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Addressing Knowledge Gaps in ITSM Practice with "Learning Digital Commons": A Case Study

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Abstract
Information Technology Service Management (ITSM) constitutes a suite of specialized organizational capabilities aimed at optimizing the value derived from IT services. The practice of ITSM encompasses a range of complementary frameworks. However, the practitioner community lacks a comprehensive, holistic understanding of the knowledge embedded within these frameworks.
Addressing this gap, we developed *Service-Symphony*, an instance of a Learning Digital Commons (LEDICO) designed to empower the ITSM community with a holistic knowledge-learning experience, with design principles based on epistemic logic, cognitive constructivist learning theory and cognitive schema theory. Leveraging the Design Science Research (DSR) paradigm, we systematically constructed and assessed Service-Symphony. Evaluation tools included surveys and web analytics. Survey responses revealed a consensus among participants, with the majority expressing alignment with the four design principles underpinning Service-Symphony. Web analytics data further indicated significant engagement, with 148,796 users accessing Service-Symphony between April 2019 and September 2022.
This paper contributes both to theory and practice. Theoretical contributions include the establishment of a conceptual model and a multi-grounded design theory based on cognitive constructivist learning, cognitive schema and epistemic logic. The practical contributions include e the deployment of a public domain ITSM digital commons tailored to the specific needs of the ITSM community, which is also used as supplementary learning resource for ITSM students.

Keywords IT service management · Knowledge commons · Design science research · Epistemic logic · Learning digital commons · Cognitive constructivist learning · Cognitive Schema

1 Introduction

IT Service Management (ITSM) is a set of specialized organisational capabilities for optimising value from IT services (Axelos, 2019). Broad ITSM practice encompasses many complementary sub-practices that are developed and maintained by the practitioner community. The practitioner community has developed frameworks such as COBIT, ITIL, ISO/IEC 20000, CMMI-SVC, TOGAF to support practice areas (Auth, 2021) Governance, Service Value Management, Quality Management, Integrated Service Management and Enterprise Management.

ITSM is a mainstream management practice that has a long history since it was introduced in the 1980s with the development of the ITIL framework (Eikebrokk & Iden, 2017; Iden & Eikebrokk, 2016; Marrone et al., 2014). The practice has evolved over the years and is still relevant in the current business environment as ITSM can play a pivotal

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role in digital transformation of an organization (Auth, 2021; Korachi & Bounabat, 2020; Reiter & Miklosik, 2020). The principles of ITSM are aligned with Service Dominant Logic and underpin value co-creation (Cronholm et al., 2020; Winkler & Wulf, 2019). Often an organisation needs to leverage more than one process framework (Cater-Steel et al., 2006) and hence practitioners should have a good understanding of the knowledge eco-system (Ramakrishnan et al., 2018).

Though ITSM practice is mature, learning about appropriate ITSM process frameworks can be a challenge due to a lack of knowledge about existing frameworks and their relationship with other frameworks (Mejia et al., 2016; Valiente et al., 2012). The existence of multiple process frameworks can lead to confusion, inefficiency, and ineffectiveness (Hesston & Phifer, 2011). A lack of understanding of the process landscape is an impediment to adopting practices that improve organisational processes (Heston & Phifer, 2011; Mejia et al., 2016; Pardo et al., 2013; Valiente et al., 2012). Since practice areas evolve independently there is a lack of overarching, holistic knowledge within the broad ITSM knowledge eco-system (Shrestha et al., 2016). Knowledge sharing practices in gerenal facilitate innovation and firm performance (Wang & Hu, 2020; Wang & Wang, 2012). However, there is limited knowledge sharing between the sub-practices within the ITSM community. To address the lack of holistic knowledge, we embarked on a Design Science Research project to address the research question, ***"How can we design a knowledge repository that addresses the knowledge gaps within ITSM practice?"***

One mechanism for sharing knowledge is through the creation of "digital commons." The term "commons" refers to sharing of resources that are subject to social dilemmas such as rivalry, conflicts, and unfair appropriation of resources (Hess & Ostrom, 2007; Laerhoven, & v.,, & Ostrom, E., 2007; Ostrom, 1990). Digital commons are a sub-set of commons where data, information, knowledge, intellectual property, and community wisdom are created and shared online (Dulong de Rosnay & Stalder, 2020). A Learning Digital Commons (LEDICO) is the term used here for a digital commons that is created to facilitate learning amongst community members.

This research developed, deployed, and evaluated an instance of a LEDICO that we refer to as *Service-Symphony*. Service-Symphony is a public-facing ITSM digital commons that was released in February 2019 to facilitate learning among ITSM community practitioners and higher education students. Service-Symphony has been visited more than 148,000 times since its release. Service-Symphony was also used as a complementary learning resource for higher education students at an Australian university (Ramakrishnan et al., 2020).

The research follows the design science research (DSR) paradigm (Baskerville et al., 2018; Hevner et al., 2004), which is suited to research involving the design and evaluation of IS artefacts (Hevner et al., 2008; Meske & Bunde, 2022; Peffers et al., 2007; Peffers et al., 2018; Vaishnavi & Kuechler, 2015). The paper makes the following significant contributions to the body of knowledge: (1) developing DPs and a conceptual model based on epistemic logic for LEDICO; (2) applying the DPs to develop *Service-Symphony;* and (3) evaluation of *Service-Symphony* against the DPs.

This paper follows the structure proposed by (Gregor & Hevner, 2013a) to present DSR research. The remainder of the paper is organised as follows. The theoretical background section analyses learning through the lens of epistemic dimensions and builds a conceptual model for LEDICO. The methodology section describes the steps followed in designing and evaluating the artefact. The evaluation section describes the evaluation strategy and the results of the evaluation. The discussion and conclusion section reflects on the approach, results, and implications. This research concludes by acknowledging limitations and identifying future research opportunities.

2 Need for a LEDICO in ITSM Practice

ITSM has been researched by academics since 2005 (Hochstein et al., 2005). Early research focused on the ITIL framework which is considered a de facto standard for ITSM (Cater-Steel et al., 2006; Jarman, 2011; Latif et al., 2010; Marrone et al., 2014).

There are other aligned and complementary frameworks that support ITSM practice. COBIT focusses on the governance aspect of ITSM (Parvizi et al., 2013; Sánchez Peña et al., 2013; Steuperaert, 2019; Stroud, 2010; Veronica & Suryawan, 2017) and ISO/IEC 20000 provides a quality management framework that enables the organisations to be audited (Cater-Steel et al., 2010; Van Bon & van Selm, 2008).

When a broader interpretation of ITSM is considered, as opposed to operations, the scope of the practices covered expands accordingly. The practices covering strategy, knowledge management, enterprise architecture, continual improvement, portfolio management, program, and project management, DevOps and customer relationship management become part of broad ITSM.

ITSM is expanding as an enterprise practice as opposed to limiting the scope only to IT. The Enterprise Service Management (ESM) encompasses human resources (HR), Legal, property development and field service management (FSM) besides IT (Maes, 2022).

The broad interpretation of ITSM and the ESM trend implies that the ITSM practitioners need to consider multiple processes to design an end-to-end optimum process framework in their organisation Given the disparate nature of the ecosystem's independent knowledge artifacts, staying abreast of changes is challenging due to distinct release cycles within each knowledge community, as depicted in Fig. 1.

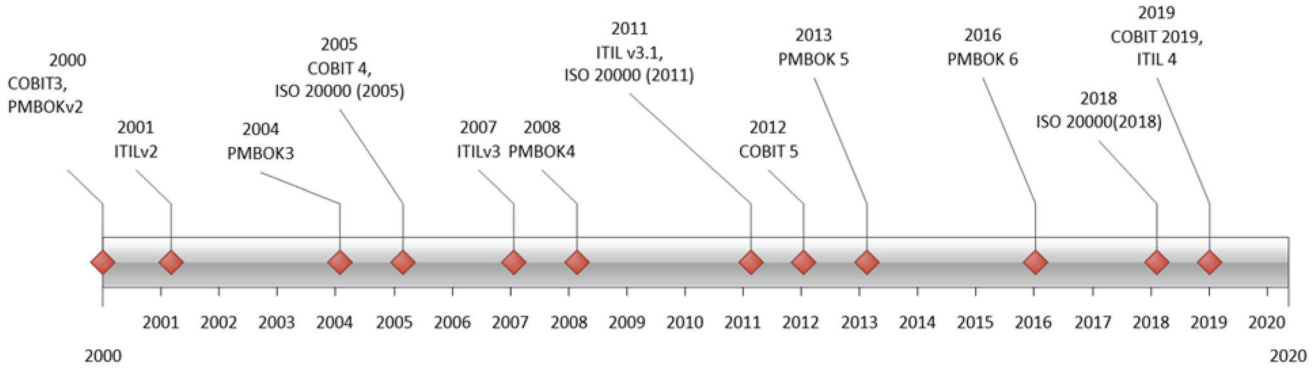

Fig. 1 Release Cycles of Process Reference Frameworks Relevant to ITSM (Ramakrishnan et al., 2018)

Figure 1 illustrates that the release cycles of frameworks operate independently, with some frameworks exhibiting aperiodic patterns. Notably, between 2018 and 2020, ISO/IEC 20000, COBIT 2019, and ITIL 4, three interconnected ITSM frameworks, were released. Organizations often find themselves compelled to implement multiple process frameworks (Cater-Steel, Tan, & Toleman, 2006). The coexistence of multiple frameworks, however, leads to confusion, inefficiency, and ineffectiveness (Heston & Phifer, 2011). Without a holistic knowledge repository, understanding the impact and relationships of new releases within an organization becomes labor-intensive. The academic community faces similar challenges in keeping pace with changes in the ITSM knowledge ecosystem (Cater-Steel et al., 2010). Academic curricula based on these frameworks necessitate careful consideration of the impact of releases for ongoing updates.

Monitoring emerging best practices poses an additional challenge within the ITSM knowledge ecosystem. For instance, the growing interest in DevOps practice (Ebert et al., 2016) lacks a comprehensive view, often being confined to specific interest groups. While industry forums offer insights, they tend to be group-specific rather than providing a holistic view of broader IT practices. Service-Symphony aims to bridge this gap by offering a real-time overview of emerging best practices across the entire ITSM ecosystem.

Our approach underscores the importance of practitioners comprehending the dynamically evolving ITSM knowledge ecosystem before engaging in the integration of various process frameworks (Reference removed for review). This approach offers a comprehensive perspective encompassing key frameworks, technological tools, and requisite skills within the ITSM ecosystem, elucidating interrelationships among diverse frameworks, including emerging ones. Service-Symphony serves as an instrument ensuring the continuous evolution of knowledge, providing a contemporaneous landscape with the right level of knowledge abstractions.

3 Theoretical Background

Learning is a fundamental human-centric activity that can happen at an individual level (Tavangarian, 2004), organisational level (Polanyi, 2009; Senge, 1995) or community level (Wang & Ramiller, 2009). Learning is a process of moving from existing knowledge to new patterns of knowledge, irrespective of whether the learning happens at the individual, organisational or community level.

Constructivism is a learning theory that suggests learners actively build their own knowledge and understanding of the world through experiences and reflections (Hein, 1991). It's rooted in the idea that learning is an active process where individuals make sense of new information based on their existing knowledge and experiences. The theory views learning as a social activity where interactions and collaboration with others play a crucial role.

Cognitive Constructivism builds on the constructivist foundation but places a stronger emphasis on the role of individual cognitive processes (Kalina & Powell, 2009). It focuses on how learners actively process and organize information internally. Cognitive constructivism acknowledges the importance of social interactions but underscores the significance of internal mental processes in constructing knowledge.

In a contemporary view of learning, people construct new knowledge and understandings based on what they already know and believe (Bransford et al., 2000). Bransford et al. (2000) argue that the logical extension of facilitating individual learning is to validate the learners' current knowledge and belief before imparting new knowledge. In the absence of an active educator intervention, a LEDICO should facilitate knowledge validation.

Common knowledge enables different stakeholders to cooperate by establishing a common context and terminology. Common knowledge accelerates learning and knowledge collaboration as it enables individual learners

operating in silos to communicate with peers using a common language and a clear understanding of their positions.

Knowledge is considered to be 'distributed' since it emerges primarily through social interactions (Kirkman, 2016). Tsoukas (1996) observes that there are two schools of thought in classifying knowledge. One group of researchers, including Polanyi (1961) and Nonaka (1994), propose a typology-based model that classifies knowledge as either tacit or explicit. Although the contributions of this typology have clarified our understanding of organisational knowledge, there are limitations to this approach. Tacit and explicit knowledge are not dichotomous as they are inseparable (Tsoukas, 1996). A second group of researchers attempts to model organisations as similar to human brains or collective minds. Weick and Roberts (1993) observe that the collective mind is a distributed knowledge system. The distributed knowledge system stream of research avoids the dichotomies inherent in other typologies of organizational knowledge.

The following section describes the categories of self-knowledge, common knowledge, and distributed knowledge through an epistemic logic lens.

Epistemology is the study of knowledge that has a long tradition in philosophy, starting with the early Greek philosophers and applied in diverse fields including economics, computer science, and Artificial Intelligence (Fagin et al., 2004; Meyer & Van Der Hoek, 2004). Epistemic logic is a study of systemic properties of knowledge (Hendricks, 2015).

Epistemic logic is highly relevant in IS research as it helps to formalise reasoning methods and provides a logical approach to decision making and developing formal descriptions (Meyer & Van Der Hoek, 2004).

3.1 Suitability of Epistemic Logic to Design a Digital Commons

Epistemic logic's suitability for knowledge-intensive systems lies in its capacity to elegantly capture and model the intricate dynamics of knowledge, beliefs, and information within complex environments. In the context of LEDICO, which inherently deals with the representation and dissemination of information within a community, several key aspects underscore the appropriateness of epistemic logic. Some of the key features of epistemic logic are:

3.1.1 Rich Representation of Knowledge Structures

Epistemic logic provides a robust framework for representing complex structures of knowledge (Fagin et al., 2004). It allows for the formal expression of what agents know, believe, or are uncertain about in a way that is nuanced and detailed. This richness is crucial when dealing with diverse forms of knowledge in a digital commons.

3.1.2 Formalization of Knowledge and Information Flow

Knowledge-intensive systems involve multiple entities with varying perspectives. Epistemic logic excels in formalizing these beliefs and representing the flow of information among different agents. This is particularly relevant in a digital commons where users may contribute, consume, and evolve information.

3.1.3 Dynamic Updating of Knowledge

Epistemic logic supports dynamic reasoning, enabling the system to update knowledge and beliefs in response to changing information (Ditmarsch et al., 2007). In a digital commons, where information is continuously evolving, the ability to dynamically adapt to new knowledge is vital. Epistemic logic facilitates this by providing a logical basis for updating beliefs considering new evidence.

3.1.4 Handling Uncertainty and Incomplete Information

Knowledge-intensive systems often grapple with uncertainty and incomplete information. Epistemic logic provides a formal mechanism to represent and reason about uncertainty and incomplete knowledge. This is valuable in scenarios where users may have varying levels of certainty or incomplete information about certain aspects of the digital commons.

3.1.5 Modelling Multiple Perspectives and Agents

In a digital commons, there are likely multiple perspectives and stakeholders with different knowledge bases and beliefs. Epistemic logic is well-suited for modelling these diverse perspectives and the corresponding information each agent possesses. It allows for a nuanced understanding of the knowledge landscape, catering to the multi-agent nature of your digital commons.

Given its formal and logical nature, epistemic logic provides a strong foundation for deriving design principles. It allows for the systematic extraction of principles governing the knowledge dynamics of the digital commons. This ensures that design decisions are grounded in a rigorous theoretical framework, contributing to the robustness of the resulting artifacts. In our research, we have used only a subset of the capabilities of epistemic logic to demonstrate the possibilities available.

3.2 Viewing the Research Problem through Epistemic lens

In our research problem of addressing the knowledge gap in ITSM practice, epistemic logic provides clarity on "what type of knowledge we need to address?". There is no dearth of knowledge within the ITSM practice. Each framework provides a substantial body of knowledge. For example ITIL, COBIT, ISO/IEC 20000 have associated body of knowledge and a structured learning pathways. However, what was lacking was a holistic view of the knowledge. We needed a formal way to address the knowledge gap and represent it. Hence, we analysed the three categories of epistemic dimensions viz., self-knowledge, common knowledge, and distributed knowledge and extended them to derive DPs that provide prescriptive guidance for the design of LEDICO.

3.2.1 Self-Knowledge

Self-knowledge implies that the agent is aware that they know a proposition "p". Self-awareness is gained through introspection. Introspection is defined as an "ongoing process of tracking, experiencing, and reflecting on one's thoughts, mental images, feelings, sensations, and behaviours" (Gould, 1995, p. 719). One of the preconditions of introspection is that the person introspecting should be knowledgeable to some extent in the topic under consideration (Gould, 1995; Xue & Desmet, 2019). Therefore, self-knowledge is a foundation for building common knowledge.

3.2.2 Common Knowledge

Epistemic logic is based on the *possible worlds* model that can be explained through a classic puzzle presented by Fagin et al. (2004). Let us consider a scenario where two children, Alice and Bob, are playing in the park and a parent strictly instructed them not to get dirty. Both have mud on their forehead. The parent declares "*At least one of you has mud on your forehead*" and asks the question "*Do you know if you have a dirty forehead*?". Each child cannot see their forehead. When the parent asks the first time, the reply will be "*No*" from both of them. However, when the parent asks the second time, both will answer "*Yes*". When Bob answers "*No*" for the first time, Alice recognizes there must be mud on her forehead, or else, Bob would have answered "*Yes*". The assumption behind the puzzle is that the children are perceptive, intelligent, truthful, and answer simultaneously.

In this concept of the *possible worlds*, besides the true state of events, there are other possible states of events, or "worlds". If we extend the example to multiple children, in which Alice notices that Bob has a muddy forehead, and no other children have muddy foreheads. This allows Alice to eliminate all but two worlds:

- Bob and Alice have muddy foreheads and the other children are clean
- Only Bob has a muddy forehead, and the other children are clean.

The knowledge provided by the parent is important. The proposition p is "at least one of you has a muddy forehead." This proposition is not new to the children as they can see each other. By announcing this proposition, the parent makes sure that "everyone knows that everyone knows p". This notion is called *common knowledge*.

3.2.3 Distributed Knowledge

Distributed knowledge is another aspect of epistemic logic (Fagin et al., 2004; Roelofsen, 2007). Consider Alice and Bob sitting in a closed room in Sydney. They are wondering whether it is a sunny day. Alice and Bob have a common friend Charlie. Alice knows that Charlie plays cricket whenever it is a sunny day. Bob mentions to Alice that he just met Charlie outside the building. Combining these two pieces of information, Alice and Bob can conclude that it is not a sunny day. The concept of distributed knowledge can be extended to organisations and communities. In the organisational context, no single agent can fully specify in advance what kind of practical knowledge is going to be relevant to the organisation. Therefore, organisations are to be considered as distributed knowledge systems. (Tsoukas, 1996). Epistemically, the distributed knowledge can be expressed as "*a formula φ is distributed knowledge among a group of agents B iff*[1] *φ follows from the knowledge of all individual agents in B put together*" (Roelofsen, 2007, p. 255). This statement represents the ideal condition of distributed knowledge that expects the knowledge is distributed to all the agents within the group. In practice, we interpret the statement as, "*A solution S is distributed knowledge among a group of agents G iff S is derived from the knowledge of some or all of the individual agents in G put together.*" This statement acknowledges the solution knowledge is broader than an individual agent, but does not necessarily needs inputs from *all* the agents in the group. Hewitt and Scardamalia (1998) point out that human cognition does not just reside "in the head" of one individual but is distributed among other individuals and influenced by their surroundings. Table 1 summarizes the three categories of epistemic dimensions.

[1] The term "iff" is an abbreviation of "if and only if"

Table 1 Epistemic dimensions

Epistemic dimensions	Description	Interpretation
Self-knowledge	Self-aware, introspection of knowledge	Agent a knows that agent a knows proposition p
Common knowledge	All members of the group know about a fact, and they know that the other members also know the fact	All agents in a group know proposition p; All agents know that the other agents in the group know proposition p.
Distributed knowledge	The group collectively knows the solution to a problem	A solution S is distributed knowledge among a group of agents G iff S is derived from the knowledge of some or all the individual agents in G put together

3.3 Development of a Conceptual Model

In this section we develop a conceptual model of LEDICO through cognitive constructivist learning theory. Cognitive constructivism is a learning theory that falls under the broader category of constructivism (Hruby & Roegiers, 2012). Cognitive constructivism posits that learners actively construct their own understanding by integrating new information with their existing cognitive structures (Wadsworth, 1996).

The constructivist approach to learning suggests that we should focus on designing learning environments that are learner-centered, knowledge-centered, assessment-centered, and community-centered (Bransford et al., 2000). LEDICO in primarily a knowledge-centered learning environment. From a constructivist perspective, knowledge-centered learning environments prioritize the types and structures of information and activities that facilitate the construction of robust understandings within specific subject areas (Swan, 2005). In contrast to memorisation of isolated facts and procedures, knowledge-centered learning places greater importance on context-based learning, the formation of complex knowledge structures.

One of the theories that support cognitive constructivism is cognitive schema theory (Derry, 1996). A schema is a cognitive structure or mental framework that helps individuals organize and make sense of knowledge (McVee et al., 2005). The congnitive schema includes information about the characteristics, attributes, and relationships associated with that concept. The learning agent, according to cognitive schema theory, actively builds schema and revises them in light on new information. We argue that the learning agent's schema development are influenced by self-knowledge, common knowledge and distributed knowledge. The information schema of LEDICO also plays a role in the development of cognitive schema. For example, the information schema provides not only new knowledge, but also the connection with the learner's existing knowledge. We call this phenomenon *"schema convergence"*. Schema convergence is used to signfiy the development of learners' cognitive schema in alignment with the information schema presented in LEDICO.

The self-knowledge of the agent is based on their prior knowledge, experience, and environment. The foundational impetus for learning is through self-knowledge. In our research context, one role of LEDICO is to stimulate the agent to reflect and introspect about what they know.

Common knowledge allows the agent to collaborate with other agents within the domain. LEDICO plays a pivotal role in disseminating common knowledge. LEDICO can equip the agent with common terminology, best practices and pointers to further resources and communities.

The distributed knowledge space is broader than the common knowledge space. Distributed knowledge can lie within the domain or outside the domain. For example, if an innovator is conducting research in metallurgy, all the related sub-domains within metallurgy are considered as distributed knowledge within the domain. The innovator can get inspiration and complementary knowledge from other domains not related to metallurgy. The conceptual diagram acknowledges the role of 'external' distributed knowledge.

Distributed knowledge within a domain can be accessed by the agent through LEDICO. It is possible that once initial knowledge is gained, the knowledge seeking agent can directly interact with practice communities to gain more knowledge about specific practices. Figure 2 provides a conceptual model of LEDICO, termed the Integrated Learning Construction (ILC) Model.

3.3.1 Advantages of the ILC Model

- The ILC model integrates key learning theories, namely cognitive constructivism and cognitive schema theory and epistemic logic. This integration provides a more holistic understanding of how learners actively construct knowledge and organize it into cognitive structures.
- The inclusion of LEDICO as a learning environment in the ILC model adds a practical and contextual layer to the framework. LEDICO not only serves as a source of

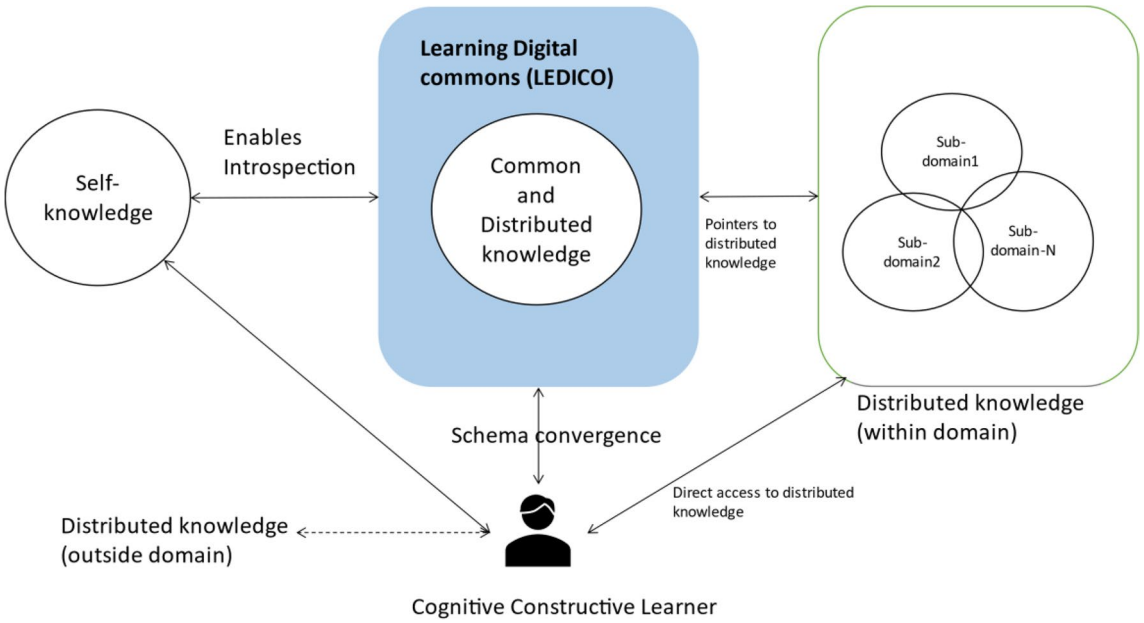

Fig. 2 Integrated Learning Construction (ILC) Model

information but also plays a crucial role in facilitating schema convergence by connecting new knowledge with existing learner knowledge.

- Introducing the concept of *schema convergence* provides a clear and specific term to describe the alignment of learners' cognitive schemas with the information schema presented in LEDICO. This concept enhances clarity and understanding within the framework.
- LEDICO serves as a practical tool for learners. Its role in stimulating reflection, providing common knowledge, and facilitating access to distributed knowledge spaces makes the framework actionable in real educational settings.

4 Research Method

This research follows the DSR paradigm which addresses the "relevance versus rigour" gap in IS research (Baskerville et al., 2018; Hevner et al., 2004). DSR involves two primary activities: (1) the creation of new knowledge through the design of novel or innovative artefacts; and (2) the analysis of the artefact's use and/or performance (Vaishnavi & Kuechler, 2015). This research follows a six-step DSR approach comprising (1) Problem identification and motivation, (2) Objectives of a solution, (3) Design and development, (4) Demonstration, (5) Evaluation, and (6) Communication (Peffers et al., 2007). Table 2 shows the objectives of each step and how our research addressed those objectives.

5 Meta-Requirements Elicitation

Iivari (2015) proposed that there can be two strategies in DSR depending upon the intent and nature of the IS artefact. In the first strategy, a general solution concept to address a class of problems is built by the researcher. In the second strategy, a client's specific problem is solved through the IS artefact. Our research is aligned to the first strategy as our research is focused on a general problem without a specific client. As there was no single client, we formed an expert panel to represent the practitioner community. The expert panel served as a mechanism for brainstorming ideas and refining objectives and requirements (Step 2). The five-panel members were experts with over 20 years of experience each and participated voluntarily. The members came from diverse backgrounds including freelance consulting, Chief Information Officer (CIO), private and government sectors. Two members were nominated by the IT Service Management Forum (ITSMF) in Australia, which is the peak body representing ITSM professionals.

The expert panel inputs were captured as meta-requirements (MRs). MRs describe the goals that are addressed in the class of problems (Kuechler & Vaishnavi, 2012; Walls et al., 1992; Walls et al., 2004). MRs and DPs are essential components of a design theory (Gregor & Jones, 2007; Walls et al., 1992).

We captured the "user stories" from different stakeholders' perspectives and consolidated these stories as a MR. A user story is a method of requirements elicitation in Agile development that captures the needs of different users

Table 2 Research Methodology Steps-Objectives-Activities

Step	Objective	Research activities
Problem Identification and Motivation	Clearly define the problem that needs to be addressed and articulate the motivation for undertaking the research	Identified gaps in current knowledge within ITSM practice Described the problem's significance and relevance to ITSM practitioners
Definition of the Objectives for a Solution	Establish clear objectives for the design and development of a solution or artifact.	Elicited meta-requirements for Service-Symphony that will address the identified knowledge gaps
Design and Development	Create the actual artifact or solution to address the problem.	Developed design principles based on epistemic logic and cognitive constructivism Developed the IS artefact, Service-Symphony
Demonstration	Illustrate how the designed artifact effectively addresses the identified problem.	After demonstrating to a small audience, released Service-Symphony to the global practice community
Evaluation	Assess the effectiveness and impact of the designed artifact	Conducted rigorous evaluation to measure the success of the solution
Communication	Share the knowledge gained from the research with the academic and practitioner communities	Published research papers, conference papers, industry presentations to disseminate knowledge

(Amorim et al., 2021; Dalpiaz & Brinkkemper, 2018; Kannan et al., 2019).

A user story is often written in the format "As a *[type of user],* I want *[some goal]* so that *[some reason].*" (Dalpiaz & Brinkkemper, 2018; Kannan et al., 2019). Based on this format, we developed the following user stories:

MR1: As an ITSM practitioner/student, I want to assess my current knowledge against the industry standard so that I can plan my development.

MR2: As an ITSM practitioner/student, I want to learn the jargons/terminologies used in the frameworks so that I do not waste time while interacting with other stakeholders.

MR3: As an ITSM practitioner, I want to learn about complementary processes so that I can leverage the best practices.

We attempted to address the MRs through the lens of epistemic dimensions, as explained in the next step.

6 Design and Development

The design and development began with consideration of cognitive constructivism learning, cognitive schema and epistemic logic as a basis for DPs to guide artefact development. DPs are prescriptive statements that describe the method for achieving a defined objective (Gregor et al., 2020; Gregor & Jones, 2007). DPs are one of the major research outcomes of DSR (Chandra et al., 2015; Gregor et al., 2020; Iivari et al., 2021).

This research derived four DPs for LEDICO based on the self-knowledge, common knowledge, distributed knowledge and integrated learning construction aspects.

In the language of epistemic logic, this paper uses the notation K_{ap} for "agent *a* knows that *p* is the case." The term "*p*" can stand for any proposition. It could be as simple as "Alice knows Bob has mud on his head" or "Organisation-A knows that a risk assessment is important in project management".

Epistemic logic allows the expression of "knowledge about knowledge". For example, let us assume Anne sends an email to Bob which is read by Bob. The email can be about any proposition "*p*," say "let us meet at 6 pm for a coffee". The statement will be:

Kbp^KbKap

The statement expresses that agent *b* knows proposition *p* AND agent *b* knows that agent *a* knows proposition *p*. The operator ^ is known as the conjunction operator is used denote "AND".

Principle of introspection-centricity*:* In epistemic terms, when the agent knows a proposition, it implies that "*agent know that they know what they know*." The epistemic statement that represents introspection is:

KaKap

where agent *a* knows that agent *a* knows proposition *p*.

This principle differentiates between "knowing something" and "awareness of knowing something." There could be many reasons why an agent may not realise what they already know. One of the reasons could be the use of different terminologies. For example, the term "incident" and "problem" have specific meanings in the context of ITSM. The "problem" is a term used to describe the underlying cause of incidents. If we ask a whitegoods mechanic if they

know "problem management," they may be likely to answer negatively. Once they are made aware that problem management deals with root-cause analysis and troubleshooting, they will be able to relate to it. The potential design features that can help to validate the self-awareness of the knowledge are pointers to training and assessments.

In this context, the first DP can be stated as follows:

6.1 DP1: A LEDICO Should Enable Users to Reflect on and Assess their Knowledge and Skills within the Practice Domain

DP1 is aligned with MR1. MR1: As an ITSM practitioner/student, I want to assess my current knowledge against the industry standard so that I can plan my development.

The common knowledge concept of epistemology is closely related to the introspection centricity discussed earlier. The common knowledge should be communicated to the group of agents within the solution domain. Each member of the group should have an understanding that the other members in the group are aware of the knowledge. For example, within the ITSM domain if two members discuss "problem management", both are aware of the context, process steps and outcomes expected from problem management. To achieve common knowledge, the knowledge provided in LEDICO should be relevant to practitioners. Epistemically common knowledge centricity can be expressed as follows:

$KaKbp\hat{}KbKap$

The expression states that agent a knows that agent b knows proposition "p" and agent b knows that agent a knows proposition "p".

Design features that support the principle of common knowledge centricity could include a unified page that presents a holistic view of the domain and effective search and compare features to explore the practice sub-domains.

In this context, the DP can be stated as follows:

6.2 DP2: A LEDICO Should Provide Common Knowledge within the Practice Domain

DP2 is aligned with MR2: As an ITSM practitioner/student, I want to learn the jargons/terminologies used in the frameworks so that I do not waste time while interacting with other stakeholders.

One of the ways to innovate is to combine different knowledge areas in a novel way or combine previously unconnected knowledge areas (Nahapiet & Ghoshal, 1998; Ruiz-Jiménez & del Mar Fuentes-Fuentes, 2013). Allowing for knowledge diversity ensures that the innovating agent is aware of diverse knowledge within and outside of the domain. For LEDICO, the scope of diversity is limited to providing diverse knowledge within the chosen domain. The epistemic expression that underpins the principle of knowledge diversity can be stated as follows:

$$Kap \wedge Kaq \wedge Kar$$

$$p \epsilon SD1, q \epsilon SD2, r \epsilon SD3$$

Where p, q, and r are propositions from separate knowledge sub-domains *SD1, SD2 and SD3*. The notation ϵ represents "element of" and means "p" is an element of SD1, q is an element of SD2 and r is element of SD3.

The design principle in this context can be stated as follows:

6.3 DP3: A LEDICO Should Contain Diverse Knowledge that Can Be Searched and Compared across Different Practice Sub-Domains

DP3 is aligned with MR3: As an ITSM practitioner, I want to learn about the complementary processes so that I can leverage best practices.

The first three DPs deal with the epistemic dimensions of self-knowledge, common knowledge and distributed knowledge. This fourth overarching DP connects these dimensions with cognitive constructivist learning theory and cognitive schema theory. The overarching DP is aligned with the ILC conceptual model. ILC DP is stated as:

6.4 DP4: A LEDICO Should Be Architected for Cognitive schema Convergence by Integrating the Epistemic Dimensions of Introspection Centricity, Common Knowledge Centricity and Knowledge Diversity

The overarching design principle emphasizes the convergence of learners' cognitive schemas with the information schema through intentional integration with the epistemic dimensions of introspection, common knowledge, and knowledge diversity. This aligns seamlessly with the principles of cognitive constructivist learning theory and cognitive schema theory, highlighting the active role of learners in constructing, revising, and aligning their mental frameworks.

The mapping of epistemic dimensions, DPs and potential design features are summarised in Table 3.

Table 3 Mapping between Epistemic dimensions, DPs and potential design features

MR Summary	Epistemic dimensions	DPs	Description	Potential Design features of an instantiated artefact
MR1: As an ITSM practitioner/student, I want to assess my current knowledge against the industry standard so that I can plan my development.	Self-knowledge	Introspection centricity	A LEDICO should have design features that enable the users to reflect and assess their skills within the practice domain.	Providing relevant knowledge to trigger introspection. Pointers to self-assessment of skills. Assessment instruments.
MR2: As an ITSM practitioner/student, I want to learn the jargons/terminologies used in the frameworks so that I do not waste time while interacting with other stakeholders.	Common knowledge	Common knowledge centricity	A LEDICO should provide common knowledge within the practice domain.	Unified landing page. Group announcements. Links to related topics. Pointers to external sources.
MR3: As an ITSM practitioner, I want to learn about the complementary processes so that I can leverage the best practices	Distributed knowledge (within a practice domain)	Knowledge diversity	A LEDICO should contain diverse knowledge across different sub-domains that can be explored by the user through searching and comparing.	Information search. Collaboration features.
All MRs	All epistemic dimensions	Integrated Learning Construction	A LEDICO should be architected for cognitive schema convergence by integrating the epistemic dimensions of introspection centricity, common knowledge centricity and knowledge diversity.	Information architecture and design features associated with other DPs

7 Description of the Artifact

Service-Symphony is developed as a green-field application. The application development used a configurable platform approach that considerably eases the application development process (Rodas-Silva et al., 2019).

7.1 Technical Architecture

This research used an open source the Content Management System (CMS). The CMS was supported by multiple technologies, known as a LAMP stack. LAMP is an abbreviation of "Linux, Apache, MySQL and PHP." The modern LAMP now provides broader stack options (Louridas, 2016). The traditional LAMP stack is consistent with Linux as the Operating System, Apache web-server, MySQL as the relational database, and PHP as the programming language (Louridas, 2016). The opensource CMS allowed integration with the professional networking platform LinkedIn and ChatGPT. Service-Symphony uses an Australian domain name and is hosted by an Australian internet provider.

7.2 Information Architecture

Information Architecture is a combination of organising, labelling, implementing navigation schemes and evaluating information spaces (Dillon, 2002; Rosenfeld & Morville, 2002).

While assembling the information in Service-Symphony, this research considered the following search goals. The user should be able to:

- search across all frameworks, lifecycle, processes, tools, skills
- search at a specific granularity (for example, within process level)
- search within a specific framework (for example, within ITIL v3)
- search within a specific framework and granularity (for example, within ITIL 4, process/practices)
- browse and access any specific process area directly without the need for searching
- utilize side-by-side comparison of specific frameworks.

A visitor can get a helicopter view of the information included by browsing the landing page of Service-Symphony as shown in Fig. 3. If they want to access a specific process framework, they can do so by directly clicking the relevant framework. The framework has further hierarchical structures that are organised as lifecycle stages and process/practices. Each framework may have their own specific terms to describe the hierarchy.

When the visitor wants to get more information about a specific framework they can do so by clicking the link. Each knowledge page of the frameworks have the following structure.

- Description of the framework
- How it fits in the holistic ITSM landscape
- The phases/processes within the framework
- Tools that underpin the framework
- Skills required along with certification bodies.

For the description of how each framework fits within the overall ITSM operating model, we use ITIL4 and COBIT as the overarching model and show how each framework fits within that model. The models ITIL 4 and COBIT were chosen because they are holistic models that encompass all aspects of an IT function. COBIT sets control objectives and metrics of all the domains and not prescriptive. While ITIL offers some best practice guidelines, they are not too prescriptive. ITIL is considered as de-facto standard. COBIT is supported by a well defined body of knowledge and communities of practice. Choosing these frameworks as overarching models enable the agents to converge their cognitive schema with new information, thereby enabling faster learning.

For example, if a practitioner or student wants to know how Agile fits within the lifecycle, they can understand that Agile is part of Obtain/Build activity as per ITIL 4 and belongs to the 'Build, Acquire and Implement' domain of COBIT 2019 as shown in Fig. 4.

Therefore, Service-Symphony's information architecture is designed to bridge existing knowledge gaps prevalent in the ITSM practitioner community. The systematically organized information not only offers visitors a comprehensive perspective of the entire ITSM knowledge ecosystem but also encompasses emerging frameworks. This structured approach allows users to grasp the interconnections between frameworks, comprehend the technological tools supporting them, and access guidance on pertinent skills and certifications. In essence, Service-Symphony stands as a solution-oriented platform, tailor-made to enhance understanding and navigate the knowledge landscape of ITSM practice.

8 Demonstration of the Application of DPs

While designing *Service-Symphony*, this research applied the four DPs of introspection centricity, common knowledge, knowledge diversity and IKC through design features. The next section discusses the design features of *Service-Symphony* that support the DPs.

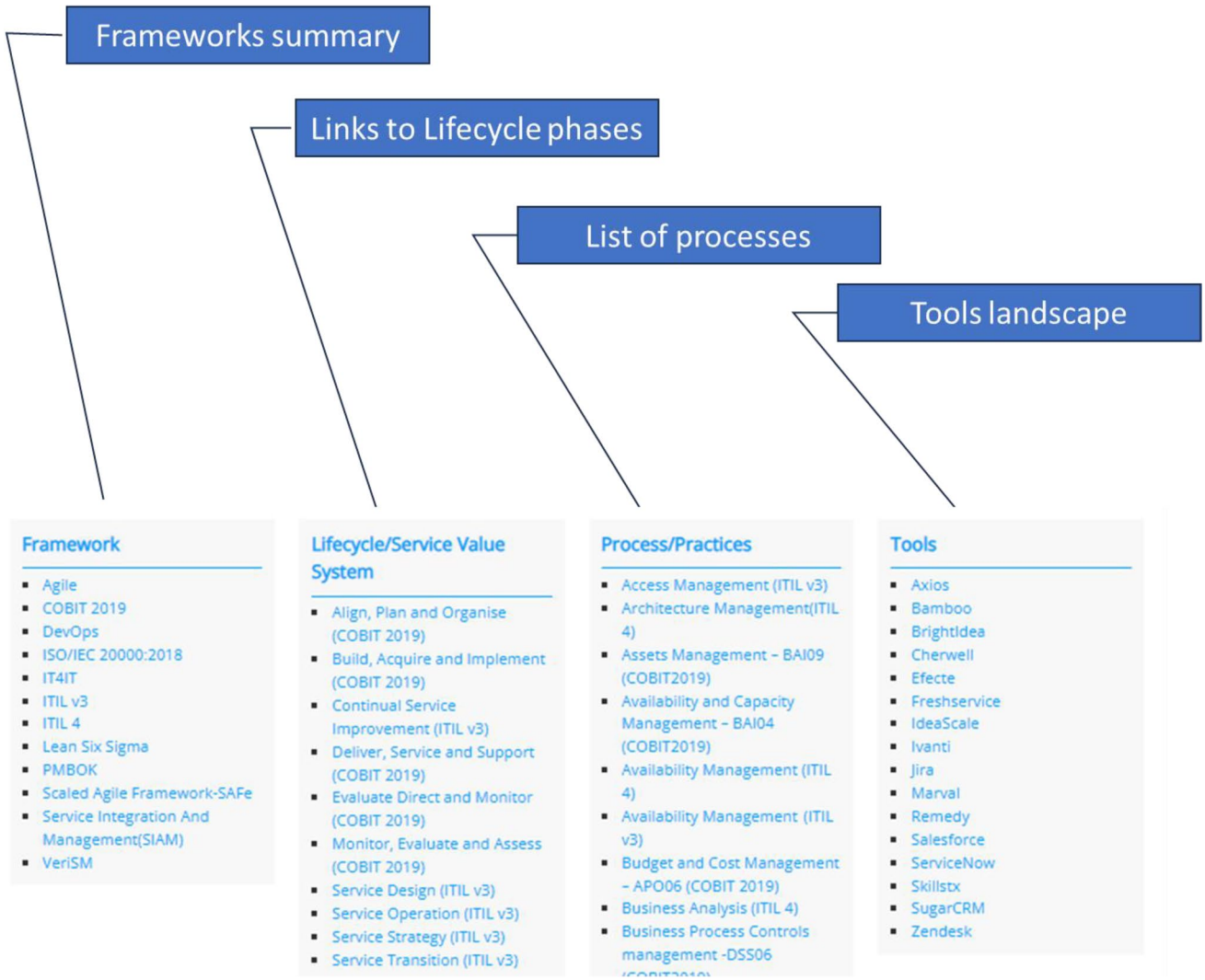

Fig. 3 A Section of the landing page of Service-Symphony

8.1 Applying the Principle of Introspection-Centricity

Introspection-centricity attempts to fulfil one of the preconditions of introspection, i.e., the agent should have some prior knowledge about the topic being considered (Gould, 1995; Xue & Desmet, 2019) . *Service-Symphony* design should enable users to introspect if they find the content relevant to them and easy to comprehend. The information architecture of *Service-Symphony* enables the user to comprehend the ITSM landscape holistically. In addition, monitoring and feedback mechanisms were implemented including web analytics and user posting to ensure that the content stays relevant to practitioners.

The Skills Framework for the Information Age (SFIA) is an international skills framework widely accepted by the IT industry and academia (Brown, 2020; Hayashiguchi et al., 2022). The skills framework enables learners to self-assess their competency level in terms of responsibility and power of influence. With respect to the proficiency of professional skills, SFIA defines 7 levels of responsibility with level 1 representing the lowest proficiency and level 7 the highest (Brown, 2020). Knowledge articles in Service-Symphony summarise the competencies of each process area and point to the corresponding competency description in the SFIA portal. Fig. 5 shows how the SFIA competency Enterprise IT Governance is aligned with the COBIT 2019 framework. Thus, Service-Symphony is providing awareness about the SFIA competency framework for a learner visiting Service-Symphony. In future, we are planning to incorporate self-assessment instruments within Service-Symphony itself.

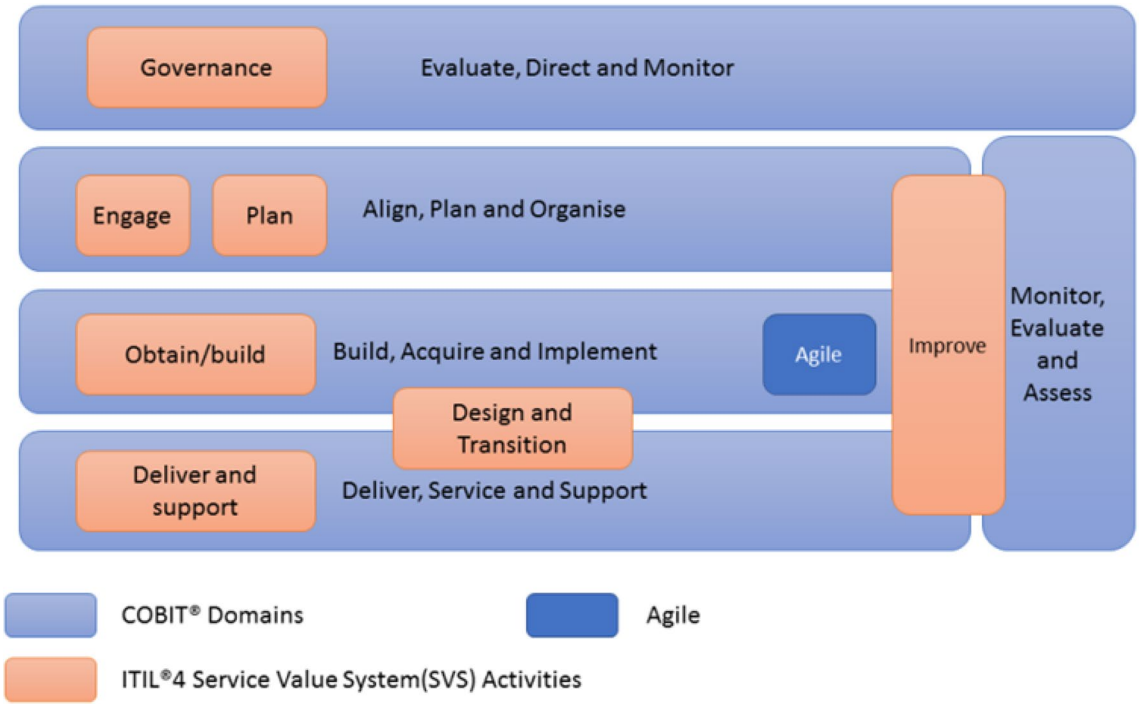

Fig. 4 Framework relationships within COBIT and ITIL 4

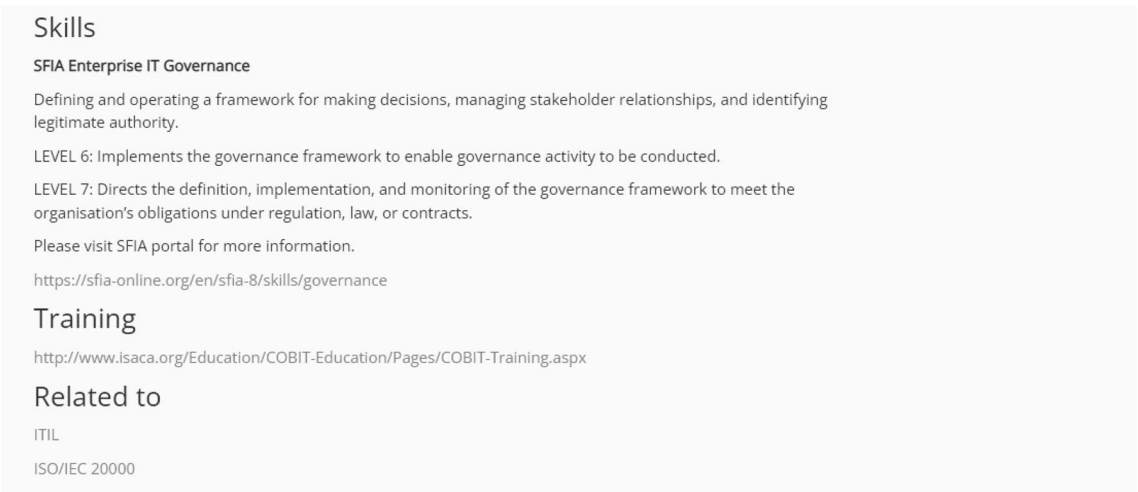

Fig. 5 SFIA competency for learner self-assessment

8.2 Applying the Principle of Common Knowledge Centricity

Service-Symphony is designed to provide an overview of relevant process frameworks. It describes all the processes and sub-processes within the frameworks. In the current version, *Service-Symphony* contains knowledge of 12 process frameworks, 11 service lifecycle stages, 35 processes, and 16 tools. Service-Symphony users can get a holistic view of the common frameworks, tools and lifecycles. This unified view enables the agents to gain an understanding of the overall landscape. By exploring the frameworks further, the agents can understand the common terminology, guiding principles, and best practices of each framework. For example, searching "change management" would reveal that there are different processes for "organizational change management" and "change management". The scope and intent of these processes are different. For an IT

professional, typically "change management" implies that a technical change is associated with deploying a change in the live production system. For a non-IT person, change management, usually implies preparing the employees for a change in the organisation. In a situation when the business and IT personnel have discussion, unless the common knowledge is clarified, there will be misunderstandings. Fig. 6 Common Knowledge Illustration – Change Management terminologyshows the search result of "change management" in Service-Symphony showing the difference between Organizational Change Management and Change Management.

8.3 Applying the Principle of Knowledge Diversity

Service-Symphony provides diverse knowledge within the ITSM domain. We carefully considered the boundaries of the domain. If a domain is defined too narrowly, the opportunity to draw from diverse knowledge is lost. If the domain is defined too broadly, the relevance to practice will be lost. In designing Service-Symphony, we defined broad boundaries of the ITSM domain as encompassing IT Governance, service management, project management, enterprise architecture, DevOps and continual service improvement. The frameworks underpinning these sub-domains have overlapping aspects as well as diverse aspects. *Service-Symphony* enables its users to search in different ways, including

- across all frameworks, lifecycle, processes, tools, skills
- within a specific framework (for example, within ITIL4 framework)
- within a specific framework and with specific granularity (for example, within ITIL4 and across relevant process/practices)
- side-by-side comparison of specific frameworks.

The organisation of *Service-Symphony* is shown in Fig. 7.

8.4 Applying the Principle of Integrated Learning Construction

The culmination of the epistemic DPs is encapsulated in the Integrated Learning Construction DP. This principle serves as a holistic reminder to designers to step back and critically assess whether individual design features collectively address the diverse needs of the learner. The genesis of these features

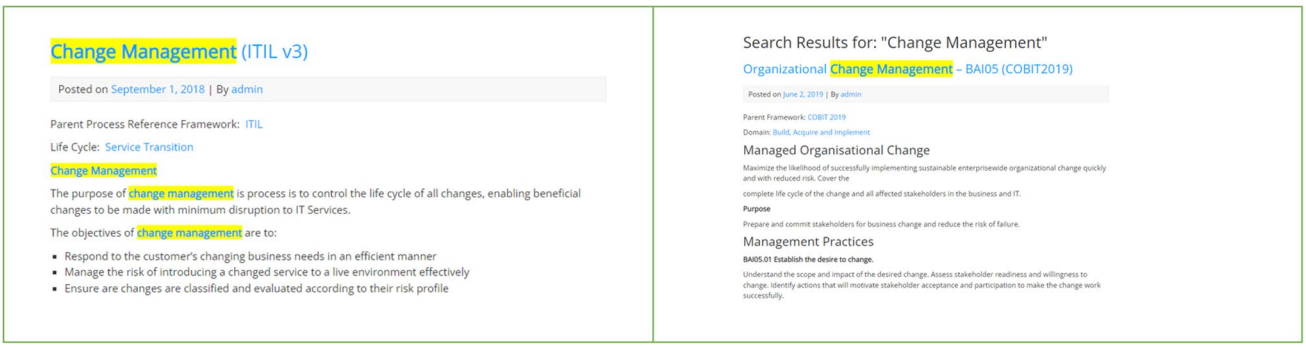

Fig. 6 Common Knowledge Illustration – Change Management terminology

Fig. 7 Applying the principle of knowledge diversity

stems from the evaluative feedback received from participants. For instance, videos were incorporated to demonstrate how the Service-Symphony platform facilitates the implementation of Innovation Management in an organizational setting. In response to another user feedback, navigation experience was enhanced by implementing a 'breadcrumb' feature, visually presenting the hierarchical structure of navigation. Consequently, the Integrated Learning Construction DP functions as an overarching principle, ensuring that the overall learning experience remains aligned with user needs.

9 Evaluation

DSR advocates for rigorous evaluation of the developed artefacts (Peffers et al., 2012; Venable et al., 2016). The Framework for Evaluation in Design Science Research (FEDS) (Venable et al., 2016) classifies evaluation into formative and summative evaluation and proposes different strategies. Our summative evaluation follows the Human Risk & Effectiveness strategy that advocates practitioners evaluating the artefact in a naturalistic setting. More specifically, the evaluation approach utilized methodical triangulation. Methodological triangulation considers more than one quantitative or qualitative data source or method to evaluate a phenomenon or product (Bekhet & Zauszniewski, 2012; Jack & Raturi, 2006). The methodical triangulation overcomes the inherent flaws of a single evaluation instrument and enable researchers to derive better-founded conclusions (Jack & Raturi, 2006). This research conducted surveys and used web behavioural analytics (Plaza, 2011; Saura et al., 2017) to evaluate the DPs alignment with the *Service-Symphony* design. Figure 8 shows the methodical triangulation approach.

9.1 Survey Responses Analysis

A survey was used to evaluate the perceptions of industry practitioners (n = 24) and University students who were pursuing ITSM studies (n = 16) on the relevance *Service-Symphony*. The industry practitioners were recruited during a professional networking seminar conducted by ITSMF. The students were recruited through the course coordinator of ITSM course in which students were enrolled. The survey was conducted in compliance with the University's ethical research policy and no personally identifiable data was collected. The survey included questions to calculate the Net Promoter Score (NPS) and assess *quality-in-use* characteristics aligned with ISO/IEC 25000. The NPS is derived from responses to a single question that queries whether the user would recommend the product to a friend or colleague (Reichheld & Covey, 2006). The ISO/IEC 25000 series, known by the abbreviation SQuaRE (Software product Quality Requirements and Evaluation) series includes standards that define characteristics for internal and external quality and for *quality in-use* (Bøegh, 2008). The quality-in-use characteristics were assessed by inviting the audience to respond to questions on a five-point Likert scale (strongly agree, agree, neutral, disagree and strongly disagree). The list of survey questions is provided in Appendix-A.

Table 4 shows the mapping between the MRs, DPs and survey questions.

We interpret the term "introspection" pragmatically as enabling the learner to reflect on what they already know and to build new knowledge. We hypothesised that introspective learning occurs when the participant finds the knowledge presented is useful and relevant to them. One of the indicators to determine the usefulness is through the evaluation of the NPS. The NPS is calculated based on the response to a

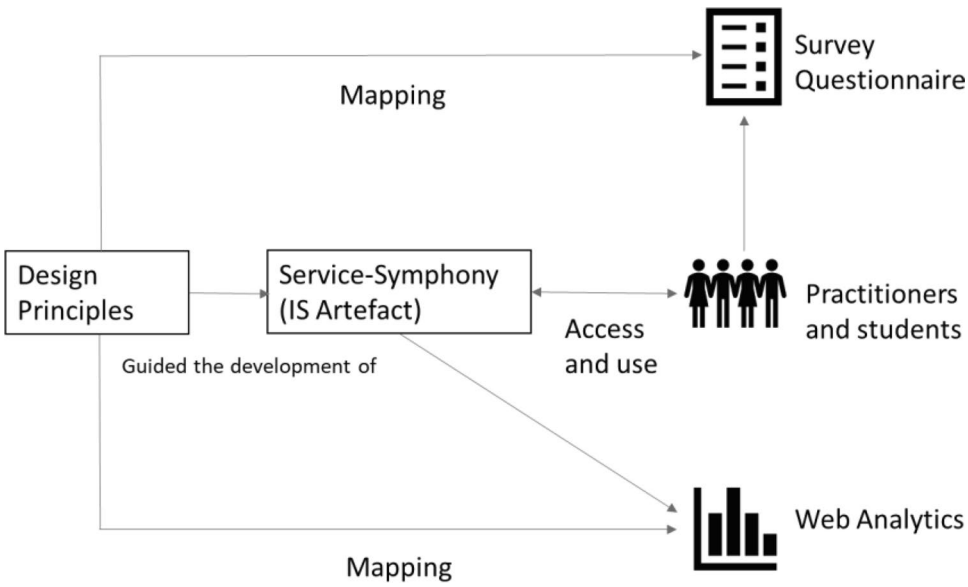

Fig. 8 Methodical triangulation approach to evaluating DPs

Table 4 Mapping between MRs, Epistemic DPs and survey questions

MR	DP	Design dimensions based on ISO/IEC 25000 and NPS	Question	Response (n = 40)
MR1: As an ITSM practitioner/student, I want to assess my current knowledge against the industry standard so that I can plan my development.	Introspection centricity Integrated Learning Construction	NPS	Do you recommend Service-Symphony to your friends/colleagues?	+8 indicates more promoters than detractors
MR1: As an ITSM practitioner/student, I want to assess my current knowledge against the industry standard so that I can plan my development.	Introspection Centricity Integrated Learning Construction	Relevance	*Service-Symphony* is useful and relevant to me	90% -of the respondents agreed
MR1: As an ITSM practitioner/student, I want to assess my current knowledge against the industry standard so that I can plan my development.	Introspection Centricity Integrated Learning Construction	Readability	The content is easy to read and understand	90% of the respondents agreed
MR2: As an ITSM practitioner/student, I want to learn the jargons/terminologies used in the frameworks so that I do not waste time while interacting with other stakeholders.	Common Knowledge Centricity Integrated Learning Construction	Ease of finding	It is easy to find the relevant knowledge article	75% of the respondents agreed
MR2: As an ITSM practitioner/student, I want to learn the jargons/terminologies used in the frameworks so that I do not waste time while interacting with other stakeholders.	Common knowledge Centricity Integrated Learning Construction	Currency	The knowledge reflects current state of ITSM practice	85% of the respondents agreed
MR3: As an ITSM practitioner, I want to learn about the complementary processes so that I can leverage the best practices	Knowledge diversity Integrated Learning Construction	Coverage	The knowledge coverage is well distributed between multiple process reference frameworks and supporting tools	98% of the respondents agreed

question, "Do you recommend ITSM knowledge repository to your friends or colleagues?" with a rating of zero (0) to ten (10). Promoters include anyone who responds with a score of nine (9) or ten (10). Detractors are those who score between zero (0) and six (6). NPS is determined by subtracting the percentage of detractors from the percentage of promoters (Lee, 2018). The survey responses resulted in 28% promoters, and 20% detractors resulting in the NPS of +8. A score above zero is considered favourable as it implies that there are more promoters than detractors. For the questions as to whether Service-Symphony was useful and relevant, easy to read and understand, 90% of the participants agreed. Thus, we observe that the introspection-centricity dimension is addressed by *Service-Symphony* as the participants indicated the product was relevant and useful to them.

The DPs for Common knowledge centricity were assessed through searchability and currency. The responses to searchability ("it is easy to find the relevant knowledge article": 75%) and currency ("the knowledge reflects the current ITSM practice": 85%) resulted in an average score of 80%. The results indicated that there were improvement opportunities in searchability.

The knowledge diversity was measured through the response of the question "the knowledge coverage is well distributed". The 98% agreement on the responses to knowledge diversity indicated that the *Service-Symphony* design enabled the participants to get diverse knowledge from different sub-domains within the ITSM domain.

ILC DP is applicable to all the questions as it is an overarching DP. By including ILC, the designer is remided about the overall objective of integrated learning construction while considering the individual design features.

9.2 User Behaviour Analysis through Web Analytics

This research also utilized Google Analytics for monitoring the performance of *Service-Symphony*. Google Analytics has been used to analyse diverse types of web portals including academic courses (Yamba-Yugsi et al., 2019), tourism websites (Gunter & Önder, 2016; Plaza, 2011), library websites (Fang, 2007) and e-commerce sites (Hasan et al., 2009). Table 5 shows the mapping between the DPs and Web Analytics metrics.

The overall and visitor trend is an indicator that the learners are interested in the knowledge provided by Service-Symphony. However, we cannot rule out that many could be casual visitors and clicked accidentally while browsing. One of the more reliable metrics is the returning visitors, who visit Service-Symphony more than once. We hypothesis that these visitors are interested in learning and validating their existing skills. Fig. 9 indicates that over 15% of visitors (22,547, of the total 148,796) visit *Service-Symphony* more than once.

Another indicator of the learner alignment is the time spent on *Service-Symphony*. When the user spends considerable time, they are likely to be reflecting on the knowledge provided. Figure 10 shows a histogram where the second and third rows show the number of sessions from 10 minutes to 30 minutes and more than 30 minutes, respectively. We assume that if a user spends more than 10 minutes on a session, the user is engaged in some learning and reflecting. The histogram shows that 13,538 sessions (a total of 10,148 and 3390) were for more than 10 minutes.

The Common knowledge centricity DP was monitored through the page views. *Service-Symphony* shows the holistic view of all the related frameworks so that the practitioners get an appreciation of common knowledge across the ITSM practice. Fig. 11 shows that most users were interested in gaining common knowledge about ITIL4 (63,904 page views), followed by COBIT (27,279 page views). The visit to the root page (/) shows 9678 page views and indicates the number of users who obtained an overview of all the process frameworks.

Table 5 Mapping between Epistemic DPs and Web Analytics indicators

MR	DP	Web Analytics metrics	Value
All MRs	All DPs, as these metrics indicate the overall relevance of Service-Symphony	Visitor Trend	148,796 sessions from 2019 to 2022
		Returning visitors	15%, 22,547 sessions
		Session Duration	13,538 sessions more than 10 minutes
MR2: As an ITSM practitioner/student, I want to learn the jargons/terminologies used in the frameworks so that I do not waste time while interacting with other stakeholders.	Common Knowledge Centricity	Page visits	ITIL – 63,904 views COBIT – 27,279 views
MR3: As an ITSM practitioner, I want to learn about the complementary processes so that I can leverage the best practices.	Knowledge diversity	Page Depth	13,394 sessions visited more than 4 unique pages

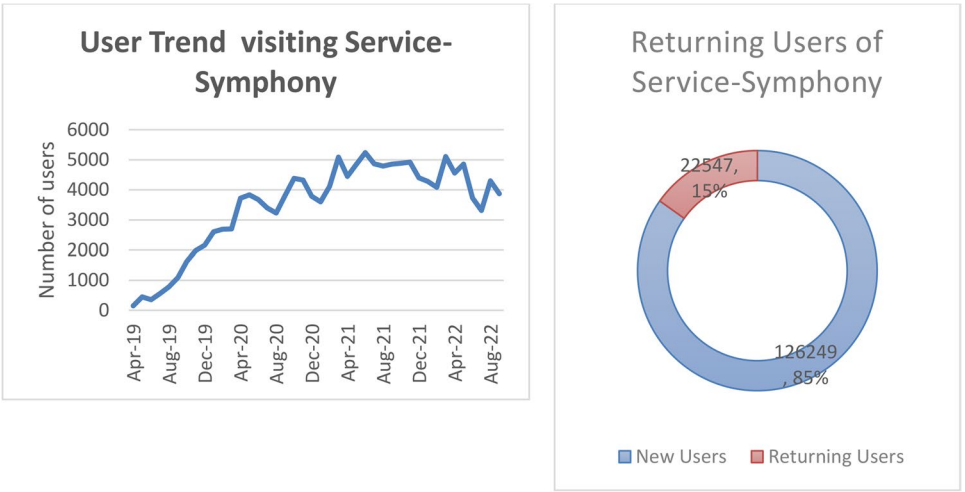

Fig. 9 Web Analytics Metrics – User Trend and Returning visitors

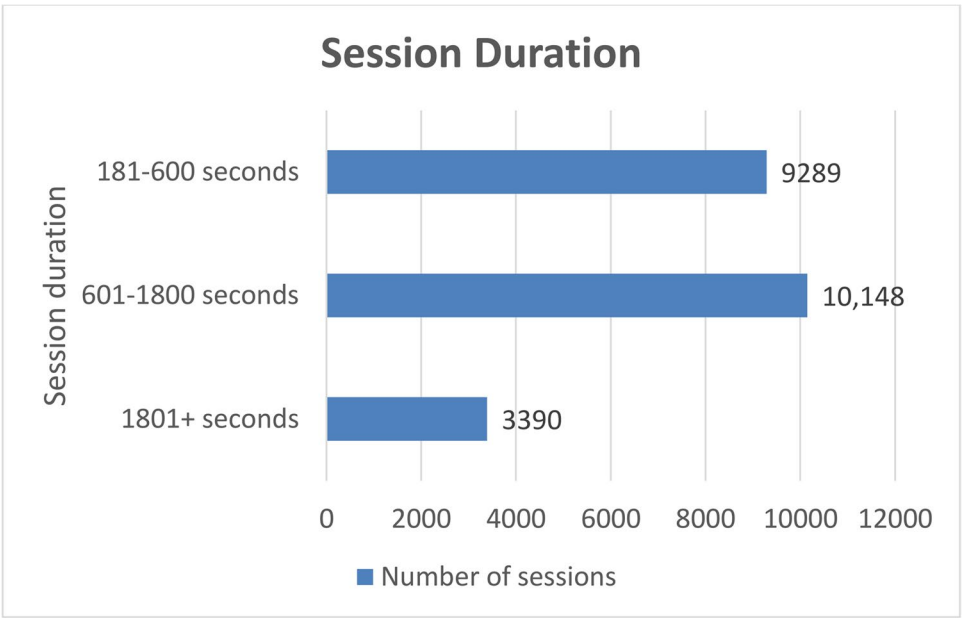

Fig. 10 Web Analytics metrics - Session Duration Histogram

The knowledge diversity DP was assessed through the page-depth metrics. If the visitor accesses multiple pages, they are gaining knowledge from diverse knowledge bases within the ITSM domain. The pie chart in Fig. 12 suggests that most casual visitors accessed less than 4 pages. There were, however, 13,394 user sessions in which there were more than 4 unique pages visited per session. These sessions indicate an 8% of non-casual, power users (represented by 13,394 sessions) who were interested in gaining knowledge from diverse sources.

10 Discussion

We followed DSR paradigm which was ideal for our research. DSR addresses three core aspects of building the IS artefact: relevance, rigour and design (Hevner, 2007). The Relevance Cycle connects the target user environment with the design of the artefact. The Rigor Cycle establishes and/or leverages theories and methods. The design of the artefact bridges the relevance and rigour cycles through multiple iterations. We established the relevance of the artefact through engagement with ITSMF, the industry

	Page	Pageviews
		315,039 % of Total: 100.00% (315,039)
1.	/framework/lifecycle/service-value-systemitil-4/	24,755 (7.86%)
2.	/framework/lifecycle/process/monitoring-and-event-management-itil-4/	9,921 (3.15%)
3.	/	9,678 (3.07%)
4.	/framework/itil-4/	8,420 (2.67%)
5.	/framework/cobit/	7,574 (2.40%)
6.	/framework/lifecycle/process/service-configuration-management-itil-4/	7,283 (2.31%)
7.	/framework/lifecycle/process/deployment-management-itil-4/	6,941 (2.20%)
8.	/uncategorized/security-service-management-dss05-cobit2019/	6,672 (2.12%)
9.	/framework/lifecycle/process/capacity-and-performance-management-itil-4/	6,584 (2.09%)
10.	/framework/lifecycle/evaluate-direct-and-monitor-cobit/	5,459 (1.73%)

Fig. 11 Web Analytics metrics - Page views

peak-body. We designed the artefact and derived the DPs as part of the rigour cycle. This research contributes to the DSR knowledge by deriving and applying IS-specific design principles (DPs) that capture the 'know-how' aspect of building the IS artefact (Gregor et al., 2020; Gregor & Hevner, 2013b). The DPs are considered a key part of design theory (Baskerville et al., 2018; Gregor et al., 2013; Gregor et al., 2020; Gregor & Jones, 2007).

Lukyanenko and Parsons (2020) point out that there could be a gap between in the intended outcome proposed by the design theory and the actual result. Their central inquiry revolves around whether design theories can seamlessly guide practitioners in generating anticipated outcomes. This challenge is encapsulated as "design theory indeterminacy," signifying a gap between theoretical propositions and the complex realities encountered in practical implementation (Lukyanenko & Parsons, 2020). To reduce the indeterminacy Lukyanenko and Parsons (2020) propose to classify the features as core, auxiliary and emergent and assess them.

In the case of Service-Symphony, we can reasonably conclude that the design features are aligned with the practitioner expectations as evidenced by the feedback and usage pattern. We consider the features that underpin the DPs as core features. There are auxiliary features including SSL certificate, antispam features, bread-crumbs

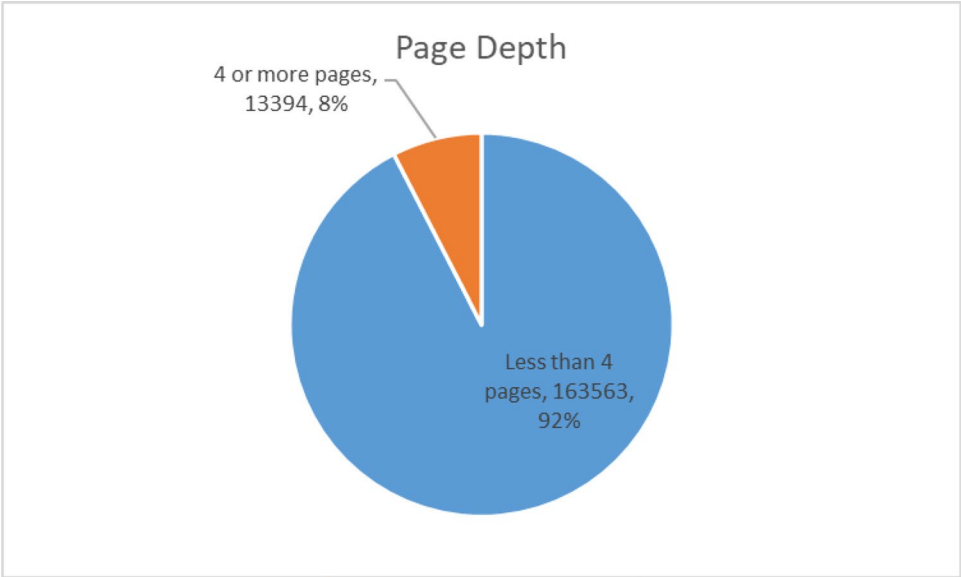

Fig. 12 Web Analytics metrics - Page Depth

based navigation and overall organisation of the web page. IT artifcat designs are complex and the intended outcome can't always be understood just by looking at their core and auxiliary features. Sometimes, new things, called "emergent features," pop up from the interactions between the core and auxiliary features. IS researchers need to think about both individual features and the system as a whole. In the case of Service-Symphony, emergent feature can be how information is presented to the user. A non-optimal design can cause presentation complexity or information overload. In the current design, we conclude the emergent feature does not create indeterminacy. However, as the Service-Symphony evolves with more knowledge, there is a possibility that the information overload can happen due to visual clutter. The indeterminacy will be reduced through continual monitoring of the visitor traffic and usage patterns.

10.1 Contributions to Theory

This research makes a significant theoretical contribution by introducing the ILC conceptual model and Design Principles (DPs). The ILC conceptual model stands out for its comprehensive perspective on learning, drawing from cognitive constructivist theory, cognitive schema theory, epistemic logic, and the practical learning environment LEDICO. By integrating cognitive constructivism, cognitive schema theory, and epistemic logic, the model offers a holistic understanding of how learners actively construct knowledge and organize it into cognitive structures. The inclusion of LEDICO in the model adds a practical and contextual layer, serving not only as an information source but also as a catalyst for schema convergence, connecting new knowledge with learners' existing knowledge. The concept of schema convergence enriches the framework by providing a specific term to describe the alignment of learners' cognitive schemas with the information schema in LEDICO. This research introduces LEDICO as a practical tool for learners, stimulating reflection, providing common knowledge, and facilitating access to distributed knowledge spaces, making the framework applicable in real educational settings.

The second theoritical constribution of this research is the development of DPs. DPs are regarded as one of the important outcomes of design knowledge (Cronholm & Göbel, 2018; Iivari et al., 2018; Iivari et al., 2021). The DPs are targeted at solution designers who can use different ways to apply the DPs to create specific instances.

Before embarking on the development of Service-Symphony, we reviewed the literature to see whether any prescriptive guidelines were available. Prescriptive guidelines are often formulated through Design Principles (DPs) (Gregor et al., 2013; Iivari et al., 2021). The formulation of DPs is one of the salient outcomes of research that conveys design knowledge (Chandra et al., 2015; Cronholm & Göbel, 2018; Gregor et al., 2020; Meske & Bunde, 2022).

We noted a lack of DPs for IS practitioners to systematically develop and use a LEDICO apart from commons theory. Commons theory, as originally developed by Ostrom (Hess & Ostrom, 2007), included a set of DPs that provided guidance for governing resources, including knowledge. The extant research is limited with respect to the application of Ostrom's DPs to digital commons (Forte et al., 2009; Gazi & Sahdev, 2022; Linåker & Runeson, 2022; Safner, 2016; Viégas et al., 2007). While knowledge governance DPs are important, the extant research is largely silent about the design aspects from a learning perspective

in our observation. Effectively governing a LEDICO does not imply that the artefact is designed to facilitate learning. In this research, we ground our theory for LEDICO DPs in epistemic logic, the study of the properties of knowledge (Fagin et al., 2004). Epistemic dimensions are based on epistemic logic that can be grouped in three categories: self-knowledge, common knowledge, and distributed knowledge (Ditmarsch et al., 2015). As epistemic dimensions are fundamental properties of knowledge, deriving DPs from these dimensions can lead to robust set of DPs that guide the development of Service-Symphony, the ITSM Digital Commons.

This research contributes to the DSR body of knowledge through the development of Epistemic DPs. MRs and DPs contribute to design theory. According to Goldkuhl (2004) a good design theory should be grounded in multiple dimensions, namely internal, external and empirical. Internal grounding implies the grounding of a design theory in its own background knowledge. The external theoretical grounding describes how the proposed design theory relates to other external theories. The empirical grounding is established through the feedback data gathered in the evaluation phase.

The internal grounding of our research was established by eliciting MRs through the expert panel and aligning them with the DPs. The epistemic logic theory was used to externally ground the design theory. The survey and web analytics formed the basis of empirical grounding.

This research brings the following significant insights into the DSR knowledge:

- This study has formulated DPs for a specific solution category, namely digital commons. Given the crucial role of this solution class in the knowledge economy, the associated DPs assume a pivotal role by offering clear guidance to Information Systems (IS) developers. The DPs have a wide-ranging scope, encompassing the socio-technological landscape rather than being limited solely to the technical platform.
- The approach employed in formulating the DPs holds particular significance. Typically, IS DPs articulate principles abstracted from an IS artifact to address an abstract problem class., The novel approach of this research involves beginning with philosophical theory, adapting it to align with IS practices, and subsequently applying the refined theory pragmatically to construct an IS artifact.
- The design theory is aligned with Goldkhul's definition of "Good design theory" as we have established multiple grounding to support the theory
- We have also established that "design theory indeterminacy" is low by establishing the core features are evaluated by the practitioners and the overall product meets the expectations

10.2 Contributions to Practice

The launch of the "Service-Symphony" tool in 2019 marked the beginning of its steady growth, presenting a valuable resource for ITSM practitioners globally. This research carries significant implications for professionals who hold pivotal roles within organizations, catering to a vast and diverse ITSM community that spans the globe. With an estimated population exceeding half a million practitioners, this community includes consultants, practice managers, auditors, project managers, DevOps professionals, service desk professionals, technology providers, training providers, certification bodies, students, and higher education institutions.

The tool's substantial impact is reflected in key performance indicators. The Net Promoter Score (NPS) of +8, positive responses gathered through survey questions, and an overall trend of 148,796 sessions with a notable 15% return visitor rate indicate that practitioners find Service-Symphony highly relevant to their work. These metrics highlight the tool's consistent and positive reception within the ITSM community.

Service-Symphony plays a pivotal role as a supplementary learning resource for students enrolled in the IT Service Management course at an Australian University. Specifically tailored to the curriculum, Service-Symphony serves as a comprehensive tool for introducing ITIL 4 and fostering a nuanced understanding of its interrelation with other frameworks. The student responses through survey affirm that the utilization of Service-Symphony has significantly enriched their learning outcomes, providing a dynamic and engaging platform for grasping complex IT service management concepts and their real-world applications.

Moreover, the acknowledgment from IT Service Management Forum (ITSMF) Australia, manifested in the "Business of Innovation of the Year 2019" award during their annual conference, serves as additional validation of the tangible contributions made by Service-Symphony. This esteemed award underscores the practical relevance and impact of the DSR project conducted, reinforcing its alignment with the evolving needs and innovations within the ITSM community.

11 Conclusions

This research addressed the research question ***"How can we design a knowledge repository that addresses the knowledge gaps within ITSM practice?"***

The answer to the question has three components, namely: 1) identifying the knowledge gap and elicting meta-requirements 2) formulation of LEDICO DPs based on cognitive constructivist learning, cognitive schema and epistimic logic theories 3) the instantiation of *Service-Symphony*, a digital commons for ITSM practice. This research demonstrated a

systematic approach for formulating DPs and pragmatically applying those DPs to build a digital commons. The survey results and web analytics indicate that Service-Symphony is aligned with the DPs.

We followed the six-step approach for the DSR project (Peffers et al., 2007). Using cognitive construtivist learning, cognitive schema and epistemic logic, this research developed a conceptual model and DPs for LEDICO. The epistemic dimensions are not necessarily obvious to the designers of LEDICO, an observation supported by the fact that they have not, to our knowledge, been elucidated in the literature previously. Thus, the epistemic DPs provide a critical and novel perspective to designing a LEDICO. To bridge theory and practice, we instantiated the DPs through a purpose-built, public domain *Service-Symphony* instance.

The the cognitive constructivst theory, cognitive schema and epistemic dimension enabled us to systematically design the learning aspects of the portal. DPs also provide a road map to enhance the artefact through additional design features by carefully analysing the improvements in each epistemic dimension. For example, in future design of *Service-Symphony,* we could incorporate self-assessment modules to facilitate introspection, add a common terminology list to promote common knowledge, and include additional practices to broaden diversity.

The evaluation followed methodical triangulation approach through surveys and web analytics. The survey responses (n = 40) showed that 90% of the respondents agreed that *Service-Symphony* was relevant to them. The relevance question is considered as an indicator of introspection centricity, as a relevant knowledge source enables introspection. 98% of the users agreed the knowledge was well distributed within the ITSM domain, which is an indicator of knowledge diversity. The Web analytics indicators supported the conclusion that the *Service-Symphony* design is aligned with the DPs.

One of the limitations of this research is not evaluating the reusability aspects of the DPs with designers of future LEDICO. If the DPs are not validated by practitioners, there is a risk that the DPs may not be useful in practice (Cronholm & Göbel, 2018; Iivari et al., 2018; Iivari et al., 2021). The researchers acknowledge this risk.

Another limitation is validating with users whether they had used *Service-Symphony* to improve the processes in their organisation. In the organisational setting, there could be more targeted analysis and interventions possible. For example, we could identify specific power user groups, design strategies to improve usage and invite the power users to collaborate to improve and innovate processes. This research will consider an organisational case study as part of future research.

This research marks the initiation of our exploration into the realm of epistemic logic, recognizing its substantial potential in shaping the design of Digital Commons. A recent development involves the integration of ChatGPT with Service-Symphony. Examining an AI agent through the lens of epistemic logic stands out as a fascinating avenue for future research.

This research has broader implications to the research and practice communities, as it serves as an exemplar case study in DSR covering the complete life cycle of problem identification, setting objectives, design, development, and evaluation of a Learning Digital Commons. While this paper discussed about one instance of LEDICO, the DPs can be applied to design other instances in different domains.

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Declarations

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