Issues in Information Systems
Volume 26, Issue 4, pp. 264-281, 2025

DOI: https://doi.org/10.48009/4_iis_2025_122

Towards design principles for knowledge management systems that support experientially derived tacit and procedural knowledge

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Abstract

Lessons-learned systems (LLS) are intended to capture and disseminate experientially derived knowledge. However, their use has delivered limited organizational benefits. One cause for this may be the lack of support for tacit and procedural knowledge (TPK), which are often regarded as synonymous with the expertise and skill enabling execution of tasks. Despite the importance of TPK for organizational performance, there is little to no extant design knowledge on how to design KM systems suitable for their management. Towards this gap in the literature and to help address this important problem, we reference the literature and formulate design principles for a class of KM systems that can capture and disseminate experientially derived TPK. We demonstrate the utility of our design principles by developing a prototype to support the knowledge-intensive task of aerial surveys for wildlife. Through exploration of the protype's use in a detailed scenario, we demonstrate the utility of the artifact and its underlying design principles. Our study contributes novel design knowledge and provides design guidance for practitioners.

Keywords: design principles, tacit knowledge, procedural knowledge, knowledge management systems

Introduction

Organizations of all sizes and sectors rely on effective knowledge management (KM) to execute critical business processes and respond to emergent challenges. For this reason, many organizations rely on technology-based systems to support knowledge management processes and mechanisms that capture and disseminate knowledge (Becerra-Fernandez & Sabherwal, 2014). Given the diversity of knowledge types, mechanisms, and KM objectives, numerous classes of KM systems have been developed and investigated. Our research focuses on lessons-learned systems (LLS), a class of knowledge management systems (KMS) designed to capture and disseminate experientially derived knowledge created during the execution of organizational activities that can help organizations achieve or avoid specific outcomes (Secchi et al., 1999; Weber et al., 2001).

Despite their intent, many LLS fail to deliver benefits to organizations (Badr & Ahmad, 2013; Liebowitz, 2009; Weber et al., 2001). While human and organizational factors affect the utility of any technological artifact, the design of the artifact is equally important, as a poorly designed system is likely to be ineffective for its intended purpose. One cause for the limited utility of LLS may be their emphasis on explicit and declarative forms of knowledge rather than tacit and procedural knowledge (Hou & El-Gayar, 2024). Such an omission is curious, as the expertise and experiential knowledge that enable the execution of tasks and processes are highly tacit and procedural in nature (Georgeff & Lansky, 1986; ten Berge & van Hezewijk, 1999). Despite the long-recognized importance of tacit and procedural knowledge (TPK), the challenge of designing KMS suitable for its support has drawn limited academic attention (Harlow, 2008; Hurnonen et al., 2015; Manfredi Latilla et al., 2018), with few studies primarily concentrated in the context of craft works (e.g., Hsu & Wu, 2020; Yasuoka & Hirata, 2020). Moreover, these works have primarily focused on solving a problem by developing an instantiation rather than providing generalizable design knowledge.

While past works have proposed more abstract design artifacts such as design principles and theories that enable the development of KMS suitable for ethical co-creation and application of knowledge (Richardson et al., 2006), emergent knowledge processes (Markus & Majchrzak, 2002), and systems that enable collaborative creation and dissemination of pedogeological knowledge (Hung & Wang, 2020) to the best of our knowledge, such related past works have not investigated design principles for a class of KM systems suitable for supporting experientially derived tacit and procedural knowledge. Combining these threads in the literature and addressing an important practical problem, the objective of our study is to develop design principles that guide the design of KMS suitable for capturing and disseminating experimentally derived tacit-procedural knowledge. It follows that our study is concerned with the following research question:

RQ: *What design principles guide the design of KM systems that capture and disseminate experientially derived tacit-procedural knowledge?*

Our study follows the design science research methodology (Peffers et al., 2007), given its focus on developing a novel artifact. More specifically, we follow the design principle formation method of Möller et al. (2020) by synthesizing Nonaka's (1994) theory of organizational knowledge creation and media richness theory (Daft & Lengel, 1983) with relevant literature. We demonstrate the utility of our design principles by illustrating their effectiveness in developing a KM system to support survey aviation. Through the exploration of a detailed scenario, we find that the prototype is well-suited for its intended purpose, thereby offering evidence of the satisfactory specification of our design principles.

The rest of this paper is organized as follows. We present an overview of related literature and our theoretical foundation. A brief discussion of methodology is followed by the development of design principles, demonstration, and evaluation. The results are presented and discussed, and we conclude with a discussion of limitations and future work.

Literature Review

Design Principles for Knowledge Management Systems

Design principles are prescriptive statements that guide the design of classes of artifacts that possess specific characteristics by describing desired user activity, system capabilities, or a combination thereof (Gregor et al., 2020). Given the diversity of knowledge and knowledge processes and the importance of effective KM for organizational performance, it is no surprise that numerous past studies have investigated design principles for various classes of KMS.

The seminal study of Markus and Majchrzak (2002) identifies meta-requirements and design principles for a class of KMS suitable for supporting emergent knowledge processes, and demonstrates the utility of these design principles by developing and evaluating an instantiation. Richardson et al. (2006) reference Churchman's Singerian inquiring system and Habermas's theory of communicative action and discourse, resulting in the formulation of twelve design principles that guide a KMS design process as well as the specific design of a KMS that enables the ethical co-creation of knowledge. Through numerous action design research episodes, Schacht et al. (2015) identified six design principles that guide the design of KMS better suited for enabling project knowledge reuse. Dreyer et al. (2021) reference the smart service literature to formulate 10 meta-requirements and design principles that guide the design of KM systems, enhancing the value delivered by smart services.

Our literature review is not meant to be comprehensive; rather, it is to highlight the continued academic interest in the development of design principles for novel classes of KMS, particularly those that address new hitherto unexplored dimensions of knowledge, knowledge processes, or interactions with new technologies (e.g., humans and artificial intelligence). However, to the best of our knowledge, extant research has not investigated specific design principles that support the development of KMS that support the capture and dissemination of experientially derived tacit-procedural knowledge, despite the recognition that the use of KMS can be effective for the management of such knowledge (Natek & Lesjak, 2021).

Lessons-Learned Systems

LLS are intended to capture and disseminate experientially derived knowledge that can help organizations attain or avoid specific outcomes (Secchi et al., 1999; Weber et al., 2001). LLS often take the form of intranets or wikis that allow distributed teams to access lessons-learned (LL), though other software artifacts (e.g., building information management, custom instantiations) have been utilized (Chua, 2004; Huang et al., 2015; Jung et al., 2014; Yildiz et al., 2014). The findings of Hou and El-Gayar (2024) suggest LLS design research has been primarily concentrated in relatively few contexts and has largely failed to consider forms of knowledge other than explicit-declarative knowledge, which may limit the utility of LLS given the connection between expertise, experiential knowledge, and tacit-procedural knowledge (TPK). Studies considering the design of KMS for TKP are rare: to the best of our knowledge, only two studies have focused on TPK, primarily in the crafting context (Hsu & Wu, 2020; Yasuoka & Hirata, 2020). This lack of generalizable design knowledge underscores the need for additional research.

Theoretical Foundations

The Nature of Knowledge

The nebulous nature of knowledge necessitates that we adopt clear and specific operational definitions. We synthesize several conceptualizations, defining knowledge as "valid and true information that helps guide actions" (Becerra-Fernandez & Sabherwal, 2014; Davenport & Prusak, 1998). One common dimension for classifying knowledge is whether it is explicit or tacit. Explicit knowledge is that which is easily expressed in forms such as spoken or written word and thus is commonly regarded as "know what" knowledge (Nonaka, 1994; Polanyi, 1966). In contrast, tacit knowledge is difficult to explicate in meaningful forms as it defies explanation through logic or language. Instead, tacit knowledge transfer primarily relies on social mechanisms, such as teaming of experts and novices (Collins, 2010; Nonaka, 1994).

Another dimension of knowledge relates to whether it is declarative or procedural, with declarative knowledge taking the form of expectations, facts, and propositions (Becerra-Fernandez & Sabherwal, 2014; ten Berge & van Hezewijk, 1999). Conversely, procedural knowledge refers to the embodied knowledge on how to carry out tasks (ten Berge & van Hezewijk, 1999; Veselý, 2006). Akin to tacit knowledge, procedural knowledge is more difficult to explicate as it is highly embodied, and its conversion into declarative forms often robs it of meaning (Polanyi, 1966; ten Berge & van Hezewijk, 1999). Here, a relationship between tacit and procedural knowledge emerges. Procedural knowledge is created through the repeated practice of steps and guidelines, ultimately resulting in the embodiment of knowledge that enables the skillful execution of tasks (Herz & Schultz, 1999; Lang et al., 1991).

The Theory of Organizational Knowledge Creation

Though decades have passed since its introduction, Nonaka's (1994) theory of organizational knowledge creation continues to inform KMS design research as one of the most popular kernel theories in use (Riswanto & Sensuse, 2021). The theory of organizational knowledge creation theorizes that knowledge is created through the continuous conversion between tacit and explicit forms through the processes of socialization (tacit to tacit), externalization (tacit to explicit), combination (explicit to explicit), and internalization (explicit to tacit). These conversions are enabled through KM mechanisms such as training, mentoring, and documentation, and may be manifest in processes and procedures (Becerra-Fernandez & Sabherwal, 2014). Given the importance of these knowledge processes and mechanisms for supporting organizational performance, numerous classes of KMS have been developed to suit various KM needs, including enterprise social networks, forums, and lesson-learned systems. Regardless, the KMS must be appropriately designed to support the key knowledge mechanisms and processes.

Media Richness Theory

The richness of communication media is determined by its ability to provide instant feedback, provide multiple cues for communication, support natural language, and express human emotions (Daft et al., 1987; Daft & Lengel, 1983). To maximize communication efficiency, the medium of communication must match the complexity of the concept being communicated (Sheer & Chen, 2004). For example, face-to-face communication is highly rich as it provides immediate feedback and visual cues (e.g., gestures and expressions), while the written word is leaner as more effort must be expended to ensure that the message is communicated faithfully (Daft et al., 1987; Kahai & Cooper, 2003). As such, care must be taken to ensure that the richness of the selected communication medium matches the complexity of the concept (Kahai & Cooper, 2003; Rice, 1992). For these reasons, complex concepts are often best communicated through pictures, videos, and graphics (Mayer, 2017; Sun & Cheng, 2007). These findings suggest that the representation of complex forms of knowledge must be equally rich to support its unequivocal transfer.

Methodology

The objective of our design science research is to formulate design principles that guide the design of a novel class of KM systems (Gregor et al., 2020; Peffers et al., 2007). Towards this goal, we employ the design principle formulation method of Möller et al (2020), adopting a supportive strategy where we first formulate meta-requirements based on kernel theory and literature, followed by design principles that guide the design of a class of KM systems suitable for capturing and disseminating experientially derived tacit-procedural knowledge. We refer to such a class of KM systems as a TPK-LLS. We demonstrate the utility of our design principles by developing a prototype to support the knowledge-intensive process of conducting low-altitude aerial surveys (Hou & El-Gayar, 2025; Reynolds et al., 2012). To evaluate the suitability of the prototype, we assess the utility of our prototype by exploring its use in a detailed hypothetical situation based on actual practice—a technique commonly employed to facilitate design and evaluation in both computer science and system design practice (Hertzum, 2003; Hevner et al., 2004).

Meta-Requirements and Design Principles

Meta-Requirements

Our study adopts a supportive strategy where our meta-requirements are formulated from literature and theory (Möller et al., 2020). First, the representation of TPK by the KM system must be suitable for users of varying expertise, including both novices and experts. Through experience and practice, experts have internalized the procedural knowledge required to complete the task asked of them successfully (Herz &

Schultz, 1999). As such, presenting them with rich representations of knowledge artifacts can support the unequivocal communication of knowledge on the specific procedure to undertake or task asked of them (Daft et al., 1987). As novices lack such experiences, they must internalize such knowledge. Given that tacit knowledge is best transmitted through social mechanisms, the use of highly rich forms of media (e.g., pictures and videos) is effective for transferring knowledge and supporting tacit knowledge internalization (Anandarajan & Akhilesh, 2013; Hsu & Wu, 2020; Kozma, 1991; Yasuoka & Hirata, 2020). Thus, we specify MR1: the TPK-LLS must provide a sufficiently rich representation of codified knowledge to ensure its conversion into tacit forms. Second, in the same vein, such a system should also represent knowledge that is useful for users with heterogeneous expertise (MR2), so that experts can intuitively understand and execute the procedure successfully while referencing their internalized tacit knowledge, and novices can better understand and internalize the TPK through a rich representation of the procedure.

Third, the development of procedural knowledge relies on repeated practice and execution of guidelines, through which explicit and declarative knowledge are converted into tacit procedural knowledge (Gil, 2015; Herz & Schultz, 1999). Tasks that rely on expertise and TPK benefit from repeated practice and receiving explicit guidance from an expert, suggesting that explicit and declarative forms of knowledge are crucial for developing tacit-procedural knowledge. It follows that the TPK-LLS must support both representation (MR3) and capture (MR4) of EDK (Natek & Lesjak, 2021; Shum, 1998).

Fifth, the TPK-LLS must capture TPK with sufficient richness to support its unequivocal communication (Daft et al., 1987; Sheer & Chen, 2004). Communication media, such as pictures and video, have been found to be highly effective for capturing and transferring tacit knowledge (Hsu & Wu, 2020; Yasuoka & Hirata, 2020), as they encode the various social cues and other nuanced and contextual information that humans rely on. It follows that the TPK-LLS must be able to capture TPK with sufficient richness to facilitate unequivocal transference for subsequent reuse (MR5).

Table 1. Meta-Requirements of a Solution

Code	Specification
MR1	Represent tacit-procedural knowledge with sufficient richness to support conversion to tacit forms
MR2	Represent codified knowledge in forms useful for both novice and expert
MR3	Represent explicit-declarative knowledge
MR4	Capture explicit-declarative knowledge
MR5	Capture tacit-procedural knowledge with sufficient richness to enable its reuse
MR6	Only contain knowledge that is useful
MR7	Retrieve relevant lessons based on some attribute of the EDK or TPK

Sixth, knowledge must be valid and true to be useful, as inaccurate and irrelevant knowledge can adversely impact organizational processes. Over time, newly created procedural knowledge may supersede previously codified knowledge. Thus, failure to remove irrelevant and outdated knowledge artifacts can result in "knowledge overload," which can lead to costly errors (Kivrak et al., 2008). Ensuring that the knowledge base only contains useful knowledge is important when considering procedural knowledge as there may be numerous methods for completing a task but some may bear some key advantages that staff should be cognizant of. Thus, we specify that a TPK-LLS should only contain useful knowledge (MR6).

Last, as LLS are concerned with the capture and dissemination of lessons-learned, the TPK-LLS must allow for efficient knowledge retrieval. As scholars have noted, text-based identification of relevant knowledge artifacts be challenging considering the complex nature of knowledge (Andrade et al., 2013; Huang et al., 2015). Other strategies such as those that retrieve relevant LL based on some aspect of the TPK have been shown to be successful. For example, the use of radio tags on tooling to facilitate retrieval of task-specific knowledge (Yasuoka & Hirata, 2020). Because both explicit and tacit knowledge are vital for supporting the execution of organizational activities, a TPK-LLS must be able to retrieve relevant knowledge artifacts based on some explicit-declarative or tacit-procedural attribute (MR7).

Design Principles

We formulated six design principles supporting the meta-requirements and developed a mapping diagram (Figure 1) that depicts which MR relates to which design principle (DP). Our first DP stipulates that a TPK-LLS should utilize appropriately rich communication media to facilitate the transfer of experientially derived TPK through social knowledge processes, such as socialization and internalization. As noted in the literature, the use of rich communication media is an effective means of documenting tasks and procedures that rely heavily upon tacit expertise. Thus, a TPK-LLS should utilize rich forms of media that are suitable for the task it is intended to support. Second, a TPK-LLS should support the successful execution of the task (DP2). As LLS are ultimately concerned with providing experientially derived knowledge that can support future decision-making, the TPK-LLS should support decision-making that enables the successful execution of the business process or task. Here, the presentation of both TPK and EDK supports knowledge transfer through social mechanisms, providing insights into past experiences (i.e., positive or negative).

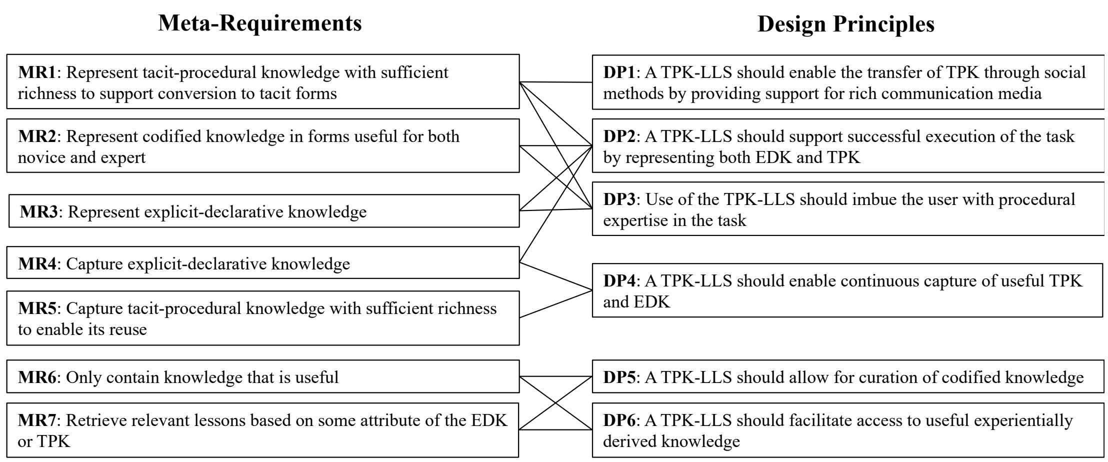

Figure 1. Mapping Diagram of Meta-Requirements and Design Principles

Our third design principle focuses on the development of tacit procedural expertise, which facilitates the internalization of procedural knowledge. The TPK-LLS must richly represent TPK alongside explicit guidance on task execution. For experts, rich media may be sufficient for knowledge application, but for novices, the inclusion of explicit guidance may be necessary (Herz & Schultz, 1999). As organizational KM efforts should result in sustained competitive advantages, the use of the TPK-LLS should equip staff with the knowledge necessary to execute tasks effectively. Fourth, we argue that a TPK-LLS must be able to continuously capture both TPK and EDK in order to develop the knowledge base. As noted above and in the literature, both TPK and EDK are helpful for both task execution and knowledge transfer.

Given that LLS are designed to capture experientially derived knowledge, it follows that a TPK-LLS must also be able to capture newly created experiential knowledge as it is discovered. Fifth, as incorrect or irrelevant knowledge is unhelpful or even hurtful to organizational performance, it follows that careful management of the knowledge base is warranted. It follows that the TPK-LLS should facilitate identification of lessons that need to be modified or removed, ensuring that only practical knowledge is stored and avoiding knowledge overload (DP5). Last, as accurate knowledge is only valuable when it is accessible by its intended users, the TPK-LLS must also enable users to locate TPK and EDK effectively.

Demonstration of Design Principles in the Context of Survey Aviation

We apply our design principles by developing a proof-of-concept using QT Designer (www.qt.io) to support the knowledge-intensive business process of low-altitude aerial surveys for wildlife (Eppler et al., 1999). We selected the aerial survey context as this business process requires close collaboration between aviators operating the aircraft and observers identifying wildlife and providing directions on how to position the aircraft (Beard, 1999; Dirschl et al., 1981). Here, both aviator and observer must continuously collaborate and innovate, mobilizing their tacit knowledge to develop procedures that ensure successful data collection (Clark et al., 2010; Finch et al., 2021).

Despite the knowledge-intensive nature of survey aviation and the recognition that better knowledge management practices could be effective for improving safety and efficiency, the practice of KM is limited due to a lack of suitable technology-based KM systems (Hou & El-Gayar, 2025). For these reasons, we decided to demonstrate the utility of our design principles to develop SAGE: the System for Aerial Guidance and Expertise.

SAGE System Architecture

Following Chua (2004), SAGE adopts a three-tier architecture (Figure 2) consisting of an infrastructure tier (IFT), knowledge services (KS), and a presentation tier (PT). The IFT comprises a knowledge warehouse and an external interface component, facilitating connectivity with other instruments that can capture rich representations of knowledge. We include a knowledge representation component in the KS tier to create rich representations of TPK and EDK. Similarly, the knowledge capture component is included to capture both TPK and EDK.

The knowledge access interface allows users to access codified representations of TPK and EDK by coordinating with the knowledge representation component to facilitate access. To enable efficient knowledge retrieval, we include the knowledge discovery component that coordinates with external interfaces and the knowledge access interface to identify relevant knowledge. To facilitate the creation and codification of new knowledge, we include a knowledge capture interface that allows users to capture knowledge in both procedural and declarative forms. Last, we include the knowledge verification interface to facilitate the curation of knowledge through the correction or removal of knowledge artifacts.

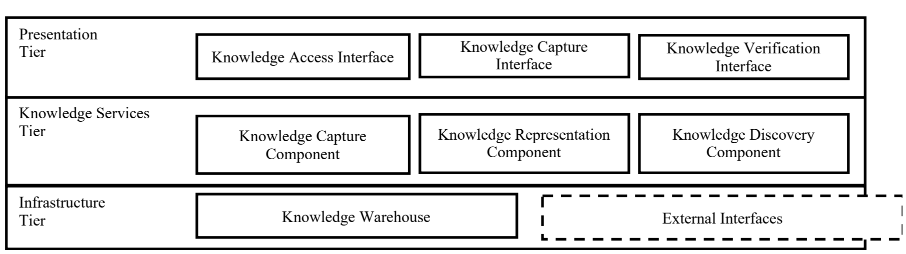

Figure 2. Proposed SAGE System Architecture

SAGE User Interface

We developed a prototype user interface as informed by our design principles and our proposed system architecture. Given that our demonstration centered on survey aviation, we referenced Hou and El-Gayar's

(2025) study of the knowledge types, knowledge management mechanisms, and media that support survey aviation, as they provide practicable insights for the design of KM systems. Specifically, they find that aerial surveyors prefer visual forms of communication media, such as maps or pictures, as they are helpful for quickly capturing and applying knowledge on how to perform surveys through regions of interest. This capability is highly desired considering the highly tacit and procedural nature of knowledge employed by both the aircraft operator and aerial observer, and the heterogeneous backgrounds of both agents.

The knowledge access interface (KAI) is depicted in Figure 3 and provides the functionality that allows users to access and view previously captured lessons in both tacit and explicit forms. As a TPK-LLS should facilitate access to useful experientially derived knowledge (DP6), SAGE allows for the retrieval of relevant lessons through a connection with a GPS device facilitated by the external interface component, as geographic location is useful for indexing and selecting pertinent lessons (Reynolds et al., 2012).

However, we also include functionality that allows for lesson retrieval via text-based search. To ensure that SAGE supports the transfer of TPK through social methods (DP1), the successful execution of tasks (DP2), and to provide the user with sufficient knowledge of TPK and EDK to develop expertise (DP3), the KAI provides a rich representation of TPK in the form of a visualization of the path of the aircraft plotted on a map, which is paired with EDK that provides experientially derived knowledge in the form of guidance and outcomes.

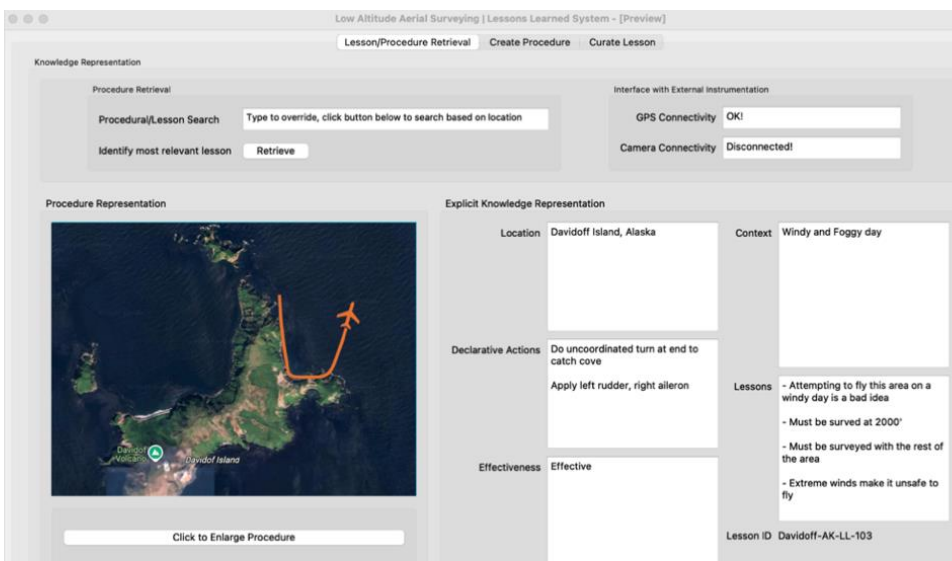

Figure 3. Knowledge (Lesson/Procedure) Access Interface (KAI).

The design of the knowledge capture interface (KCI) is illustrated in Figure 4 and follows DP4 to support the continuous capture of TPK and EDK. Specifically, the KCI allows users to capture new lessons by recording knowledge tacitly by interfacing with external instruments (e.g., GPS, cameras) to codify rich representations of procedural knowledge. In addition, the KCI also provides the requisite fields to capture EDK, such as specific task execution guidance, the presence of hazards, or other experientially practical knowledge. Such experientially derived knowledge helps support both aviators and observers in internalizing TPK while facilitating subsequent task execution through knowledge reuse (DP3).

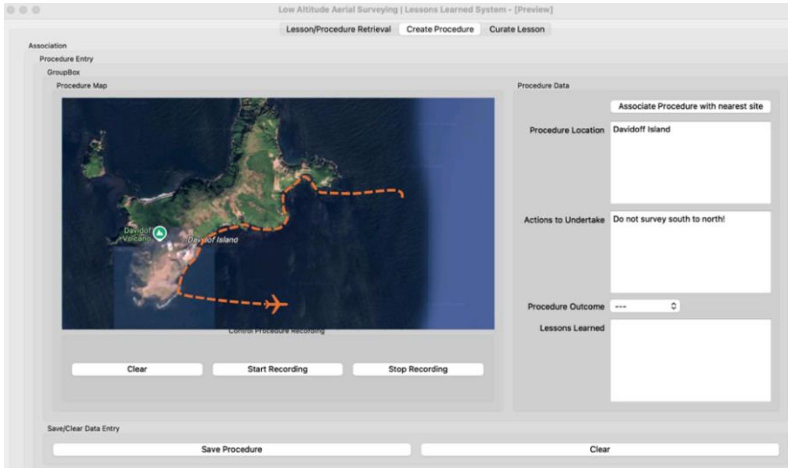

Figure 4. Knowledge Capture Interface (KCI).

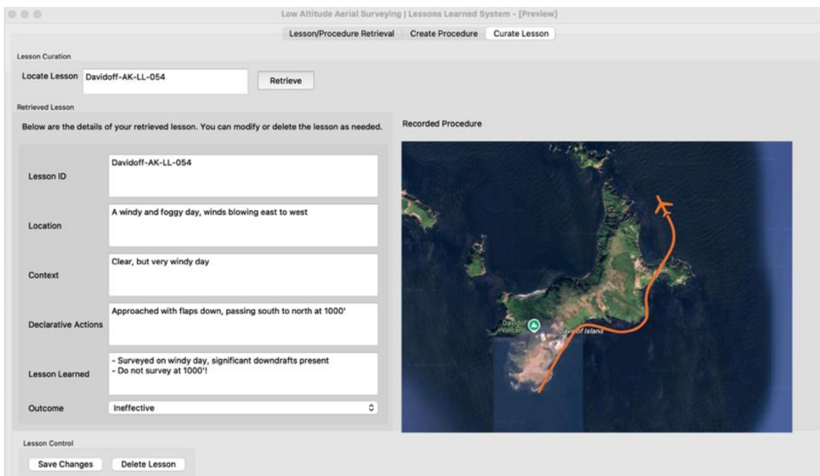

Fig. 5. Knowledge Verification Interface.

The Knowledge Verification Interface (KVI) enables knowledge curators to retrieve, modify, or delete previously created lessons. Figure 5 depicts the design of the KVI. We apply DP5 (enable cultivation of knowledge) by providing functionality that allows knowledge curators to identify and retrieve lessons, and incorporates functionality that enables curators to amend captured lessons, provide additional guidance on actions to undertake, or update the outcome of the procedure based on review of data products. As needed, curators can also remove duplicate or irrelevant lessons from the knowledge warehouse using the KVI.

Evaluation

To support the evaluation of our proposed instantiation and the design principles underlying its design, we explore the utility of SAGE by exploring its use in a hypothetical situation where a team of aviators and observers utilizes it to support decision-making during aerial surveys. This scenario is informed by the authors' past participation in aerial surveys but also references related works detailing survey methods and conditions (Reynolds et al., 2012; Sweeney et al., 2022). In our scenario, a crew consisting of aviators and observers conducts aerial surveys for a species of marine mammal that is widely distributed along the shorelines of Alaska, USA. As a visual survey, observers must see the animals directly, and thus must operate at relatively low altitudes compared to typical aviation practice (Reynolds et al., 2012; Sweeney et al., 2022).

Although the locations of animals are well understood, the geographic scope of the study area makes it difficult to memorize specific procedures for each location, necessitating innovation and mobilization of knowledge held by both aviator and observer to properly align the aircraft with the animals. This challenge is exacerbated by interactions between local topography and meteorological conditions that can present safety of flight challenges. As the reuse of experientially derived knowledge on previously undertaken procedures and the results thereof are helpful for improving efficiency (Hou & El-Gayar, 2025), the survey team has elected to use SAGE to facilitate their aerial operations.

Each member of the survey team has a tablet computer bearing an instance of SAGE. As the survey team approaches the survey location of interest, they retrieve relevant LL based on their GPS coordinates. SAGE identifies the most relevant lessons and provides rich representations of past survey experiences in the study area by plotting the aircraft's movement on a map and providing text on past weather conditions, hazards encountered, as well as the outcomes of the procedure. Providing access to the TPK in the form of a visualization as well as guidance on how to survey the area and past outcomes supports in-air decision-making and formulation of survey plans at lower altitudes that improve efficiency and safety. Given an effective procedure in visual form, the expert aviator can quickly understand what is asked of them and can effectively maneuver the aircraft to execute the task (Hou & El-Gayar, 2025). At the same time, the novice aviator can reference the map and other codified procedural knowledge on specific actions to undertake to develop the tacit procedural expertise required to complete the survey pass.

Observers utilize previously codified TPK and EDK to inform decision-making and provide guidance to the aviator, as understanding what has and has not worked facilitates the development of a novel procedure. In the present survey effort, the previously captured lesson indicated that the procedure undertaken was ineffective, prompting the survey team to develop a new procedure. As the aircraft approaches from a new direction, the observer uses SAGE to record GPS data provided by the external interface with the GPS, thereby capturing a rich representation of the aircraft's movement through the site. After the pass, the observer codifies experientially derived knowledge on hazards encountered, conditions, and outcomes of the survey, as well as any special maneuvers required for success, thereby creating a new lesson learned (LL).

This process is repeated throughout the survey, culminating in the addition of numerous LL to the knowledge base. After the effort, the survey team reviews the knowledge base to identify errors, as well as irrelevant and ineffective LL. In the following year, a new survey team comprised of new aviators and surveyors, approaches the same study site and accesses the previously codified LL. The representation of the aircraft's movement through space combined with explicit guidance and knowledge of effectiveness, enables the survey team to collect data efficiently while developing procedural expertise in executing aerial surveys.

Results

The presentation of EDK alongside TPK enables expert aviators to understand and intuit the desired procedure, while providing novices with sufficient detail to support the internalization of the procedure through explicit guidance alongside its tacit, visual codification. That is, SAGE enables the effective transfer of TPK and EDK in ways that are useful and effective for guiding task execution and imparting expertise to novices. SAGE's knowledge access interface provides users with the ability to locate relevant knowledge based on geographic location or text through leveraging the external interface with GPS instruments as facilitated by the knowledge discovery component. This functionality enables users to access previously codified lessons, supporting quick and effective improvements to operational efficiency. SAGE's knowledge capture interface enables users to capture both tacit and explicit knowledge as they perform tasks. Through SAGE's external interface with the GPS device, users can capture procedures undertaken along with explicit knowledge related to the context, outcomes, and other experientially derived knowledge, such as local hazards or other helpful information. This capability allows for the codification of knowledge shortly after it is created. The inclusion of the knowledge verification interface allows organizational knowledge workers to curate captured lessons by making corrections to LL, removing irrelevant lessons, or adding additional details that can further improve task execution.

Discussion

The results of our evaluation suggest that SAGE is well-suited for supporting KM in the survey aviation context, thus providing evidence as to the satisfactory specification of our design principles. Overall, this finding aligns with our expectations, given our selection of the theory of organizational knowledge creation and media richness theory to inform the specification of our design principles. In particular, the utility of our design principle on ensuring the use of social methods through the use of sufficiently rich communication media (DP1) is corroborated by related works investigating the use of contextually appropriate rich multimedia, such as pictures and video, to codify social nuances and critical contextual information that supports tacit knowledge dissemination (Andersson, 2013; Hsu & Wu, 2020; Yasuoka & Hirata, 2020).

Similarly, our second design principle, proposing that such a class of KMS must represent both explicit and tacit knowledge about the execution of tasks and procedures, is supported by past research on the importance of appropriate codification of knowledge for supporting and enabling the internalization and development of tacit knowledge (López-Cabarcos et al., 2020; Steeples & Goodyear, 1999; Tsai & Lee, 2006). One interesting concept that arose during our descriptive evaluation was the utility of the codified knowledge collaboratively created by the aviator and the observer.

Specifically, the combination of explicated tacit knowledge resulted in the codification of newly created knowledge that was helpful for both aviator and observer in supporting future survey efforts in the same area, even if the specific aviators or observers are different. The importance of collaboration for tacit knowledge transfer and the creation of knowledge that is well represented for future use is well noted in the literature (Mezghani et al., 2016), particularly between disparate communities of practice (Carlile, 2004; Star & Griesemer, 1989). Correspondingly, past works have also noted that collaborative IT-based KM systems (e.g., wikis) are effective means for tacit knowledge management (Mezghani et al., 2016; Natek & Lesjak, 2021; Nyame-Asiamah, 2009). Although our design principles did not specify this capability, this finding is worthy of future inquiry and potential inclusion in subsequent iterative design evolutions.

While the demonstration of our design principles is centered in aviation, we believe they are generalizable to other contexts and thus can inform the design of KMS in other contexts where effective management of experientially derived tacit-procedural knowledge is important for the successful completion of complex tasks. For example, the clinical healthcare literature on KM and pedagogy has noted the importance of tacit knowledge and the use of KM mechanisms to more effectively transfer tacit and procedural knowledge from experts to novices (Dornan et al., 2019; Mitrea et al., 2023). Similarly, effective management of experientially derived tacit knowledge is vital for imbuing first responders with sufficient knowledge to address an unfolding crisis (Andersson, 2013; Cho et al., 2020; Sanford et al., 2020). While such exploration is beyond the scope of our study, a future empirical assessment of our proposed design principles, particularly in alternative contexts such as those mentioned above, is also warranted.

Returning to the broader perspective, our study is the first to provide generalizable design principles that design a class of KM systems suitable for capturing and disseminating experientially derived tacit-procedural knowledge, thereby complementing past works that prescribe methods and principles for designing various classes of KM systems, such as those that manage process-based knowledge (Sarnikar & Deokar, 2017), enable ethical co-creation of knowledge (Richardson, 2005) and support KM for smart services (Dreyer, 2021). Turning to the literature on LLS, we address a gap in knowledge on how to design LLS that supports both tacit-procedural and explicit-declarative forms of knowledge, thereby contributing to a significant gap in system capabilities and generalizable design knowledge. For practitioners, our study provides generalizable, practical guidance on how to develop KM systems, particularly lessons-learned systems that are better suited for managing an organization's tacit and procedural knowledge. Further, our proposed system architecture and user-interface design may be helpful for supporting efforts to implement such a class of knowledge management system.

Conclusion

Effective management of the tacit and procedural intellectual capital available to an organization is of critical importance as organizations adapt to an increasingly challenging and uncertain operating environment. In support of the valuable tacit and procedural knowledge that supports the efficient and effective execution of organizational tasks that rely upon procedural expertise and tacit knowledge to complete successfully, our study synthesized seven meta-requirements from the literature and formulated six design principles to guide the design of a class of KM system suitable for capturing and disseminating tacit-procedural knowledge.

Specifically, we propose that such systems must 1) enable the transfer of TPK through social methods by employing sufficiently rich communication media; 2) support task execution by capturing and disseminating both tacit-procedural knowledge as well as explicit-declarative knowledge; 3) imbue users with the procedural knowledge required to execute a task; 4) continuously captured and disseminate knowledge; 5) support the curation of codified lessons; and 6) facilitate access to knowledge. To demonstrate the utility of our proposed design principles, we developed a prototype System for Aerial Guidance and Expertise (SAGE) to address an important and unsolved problem in survey aviation (Hou & El-Gayar, 2025). Through the construction of a detailed and realistic hypothetical situation, and evaluation of SAGE's suitability for supporting KM in the survey aviation context, we concluded that both the instantiation and the meta-requirements and design principles underlying its design are well suited for the task, thereby satisfactorily addressing our research objective of formulating design principles for a class of KM system suitable for capturing and disseminating experientially derived tacit and procedural knowledge.

Our study has several limitations to discuss. First, the authors of the paper performed a descriptive evaluation of the prototype instantiation. While the use of such methods can be effective for highly abstract artifacts, the relatively concrete nature of instantiations make naturalistic evaluation methods highly feasible (Venable et al., 2016). Although time and resource constraints limited our evaluation at this time, our hypothetical situation is based on the actual practices of aerial survey teams that conduct such surveys. Future research endeavors are directed at developing a complete instantiation and employing naturalistic evaluation methods, such as case studies or convening a panel of expert practitioners to solicit feedback on the design and utility of SAGE, thereby enabling refinement of the instantiation and its underlying design principles (Venable et al., 2016). Further, such naturalistic inquiry would bolster claims of summative validity. Second, design science research requires several cycles of design iteration to refine the design of the artifact (Peffers et al., 2007). While the specification of our meta-requirements and design principles underwent several iterations of refinement, their formulation would be improved by conducting additional iterations enabled by demonstration and evaluation in a real-world organizational context. Third, our design principle formulation relied primarily on theory and related literature. Here, the use of other sources, particularly primary data sourced from workshops, focus groups, or interviews, would greatly strengthen the formative validity of the meta-requirements and, thus, the validity of the design principles. Thus, future research efforts are also directed at incorporating primary data to support the specification of meta-requirements. We look forward to continued investigation and further refinement of our design principles.

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