadings, and the square root of the AVE for each construct exceeds all correlations with that construct, suggesting adequate discriminant validity (Chin, 1998b; Fornell & Larcker, 1981). **Appendix C** presents the factor analysis results.

For the second-order formative ERP knowledge construct, weights for each first-order knowledge factor were strong and significant ($p < 0.01$). We also assess multi-collinearity for formative indicators based on variance inflation factors (VIFs), as high levels of collinearity should not affect the structural model (Chin, 1998b) but may mask significant effects (Cenfetelli

[5] We also conducted the two-stage procedure described by Wetzels et al. (2009) and obtained consistent results. For brevity, we do not include these results in the study.

& Bassellier, 2009). All VIFs are below the commonly accepted threshold of 10 (Hair et al., 1998). **Table 2** presents the first-order factor loadings on the second-order ERP knowledge construct, as well as mean and maximum VIFs for each first-order factor.

Table 2. Formative Factor Weights and VIFs

First-order Knowledge Factor	Factor Weight	Mean (Max.) Item VIF
ERP Knowledge - Business Processes	0.46	2.70 (3.86)
ERP Knowledge - Enterprise Systems	0.30	3.21 (3.90)
ERP Knowledge - Transaction Skills	0.38	3.54 (4.39)

Because the study uses self-reported data, we assess the potential threat of common method bias using three methods. Using Harman's (1976) one-factor test, we determined that single factor containing all indicators does not explain a majority of the variance. Next, we examined collinearity among reflective constructs in the model and found that all variance inflation factor (VIF) values are below the recommended threshold of 3.3 (maximum VIF of 2.02) to establish a lack of common method bias (Kock, 2015). Finally, we used a marker variable (culture masculinity-femininity) that is theoretically unrelated to the other factors in the model and found no significant correlations with any model factor (maximum absolute correlation < 0.09), suggesting that common method bias is not an issue (Lindell & Whitney, 2001).

4.2. Tests of Hypotheses and Findings

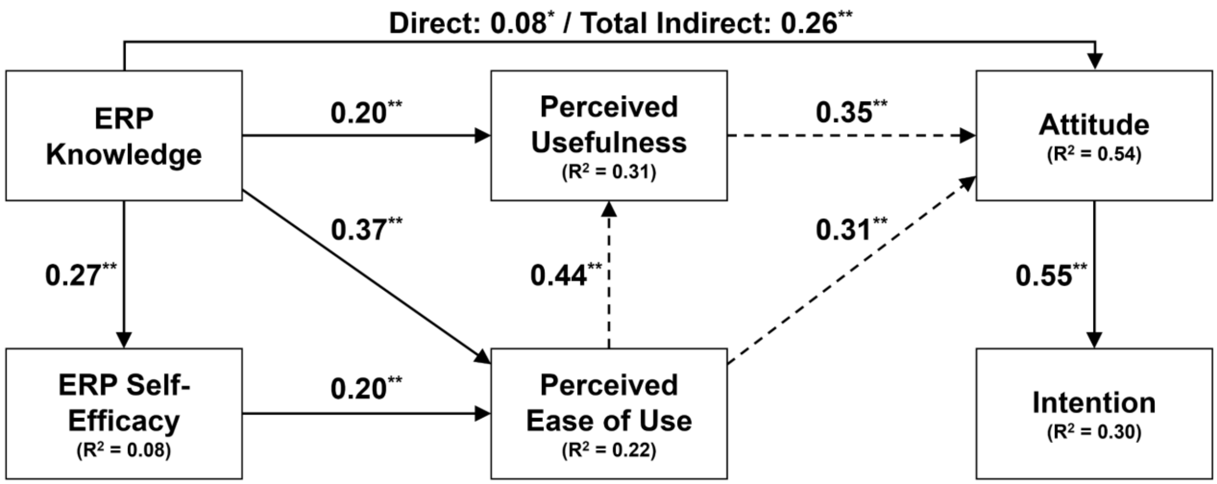
After establishing the adequacy of the measurement model, we consider the results of the structural model. **Table 3** presents the structural model results. Results of the structural model in PLS support the proposed hypotheses, with standardized coefficients and significance levels illustrated for each path in **Figure 2**.

Table 3. Structural Model Results

Hypothesis / Path	β	*t*-statistic	*p*-value	Supported?
1. ERP Knowledge → ERP Self-Efficacy	0.27	4.00	< 0.01	Yes
2. ERP Knowledge → Perceived Ease of Use	0.37	6.59	< 0.01	Yes
3. ERP Knowledge → Perceived Usefulness	0.20	3.33	< 0.01	Yes
4. ERP Knowledge → Attitude (Direct)	0.08	1.78	< 0.05	Yes
5. ERP Knowledge → Attitude (Indirect)	0.26	7.36	< 0.01	Yes
6. ERP Self-Efficacy → Ease of Use	0.20	3.27	< 0.01	Yes
7. Attitude → Intention	0.55	10.80	< 0.01	Yes
Age → Attitude	0.14	2.42	< 0.05	
Gender → Attitude	0.00	0.00	n.s.	
ERP Years → Attitude	-0.09	1.55	n.s.	
Pre-attitude → Attitude	0.21	3.44	< 0.01	
Perceived Usefulness → Attitude	0.35	5.99	< 0.01	
Perceived Ease of Use → Attitude	0.31	5.77	< 0.01	
Perceived Ease of Use → Perceived Usefulness	0.44	7.17	< 0.01	

Notes: Directional hypotheses reported using 1-tailed t-tests for significance levels.

Figure 2. Model with Path Coefficients



Notes: *p<=.05; **p<=.01 using 1-tailed tests for hypothesized relationships.

ERP knowledge, operationalized as a formative second-order construct with three dimensions, exhibits a significant ($p < 0.01$) influence on ERP self-efficacy, supporting H1. Knowledge about ERP systems, especially when gained through hands-on experience, instills confidence in the ability to successfully use an ERP system to accomplish tasks. ERP knowledge also influences perceived ease of use ($p < 0.01$), supporting H2. Gaining knowledge of and experience with ERP systems results in greater perceived ease of use. Equipped with sufficient knowledge of how to use and navigate an ERP system, what was once an imposing and complex user interface is now somewhat less so. ERP knowledge also influences perceived usefulness ($p < 0.01$), supporting H3. Developing knowledge of ERP transaction skills, business processes, and ES management promotes the perception that the use of the system supports instrumental outcomes. Finally, ERP knowledge has a significant ($p < 0.05$) direct influence on attitude toward ERP systems, supporting H4. Knowledge gained from the gamified training experience contributes to a more positive overall assessment of the ERP system.

To test H5, we examine the indirect effects of ERP knowledge on attitude in terms of the total effect (through multiple mediators) and individual indirect effect paths. The total indirect effect of ERP knowledge on attitude is 0.26 ($p < 0.01$; $t = 7.36$), suggesting a substantial overall indirect effect. The indirect effect through PEOU is 0.11 ($p < 0.01$; $t = 4.31$), and through PU is 0.07 ($p < 0.01$; $t = 2.97$). Considering the direct effect of ERP knowledge on attitude (H4), these results suggest partial mediation, supporting H5. We also note, but did not hypothesize, serial indirect effects of ERP knowledge through ERP self-efficacy (via PEOU), with a value of 0.02 ($p < 0.05$; $t = 2.06$), and through PEOU (via PU) with a value of 0.06 ($p < 0.01$; $t = 3.69$).

ERP self-efficacy has a strong and significant ($p < 0.01$) relationship with PEOU, supporting H6. In addition to replicating prior findings, our results illustrate the simultaneous effects of knowledge and self-efficacy on PEOU. Similarly, attitude exhibits a strong and significant relationship with behavioral intention ($p < 0.01$), supporting H7 and suggesting that the central role of attitude in technology acceptance extends to the context of ERP systems.

Among the control variables, two of the four have significant effects on attitude. As expected, pre-training attitude exhibits an anchoring effect with a significant relationship to post-training attitude ($p < 0.01$). Additionally, age is positively related to attitude toward ERP systems ($p < 0.05$), suggesting that attitude toward ERP systems may be higher among older and more experienced professionals. Gender and prior ERP experience did not influence attitude toward

ERP systems. As expected, both PU and PEOU show strong and significant ($p < 0.01$) relationships with attitude, and PEOU shows the expected relationship ($p < 0.01$) with PU.

Given the flow from training to knowledge to beliefs (and eventually to behavior), we have addressed a research gap in the technology acceptance literature between knowledge and beliefs, and for ERP systems more specifically. While prior literature considers many antecedents to technology acceptance beliefs (Venkatesh & Bala, 2008), our research results focus on knowledge *per se (*specifically, domain-relevant knowledge) which has been largely absent from this literature. Given the importance domain-relevant knowledge (in the ERP context) in establishing and strengthening beliefs and attitude, our research focused on *a model of informed technology acceptance* to determine the effects of domain-relevant knowledge on beliefs and attitude. Given the hypothesis test results, domain-relevant knowledge does affect beliefs and attitude, thereby establishing *informed* acceptance of ERP systems.

5. Discussion

In summary, ERP (domain-relevant) knowledge (in this study, developed through gamified training) improves salient beliefs and general attitude toward ERP systems. To achieve our primary research objective, we develop a model of informed technology acceptance based on TPB and draw on a hierarchical view of ERP knowledge to illustrate how knowledge directly influences ERP self-efficacy, PEOU, PU, and attitude toward ERP systems.

Importantly, ERP knowledge directly influences multiple salient beliefs and attitude toward ERP systems. The direct effect of knowledge on self-efficacy is consistent with prior literature (e.g., Ineson et al., 2013), and indicates how knowledge about a system impacts confidence in using that system. ERP knowledge has a particularly strong direct effect on PEOU, in addition to an indirect effect via self-efficacy. This illustrates an important, but understudied, factor in technology acceptance. For ERP systems that are often criticized as having complex and difficult interfaces, knowledge about the ERP system is critical to improving ease of use perceptions. Further, ERP knowledge directly influences PU by providing users with a holistic and multi-level perspective of how ERP systems benefit organizations. We also observe a small but significant direct effect of ERP knowledge on attitude, suggesting that promoting holistic knowledge of ERP systems and their value for an organization can improve a user's affective evaluation of the system irrespective of the system's direct benefit to the user. These findings are consistent with observed effects of domain-relevant knowledge on attitude in other contexts (e.g., Roy et al., 2017; Waris & Ahmed, 2020; Xiao et al., 2011), but go beyond prior studies by also illustrating the effects of knowledge on attitude-relevant cognitive beliefs (i.e., PEOU and PU).

The larger impact of ERP knowledge on attitude is indirect. This effect occurs through PEOU and PU as hypothesized. We also observe, but did not hypothesize, serial indirect effects stemming from self-efficacy's effect on PEOU and PEOU's effect on PU. This suggests that the effects of knowledge spread throughout the nomological network of technology acceptance; that knowledge is the "tide that lifts all boats." In fact, the total effect of knowledge on attitude in this study (0.34) is similar in magnitude to the effects of primary technology acceptance beliefs of PEOU (0.31) and PU (0.35). Thus, our model of informed technology acceptance presents initial evidence that knowledge about a system is just as important as PEOU and PU in explaining and predicting attitude toward the system.

In addition to our findings on the substantial influence of ERP knowledge on beliefs and attitude, we reaffirm prior findings on the effects of AS-CSE on PEOU (Agarwal et al., 2000). Self-efficacy reflects a user's sense of control when using the system, such that greater self-efficacy improves the perception that the system is easy to navigate and use. Similarly, we reaffirm prior findings on the effects of attitude on intention (Dwivedi et al., 2019; Rana et al., 2017). While ERP system use is often mandated, some aspects of system use may be optional, and the depth and faithfulness of use may suffer if users harbor negative attitudes toward the system.

Moreover, our exploratory analyses indicate that using ERPsim to gamify ERP training is a particularly effective method for increasing knowledge about ERP systems in addition to improving PEOU, PU, and attitude. Simulation games such as the one used in this study promote enactive learning and create an environment that encourages playful and productive exploration of a complex IT in pursuit of (simulated) organizational performance (Cronan & Douglas, 2012; Deranek et al., 2019).

Situated in the context of a gamified ERP training intervention, we find support for the proposed model and evaluate the effectiveness of a gamified ERP training intervention. The findings of this study offer valuable contributions to theory and practice.

5.1. Theoretical Contributions and Implications

This paper offers three primary contributions to theory. First, despite much research on the antecedents of technology acceptance, little prior work has examined on the influence of domain-relevant knowledge on cognitive beliefs or affective attitude toward a system. While the effect of knowledge on beliefs has been studied in other contexts, the use of a rich domain-relevant knowledge concept provides theoretical insights into the underlying mechanisms in technology acceptance. We offer theoretical rationale and empirical evidence supporting the influence of ERP knowledge on ERP self-efficacy, PEOU, PU, and attitude. The context of the study also contributes to the body of technology acceptance knowledge, answering calls for additional research on training interventions, and particularly interventions involving complex software packages such as ERP systems. Based on the results of this study, ERP knowledge positively affects attitude toward ERP systems. This effect manifests in two ways: directly from ERP knowledge to attitude, and indirectly through the positive effects of ERP knowledge on ERP self-efficacy, PEOU, and PU.

Second, we introduce collaborative application knowledge into the nomological network of technology acceptance, opening a door to further inquiry beyond the ERP system context. We present ERP knowledge as a multi-dimensional representation of an individual’s perceived comprehension of transaction skills, business processes, and ES management. Building on the ERP knowledge concept established by Cronan and Douglas (2013), we position ERP knowledge as an influential antecedent of ERP self-efficacy, PEOU, PU, and attitude toward ERP. We believe that our findings may be generalizable beyond ERP knowledge through context-specific development of other multi-dimensional knowledge constructs.

Third, as an exploratory component of the research, we contribute to the growing body of literature on end-user training by illustrating how a gamified training intervention can improve knowledge, beliefs, and attitude toward an ERP system. This study answers calls for research on simulations in complex system training through vicarious and enactive learning (Gupta et al., 2010), greater attention to context in gamification research (Liu et al., 2017), and more thorough methodological treatment in gamification research (Seaborn & Fels, 2015). Based on our results, this gamified training intervention is particularly effective for increasing ERP knowledge.

5.2. Implications for Practice

Modern organizations rely on ERP systems to support core business processes and improve firm performance, but continue to struggle with the implementation and optimization of these systems (Computer Economics, 2019). Across contexts and cultures, education and training remain significant roadblocks for ERP system success, and improving users' attitudes toward ERP systems is critical for organizations to effectively navigate the accompanying organizational change (Zhang et al., 2005). Knowledge gained through training affects users' beliefs about their own ability to successfully use the system, the amount of effort required to use the system, and the direct benefits of using the system. Those beliefs, in turn, shape their overall attitude toward the ERP system, and ultimately influence their intentions and behaviors. It is, after all, the users who will decide whether, how, and how much to use the ERP system, and thereby achieve the desired returns on these significant investments.

By providing a setting in which learning is fun and failing is safe, organizations can improve ERP knowledge at multiple levels (transaction skill, business process, and ES management).

Qualitative feedback aligns with our quantitative assessment of the effectiveness of the gamified training (presented in Appendix B). According to one participant, “[h]aving the chance to experiment within the game and change variables around to see a difference in the results made grasping the concepts more relatable and therefore easier to learn.” For another, “[t]his simulation gave me an overview of how ERP can help a business to be successful. It also taught me how group communication is critical.” Training on ERP systems needs to go beyond system navigation and step-by-step practice exercises. The integrated nature of ERP systems necessitates deeper knowledge of interdependencies between business functions, the importance of communication, and the value of transparency. By situating a real ERP system in a simulated environment, it is possible for users to learn how an ERP system supports an integrated enterprise and to understand process interdependencies through collaboration, while also acquiring the transactional knowledge of navigating a complex ERP system almost as a byproduct of the higher-level knowledge required to successfully manage the organization. This knowledge can equip users with the self-efficacy, beliefs, and attitudes to successfully navigate ERP-driven change and promote ongoing success of ERP initiatives.

By understanding the nature of factors that influence belief and attitude formation, organizations can design education and training programs to promote holistic knowledge of ERP systems by specifically targeting the three dimensions of ERP knowledge. In this study of gamified ERP training, immersion in a “fun” ERP learning environment led to significant improvements in knowledge, beliefs, and attitude toward ERP systems, highlighting the critical role of collaborative application knowledge in technology acceptance. Knowing that PEOU and PU are critical pre-conditions to user acceptance of a new technology, and that self-efficacy is important in developing PEOU, is of limited practical utility. Gaining insights about how to improve these beliefs and how they influence each other, however, is of substantially greater practical value. This study offers such insights by positioning collaborative application knowledge as an important antecedent to cognitive beliefs and affective attitude toward ERP systems.

5.3. Limitations and Future Research

We provide the following suggestions to interpret results of the study in light of its limitations. First, we use self-reported data; we measured self-assessed knowledge rather than objective knowledge. Given the nature of the study and the outcomes of interest (attitude, PEOU, PU, and ERP self-efficacy), however, we suggest that the objective level of knowledge is less important than the perceived level. It is the perceptions of the user that are of critical importance in acceptance of ERP systems. Further, prior literature finds a strong correlation between the ERP knowledge construct and an objective assessment of knowledge (Cronan et al., 2012). This suggests potential value in developing an ERP knowledge construct to incorporate both perceptual and objective components. Future research can also go beyond self-reported survey data to consider neurophysiological correlates (e.g., de Guinea et al., 2014) and the effects of actual system use (Burton-Jones & Grange, 2013) on technology acceptance beliefs in the context of a gamified training intervention.

Second, the model is primarily cross-sectional. We address the research objective effectively by using variance methods while controlling for the anchoring effect of prior attitude. Future research should more deeply investigate changes in these constructs and in the structural model before and after gamified training. Such research can advance inquiry on enduring questions in cognitive information systems research by further explicating the processes though which individuals and teams learn and make decisions using complex information systems (Browne & Parsons, 2012; Davern et al., 2012).

A third limitation of this study is the alignment of the level of theorizing, data collection, and analysis with the level of the gamified training intervention. We conduct this study at the individual level, though the intervention involved teams of participants engaged in collaborative and competitive activities. The level of data collection, theorizing, and analysis align at the individual level, and the phenomena of interest are at the individual level, rendering this limitation less severe. Both the complex nature of ERP systems and the social-cognitive influences on knowledge and self-efficacy are more salient in a team context. For example, the ERP knowledge construct derives from a hierarchical model of collaborative application knowledge (Kang & Santhanam, 2003), highlighting the importance of collective consequences of interdependencies in complex systems and making the team context appropriate for measuring and assessing such knowledge.

Finally, as with any study, we acknowledge limits to the generalizability of our findings based on the study context. This study included working professionals from three different organizations with reasonable variation in backgrounds and experience levels. While this provides some degree of confidence that the results were not specific to a single context, all three organizations are large for-profit companies located in the same geographic region. Future research should investigate similar effects across geographies and cultures, and in different types of organizations implementing ERP systems such as smaller enterprises (e.g., Haddara & Elragal, 2013). We also acknowledge limits to the generalizability beyond ERP systems and encourage future research to study informed technology acceptance in other contexts.

6. Conclusion

Training improves knowledge, and knowledge shapes beliefs and attitudes. Substantial literature in technology acceptance focuses on the effects of salient cognitive beliefs (e.g., self-efficacy, PEOU, PU) on attitude and intention, but has not deeply considered the importance of domain-relevant knowledge in the formation of beliefs. We address this gap by developing and testing a model of informed technology acceptance in the context of ERP systems, in which ERP knowledge influences self-efficacy, PEOU, PU, and attitude toward ERP systems. We test the model in the specific context of gamified ERP training and demonstrate the effectiveness of gamified training for developing ERP knowledge. Training for complex systems must move beyond transactional training and step-by-step business process walkthroughs. Interventions such as the one considered in this study can provide substantial benefits by improving employee knowledge about systems, processes, and integration, as well as developing self-efficacy in the ability to use the system. ERP implementations have been fraught with people-related failures, and interventions that improve individual acceptance of major technology-driven change can increase the success of future ERP and other complex system implementations.

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Appendix A: The Measurement Instrument

The following instructions and items were used as measures in this study.

Knowledge and Skills: The following set of questions relate to a self-assessment of your knowledge and skills regarding ERP and SAP after your participation in the ERP Simulation game. Using the seven item scale of 1="Very Low" to 7= "Very High", please indicate your knowledge and skills regarding -

Business Process (ERPK-BP):

1. Knowledge of Procurement Business Processes and Activities. (ERPK-BP1)
2. Knowledge of Sales and Distribution Business Processes and Activities. (ERPK-BP2)
3. Knowledge of Financial Accounting Business Processes and Activities. (ERPK-BP3)
4. Knowledge of Production Management Business Processes and Activities. (ERPK-BP4)
5. Knowledge of business terminology in Sales and Distribution (such as Sales order, discounts, freight, transfer goods, good issues etc.). (ERPK-BP5)

Enterprise Systems Management (ERPK-ES):

1. Ability to analyze the impact of integrated information on managerial decision making (ERPK-ES1)
2. Ability to analyze the impact of individual employee actions on the operations of other functional areas (ERPK-ES2)
3. Ability to understand the role and complexity of technology in enterprise system software solutions (ERPK-ES3)

Transaction Skills (ERPK-TS):

1. Ability to accomplish transactions to procure inventory in SAP (ERPK-TS1)
2. Ability to accomplish transactions to collect from customers (accounts receivable) in SAP (ERPK-TS2)
3. Ability to accomplish transactions to produce/manufacture goods (set up Production) in SAP (ERPK-TS3)
4. Ability to accomplish transactions to pay for purchases (accounts payable) in SAP (ERPK-TS4)

Answer these questions about the use of SAP using the seven item scale of 1="Strongly Disagree" to 7= "Strongly Agree"

Perceived Ease of Use (PEOU):

1. It would be easy for me to become skillful at using SAP. (PEOU1)
2. I would find SAP easy to use. (PEOU2)
3. Learning to operate SAP is easy for me. (PEOU3)

Perceived Usefulness (PU):

1. I would find SAP useful in my job (class). (PU1)
2. Using SAP would enable me to accomplish tasks more quickly. (PU2)
3. Using SAP would increase my productivity. (PU3)

Intention (INT):

1. I intend to use SAP in my classes (in my job). (INT1)
2. I intend to use SAP extensively in my classes (in my job). (INT2)

ERP Self-efficacy (ERPSE): I could complete a job or task using the system …

1. If I could call someone for help if I got stuck. (ERPSE1)
2. If I had a lot of time to complete the job for which the software was provided. (ERPSE2)
3. If I had just the built-in help facility for assistance. (ERPSE3)

Attitude/Feeling (ATT): Answer these questions about your attitude toward SAP using the seven item scale of 1="Very Bad" to 7= "Very Good" –

1. Your attitude/feeling about SAP's ease of use (ATT1)
2. Your attitude/feeling about integrated business processes (ATT2)
3. Your attitude/feeling about Enterprise Resource Planning (ATT3)

In addition to the above items that were used for the measures, the following items were dropped during evaluation and refinement of the measurement model.

- Knowledge of the importance of the integrated nature of the business processes. (*ERPK-BP*)
- Knowledge of business terminology in Procurement process (such as purchase order, invoice verification, goods receipt, material account, etc.). (*ERPK-BP*)
- Knowledge of the interrelationships and interdependencies between various processes (such as accounting, marketing, production, etc.) (*ERPK-BP*)
- Ability to accomplish transactions to set (and change) prices and sell products in SAP (*ERPK-TS*)
- My interaction with SAP would be clear and understandable. (*PEOU*)
- If I use SAP, I will increase my chances of getting a raise/getting a job. (*PU*)
- I could complete a job or task using the system… if there was no one around to tell me what to do as I go. (*ERPSE*)
- Your attitude/feeling about SAP (*ATT*)

Appendix B. Pre / Post Construct Differences and Effect Sizes

Construct	Pre (SD)	Post (SD)	Change	Effect Size {95% CI}
ERP Knowledge (Composite)	3.21 (1.19)	5.01 (0.87)	1.80**	1.38 {1.18, 1.58}
Business Process Knowledge	3.31 (1.32)	4.89 (0.91)	1.58**	1.11 {0.92, 1.30}
Enterprise Systems Knowledge	3.92 (1.35)	5.37 (0.99)	1.45**	1.01 {0.70, 1.07}
Transaction Skill Knowledge	2.63 (1.42)	4.88 (1.09)	2.25**	1.33 {1.13, 1.52}
ERP Self-Efficacy	4.44 (1.30)	5.55 (0.88)	1.11**	0.75 {0.57, 0.93}
Perceived Ease of Use	4.74 (1.07)	5.44 (0.89)	0.70**	0.69 {0.50, 0.87}
Perceived Usefulness	5.34 (1.15)	5.77 (0.93)	0.43**	0.38 {0.21, 0.56}
Attitude	4.85 (1.07)	5.58 (0.96)	0.73**	0.72 {0.53, 0.90}

Notes: N = 248; *p <= .05; **p <=. 01. SD = standard deviation; CI = confidence interval.

Appendix C: Factor Loadings

	PREATT	INT	ATT	PU	PEOU	ERPSE	ERPK-BP	ERPK-ES	ERPK-TS
PREATT1	**0.91**	0.35	0.46	0.37	0.37	0.04	0.20	0.09	0.14
PREATT2	**0.94**	0.28	0.42	0.35	0.36	0.01	0.19	0.11	0.15
PREATT3	**0.94**	0.36	0.48	0.38	0.34	-0.01	0.19	0.12	0.12
INT1	0.33	**0.96**	0.52	0.63	0.36	0.11	0.16	0.15	0.23
INT2	0.36	**0.96**	0.53	0.64	0.38	0.10	0.17	0.14	0.27
ATT1	0.45	0.50	**0.90**	0.56	0.50	0.14	0.38	0.26	0.25
ATT2	0.46	0.49	**0.96**	0.57	0.58	0.17	0.33	0.29	0.29
ATT3	0.46	0.53	**0.93**	0.58	0.60	0.18	0.31	0.28	0.24
PU1	0.32	0.63	0.50	**0.85**	0.35	0.21	0.26	0.21	0.25
PU2	0.39	0.61	0.60	**0.95**	0.54	0.27	0.33	0.34	0.35
PU3	0.37	0.58	0.58	**0.93**	0.52	0.25	0.32	0.37	0.33
PEOU1	0.28	0.35	0.47	0.48	**0.87**	0.28	0.30	0.29	0.27
PEOU2	0.41	0.34	0.60	0.49	**0.91**	0.27	0.35	0.32	0.38
PEOU3	0.35	0.35	0.56	0.45	**0.93**	0.27	0.34	0.37	0.38
ERPSE1	0.01	0.10	0.20	0.24	0.28	**0.85**	0.18	0.20	0.17
ERPSE2	0.00	0.09	0.14	0.24	0.25	**0.89**	0.19	0.23	0.26
ERPSE3	0.03	0.09	0.09	0.19	0.23	**0.77**	0.15	0.18	0.27
ERPK-BP1	0.20	0.19	0.32	0.32	0.33	0.20	**0.89**	0.63	0.67
ERPK-BP2	0.11	0.09	0.27	0.22	0.28	0.18	**0.89**	0.65	0.60
ERPK-BP3	0.20	0.13	0.34	0.28	0.35	0.23	**0.79**	0.55	0.57
ERPK-BP4	0.19	0.20	0.32	0.32	0.31	0.11	**0.85**	0.57	0.63
ERPK-BP5	0.19	0.11	0.27	0.28	0.28	0.16	**0.77**	0.51	0.51
ERPK-ES1	0.11	0.15	0.30	0.30	0.36	0.22	0.67	**0.93**	0.52
ERPK-ES2	0.11	0.17	0.31	0.37	0.31	0.23	0.64	**0.92**	0.50
ERPK-ES3	0.10	0.09	0.21	0.26	0.31	0.21	0.59	**0.89**	0.50
ERPK-TS1	0.17	0.26	0.30	0.38	0.39	0.29	0.60	0.51	**0.85**
ERPK-TS2	0.09	0.16	0.18	0.22	0.29	0.19	0.60	0.45	**0.87**
ERPK-TS3	0.16	0.24	0.27	0.32	0.36	0.28	0.65	0.51	**0.89**
ERPK-TS4	0.11	0.25	0.23	0.28	0.30	0.21	0.65	0.46	**0.90**

Notes: PREATT: pre-immersion attitude; INT: intention; ATT: attitude; PEOU: perceived ease of use; PU: perceived usefulness; ERPSE: ERP self-efficacy; ERPK: ERP knowledge - BP = business process, ES = enterprise systems, TS = transaction skill. Primary factor loadings are in bold for reflective indicators.