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ABSTRACT

Literature on information systems (IS) method design provides little guidance for constructing and validating IS related methods based on components of existing methods. Method engineering, including method characteristics framework and super method, is a methodology for constructing holistic new methods from existing ones, based on the elicitation and adaptation of components from the existing methods. However, while these methodologies focus on how to conceptualize, develop, adapt, and assemble new methods from existing method components, we believe that the newly formed methods need to be rigorously grounded in the field and hence should be iteratively developed and inductively validated based on empirical data. This paper proposes combining several grounded theory tools with methodologies of constructing new methods, for forming a comprehensive methodology for IS method design, so the methods created with it will be grounded. The new methodology is illustrated by designing a requirements engineering method for knowledge management systems.

Keywords

Method engineering, knowledge management, requirements engineering, grounded theory.

INTRODUCTION

Method engineering methodology[1] in the field of information systems (IS) is the discipline of constructing new methods from existing methods (Harmsen, 1996; Kumar and Welke, 1992;). It focuses on creating and evaluating methods techniques and tools that support development of information systems (Brinkkemper, 1996). Furthermore, method engineering aims at improving the usefulness of systems development methods by adapting methods to specific organizational contexts. (Rolland, 2008). Methodologies supporting method design include, for example, method characteristics framework (Hackathorn and Karimi, 1988) which aims at evaluation and comparison of characters of existing methodologies, and super method (Hong Van den Goor and Brinkkemper, 1993) which targets at the elicitation and adaptation of components from existing frameworks and the interconnection of all components within a new, coherent framework. However, we believe that newly designed and constructed methods need to be rigorously grounded in empirical findings, and therefore grounded theory tools (e.g., Strauss and Corbin, 1998) can serve as complementary means for supporting the inductive construction, evaluation and validation of new methods based on data collected in the field.

The motivation for this research was triggered during a study, in which we identified a theoretical gap regarding requirements engineering in the context of knowledge management (KM) systems development. While acting to overcome this gap, we found that existing methodologies for method design require an enhancement, which could be achieved by applying grounded theory tools. While method engineering (Rossi, Tolvanen, Ramesh, Lyytinen and Kaipala, 2000), method characteristics framework (Hackathorn and Karimi, 1988), and super method (Hong et al., 1993) allow to generate new methods based on existing methods, grounded theory tools (Strauss and Corbin, 1998) contribute the aspect of developing new theories based on empirical data. Thus, we draw from the body of literature on theory building of grounded theory, method engineering, method characteristics framework and super method, and propose a new methodology for designing

[1] We use the term methodology in this paper when referring to the systematic guidelines and procedures for forming new methods.

conceptual IS methods. We illustrate the proposed new methodology by describing our design of a new method for requirements engineering of KM systems.

The rest of the paper is structured as follows. In the next section we introduce the motivation to develop a new IS method for requirements engineering for KM systems. Following, we present the new methodology we propose for IS method design according to the principles explained above. Then we illustrate the new methodology with a step-by-step description of the process of developing a requirements engineering method for KM systems. Finally we conclude with a discussion of contributions and limitations and provide future research agenda.

THE NEED TO DEVELOP A NEW REQUIREMETNS ENGINEERING METHOD IN THE KNOWLEDGE MANAGEMENT DOMAIN

KM has been recognized as an essential component of knowledge-intensive industries, which are characterized by technological uncertainty and a competitive environment (Lonnqvist, 2005). Over the past years, we have witnessed an increased focus on KM as a major part of organizational strategy in knowledge-intensive organizations and as a significant driver for business process design and reengineering in such organizations (Gronau and Weber, 2005). KM enhances the ability of knowledge-intensive organizations to continuously learn and adapt, and to rapidly respond to changes in technology, market, and customer preferences (Lonnqvist, 2005), mainly by improving their knowledge-intensive business processes (KIBP). Hence, an effective KM solution, designed in the context of long-term organizational strategic objectives and its practical implementation, can promote achievements of strategic objectives by means of improved individual and organizational performance. A first step and crucial aspect of developing a solution in general, and a KM solution in particular, is requirements engineering.

Requirements engineering literature divides the domain of requirements engineering into requirements development and requirements management (Wiegers, 2000). Requirements development is further subdivided into elicitation, analysis, specification, and verification (Olsson, Doerr, Koenig and Ehresmann, 2005). In the case of KM solution development, the requirements development requires a triple perspective analysis of knowledge processes, IT, and KM related culture. The contention of this research is that aggregating and adapting several knowledge audit methods and KM oriented system modeling approaches may serve the purpose of KM requirements elicitation and analysis. Gardiner (1996) enhanced the utilization of audit practices for requirements elicitation and analysis, and argued that the way to improve business processes is to carry out an audit regarding the usage of good practices and to further use the audit results for improving the work process. In the context of KM, the term 'audit' refers to the capturing of existing and required KM practices within the organization. The design of any KM solution should begin with a knowledge audit aiming requirements elicitation and analysis of the current organizational KM infrastructure components, followed by the design of a complete KM infrastructure solution.

Many KM projects do not, however, meet organizational expectations, partly due to the avoidance or underperformance of knowledge audit, which are a necessary first step in any KM project (Hylton, 2002). A review of knowledge audit methods presented by previous researchers in the literature (e.g. Bright, 2007; Handzic, Lagumdzija and Celjo 2008; Iazzolino and Pietrantonio, 2005; Levantakis, Helms and Spruit, 2008; Perez-Soltero, Barcelo-Valenzuela and Palma-Mendez, 2006) reveals several issues not yet addressed in knowledge audit research, specifically in the context of KIBP:

Most of the existing methods propose general, cross-organizational knowledge audits. Empirical evidence on phenomena, conditions, and factors related to KM infrastructure within the knowledge-intensive industry is rare, especially in the context of KIBP. We believe that knowledge audits can be more effective and valuable when carried out with a focus on specific KIBP.

Various methods suggest conducting knowledge audits, usually focusing on a single component of the KM infrastructure. As far as we know, none of the existing knowledge audit methods deals with the triple perspective of the KM infrastructure, encompassing culture, knowledge processes, and information technology.

Most existing knowledge audit methods provide only theoretical descriptions of their audit steps and lack practical tools for information elicitation and analysis. Some of the methods, which do provide such tools, focus only on either the technical or social aspects of knowledge modeling. However, it is insufficient to apply only one of these approaches when analyzing the comprehensive KM infrastructure requirements of a KIBP, since KM is tightly linked to both the engineering and the social perspectives.

Our study revealed that current requirements engineering frameworks do not deal with knowledge processes, and only partially deal with social aspects. Hence, there is a need for a multi-perspective requirements engineering methodology for KM that combines the triple perspective: knowledge processes, KM related culture and technology, and creates an integrated methodology that can adequately support requirements elicitation, analysis and specification of complex KM solutions.

EMBEDDING GROUNDED THEORY TOOLS WITHIN METHOD ENGINEERING

The method engineering research methodology in IS provides the foundation to conceptualize, develop, adapt, and assemble methods, techniques, and tools from existing approaches (Braun, Wortmann, Hafner and Winter, 2005; Kumar and Welke, 1992; Jashapara, 2004). Rossi et al. (2000) describe the method engineering process that can be applied in the IS field, as demonstrated in Figure 1.

The next is a detailed description of the new methodology we propose, based on the method engineering process proposed by Rossi et al. (2000), including method characteristics framework (Hackathorn and Karimi, 1988) and super method (Hong et al., 1993), combined with applications of several grounded theory tools (Strauss and Corbin, 1998).

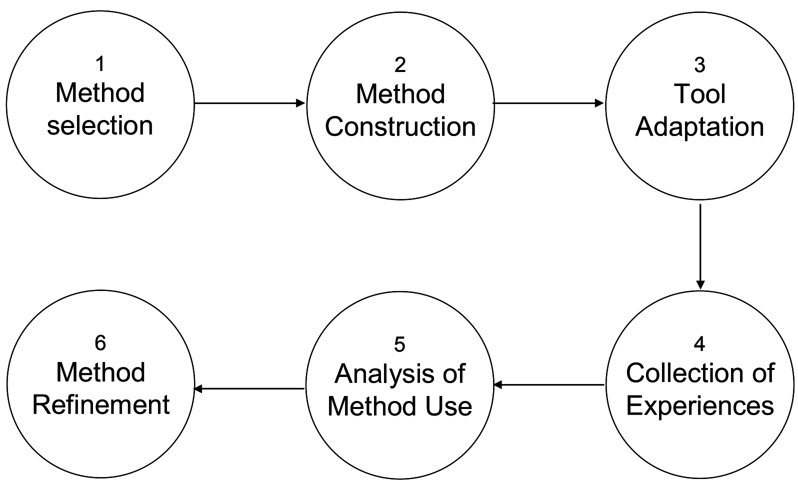

Figure 1: The method engineering process (Rossi et al. 2000)

Phase 1 – Method Selection

In the first phase of method engineering it is required to establish key activities that should be carried out during an investigated topic. First, it is required to reveal main characteristics of investigated topic. We propose to reveal the main characteristics utilizing grounded theory tools (Strauss and Corbin, 1998). Applying the essential idea in grounded theory is that theory is developed inductively from the data (Bell, 2005). The created theory, in our case method, exhibits the themes that emerged from the collection and analysis of empirical data regarding, for example, existing infrastructure components of the studied system or process. Data is transcribed line-by-line and analyzed in real time, including inductive coding, using open, axial and selective coding mechanisms, until data analysis saturation is reached (Strauss and Corbin, 1998). Data coding and analysis is carried out iteratively from the beginning of the method construction, in order to complete missing data during the data analysis stages.

Second, the main existing methods in the literature that could be potential donators for the new method should be identified. Aiming to compare existing methods, we used the method characteristics framework (Hackathorn and Karimi, 1988) which was developed for comparing IS methods. This framework is based on the comparison of methods within two dimensions: breadth and depth. The breadth dimension defines generic characteristics that are useful for comparing methods. These characteristics highlight major concerns which arise when comparing various methods. Potentially, there are a very large number of characteristics, so the set of characteristics may continue to grow in order to reflect consideration of new parameters for comparison. The method characteristics framework can accommodate new characteristics for various research fields and new methods, thus we suggest utilizing it for defining a set of characteristics suitable for in the investigated topic. In our proposed method, grounded theory tools are used to reveal the core categories of the breadth dimension characteristics.

The depth dimension of the analytical framework deals with the conceptual-to-practical dimension of compared methods. On the conceptual aspect of this dimension, a method should be a solid basis for explaining its approach, major issues, relationships among variables, and expected outcomes. Having such a conceptual basis contributes to the consistency and stability of the method. On the other hand, the practical aspect of the depth dimension focuses on tools for the actual execution of the method, considering issues of usability and efficiency. The depth dimension consists of three levels:

(1) Methodology (ME) – The term methodology is defined as "the analysis of the principles […] of inquiry in a particular field" (Hackathorn and Karimi, 1988). This definition emphasizes the conceptual basis for performing the method activities (i.e., the "what") and highlighting questions like the following: what factors or variables are important? what are the relationships among these factors? what are the desirable outcomes? what management actions can be taken from these outcomes?

(2) Technique (TE) – The term technique is defined as "a procedure for accomplishing a desired outcome." In particular, a technique specifies the steps in performing the method activities, as well as the necessary inputs and results from each step. Technique deals with the logical way of "how" to do an activity and represents knowledge more than actual products.

(3) Tool (TO) – The term tool is defined as "an instrument for performing a procedure." The method provides information elicitation and analysis tools.

The purpose of the depth dimension with its three levels is to view the various compared methods as they relate to both their conceptual foundations and practical results.

The next step is evaluating each characteristic in depth and breadth dimensions. The ranking criteria involve three levels: no coverage, partial coverage, and extensive coverage:

no coverage (blank cell), i.e. the method does not address the dimension of interest;

partial coverage (P) - the method provides some, yet incomplete, coverage of the dimensions;

extensive coverage (E) - the method has a strong capability to address the dimension.

Having the depth and breadth dimensions evaluated, during the comprehensive literature scanning and search process, enables evaluating various methods and rank and compare them, and accordingly select the most suitable methods, whose components are to be included within the new method,. This is done using the method characteristics framework (Hackathorn and Karimi, 1988).

Phase 2 - Comparison of system modeling approaches

In this phase existing tools are investigated in order to link each of the new method's sub-stages to a suitable tool. According to Hackathorn and Karimi (1988) this phase strengthen the practical aspect of the new method by selecting or developing the tools to support the execution of the method, considering issues of usability and efficiency.

Phase 3 - Method Construction

In this phase, a detailed analysis of the methods selected in the previous phase is conducted, decomposing them into their components. Then, the new method is composed of the collection of all relevant components extracted from the previously selected methods, taking into consideration the similarities, differences, and overlaps between them. Assembling a new method requires the representation of the properties of existing methods using common notations. Non-standard terminology and the different labeling of similar fragments complicate the comparison. We suggest outlining the new method using the super method presented by Hong et al. (1993). This methodology provides the construction of the holistic super method, based on the elicitation and adaptation of its components from the existing frameworks and the interconnection of all components within a new, coherent framework. Super method instructions support carrying out a detailed analysis of the selected donator methods, decomposing them into the models' components (fragments) and, comparing the fragments of these methods to the main required characteristics defined previously for the new method. A comparison indicator compares activity s of the created super method, to activity m of an existing method, as follows:

$s = m$	Activity s is equivalent to activity m.
$s > m$	Activity s does more than activity m.
$s < m$	Activity s does less than activity m.
$s >< m$	A part of activity s overlaps a part of activity m and the other parts of both activities do not overlap.

Blank This activity is absent in the existing method.

Similarly, all main activities of the new method with the selected donator methods should be analyzed, until saturation is achieved and all required activities are defined.

Phase 4 – Collection and Analysis of Experiences and Method Refinement

In this phase the developed new method should be implemented, for testing its reliability and efficiency, and identifying required improvement. Rossi et al. (2000) claim that the collection of experiences and incremental changing of method based on these experiences improves experience-based learning and the acceptance of methods. We propose to implement the new method via case study research, which, according to Yin (2003), is appropriate if it represents a critical case for testing a well-formulated theory. Yin (2003) defines a case study as an empirical inquiry that investigates a contemporary phenomenon within its real-life context when the boundaries between phenomenon and context are not clearly evident and multiple sources of evidence should be used. The analysis of the method usage experience should reveal the applicability of the new method, its clearness and efficiency. In our case, the results of a case study are to be analyzed utilizing grounded theory tools (Strauss and Corbin, 1998) and may apply also quantitative analysis mechanisms. Next, Evaluation of method use can lead to modifications in the method and tool support. These modifications are done in the final step. The iterative nature of the method engineering process implies that the refined method can be taken as such or as a re-refined method in the next research.

Table 1 summarizes the proposed methodology for IS method design:

Phase	**Research Method**	**Outcomes**
1. Setting the new required IS method objectives.	Literature review & Qualitative exploratory study grounded theory (Strauss and Corbin, 1998)	An outline of the domain for the new required method.
2. Comparison of existing methods and system modeling tools.	Method characteristics framework (Hackathorn and Karimi, 1988)	A review of existing methods, enabling to select best methods for the new required method.
3. New method Outlining	"Super-methodolgy" (Hong et al. 1993)	A description of the new method's stages and tools
4. New method implementation, analysis and refinement.	Case study, grounded theory (Strauss and Corbin, 1998) & quantitative analysis mechanisms.	A refined and validated method.

Table 1. Stages of the Methodology for IS method design

APPLYING THE NEW METHODOLOGY: THE CASE OF KM-REM CONSTRUCTION

In this section we illustrate the method construction process according to the new methodology outlined in the previous section, applying grounded theory in method engineering. In this illustration we construct a knowledge management requirements engineering method (KM-REM), taking into consideration the aspects discussed in the previous section.

Phase 1 - Method Selection

In this phase, we identified key activities that should be carried out during a requirements engineering process of KIBP, based on the integration of existing knowledge requirements engineering methods and system modeling approaches. In addition, we conducted several preliminary interviews with engineers from the organization where the case study took place (see phase 4), in order to analyze existing KM infrastructure components of the KIBP requirements engineering. Moreover, literature review identified many research works that deal with knowledge requirements engineering methods. Reviewing these methods revealed several weak points that are still uncovered in knowledge requirements engineering research. In this phase qualitative analysis, using grounded theory tools, enabled to establish key activities that should be carried out during a knowledge-oriented analysis of KIBP.

In addition, literature review identified various existing knowledge audit methods leading to comparison of these methods using the method characteristics framework (Hackathorn and Karimi, 1998). After comparing and ranking 20 KM audit methods, the most suitable methods were selected for constructing the new method KM-REM. Table 2 presents the comparison and analysis of existing methods; due to space limitation, only some of the methods are presented, however all 20 methods were similarly analyzed.

In the breadth dimension, we identified five main characteristics that influence the quality of KM oriented requirements engineering in the context of KIBP:

OA - Organizational Analysis, that included identifying areas and business processes with knowledge-oriented problems and set the basis for requirements elicitation

KI – Requirements analysis of Knowledge Inventory within KIBP

KM Infrastructure – Requirements analysis of KM infrastructure within KIBP. Due to the importance of KM infrastructure components, each of the following was analyzed separately:

KP - Knowledge Processes

KC - Knowledge Culture

KT - Knowledge Technology

We adapted the depth classification of the analysis to the following three levels:

DE – Descriptive, the method provides only a theoretical description

PRO – Procedural, the method provides a structured, step-by-step framework

PRA – Practical, the method provides data elicitation and analysis tools

The ranking of breadth and depth dimensions, as presented in Table 2 below, involves three levels:

Blank cell - no coverage, i.e. the method does not address the dimension of interest

P - partial coverage - the method provides some, yet incomplete, coverage of the dimensions

E - extensive coverage - the method has a strong capability to address the dimension

Following the method characteristics framework analysis (Hackathorn and Karimi, 1988), five knowledge audit methods were selected for the KM-REM development (Iazzolino and Pietrantonio, 2005; Perez-Soltero et al., 2006; Bright, 2007; Handzic et al., 2008; and Levantakis et al., 2008). The reason for this choice lies in the fact that all five methods provide knowledge inventory analysis and at least one of the three components of the KM infrastructure. In addition, all of the selected methods provide structured, practical frameworks and theoretical descriptions of the frameworks' components. Some of them also provide practical analysis tools (Perez-Soltero et al., 2006; Handzic et al., 2008).

No.	Knowledge Audit Methods	Depth Dimension			Breadth Dimension				
		PRA	PRO	DE	IT	KC	KP	KI	OA
1	Bonner, Libby and Nelson, 1977		P	E				P	P
2	Bright, 2007		P	P	P			P	P
3	Burnet, Illingworth and Webster, 2004		P	E				E	P
5	Levantakis et al., 2008		E	E		P	P	P	E
6	Handzic et al., 2008	P	P	P	P	P	P	P	
7	Iazzolino and Pietrantonio, 2005		P	E	P	P	P	P	P
8	Perez-Soltero et al., 2006	P	E	E			P	P	E

Table 2. Analysis of existing KM audit methods (examples)

Phase 2 - Comparison of system modeling approaches

KM literature distinguishes between two KM modeling approaches: hard thinking and soft thinking. While hard thinking deals with formal knowledge modeling including knowledge processes, structure and technologies, soft thinking relates to informal knowledge regarding organizational culture and people behavior, which are important and complex elements (Gillingham and Roberts, 2006). These two approaches combined together reflect the most important factors involved in capturing, disseminating and sharing of knowledge (ibid).

In this phase, we investigated existing modeling tools in order to link each of the KM-REM's relevant components to a suitable modeling tool that encompasses both hard and soft perspectives. According to Dennis, Daniels, Hayes and Nunmaker (1993), the KM business model should maintain a good balance between formal and informal knowledge, reflecting various modes of business analysis. Hard thinking based knowledge audit accomplishes the analysis and documentation of formal knowledge inventories of business processes, while soft thinking based knowledge audit is very useful in extracting the informal aspects of the organizational knowledge resources and assets.

Phase 3 – Method Construction

In this phase, we carried out a detailed analysis of the methods selected in phase 2, decomposing them into the KM-REM components. KM-REM was composed of the collection of all relevant components extracted from the chosen methods, taking into consideration the similarities, differences, and overlaps between them. We outlined KM-REM using the super method presented by Hong et al. (1993), comparing the fragments of the five selected knowledge audit methods to the main characteristics defined in phase 1. In addition to Organizational Analysis as requirements elicitation stage, Knowledge Inventory and KM Infrastructure as requirements analysis stage, we also added two additional stages that are important activities of any requirements development process: requirements specification and requirements validation (Olsson et al., 2005). Thus, the main requirement development phases of the final established KM-REM are:

1 - Organizational Analysis;

2 - Requirements Analysis of Knowledge Inventories;

3 - Requirements Analysis of KM Infrastructure;

4 - Requirements Specification;

5 - Requirements Validation;

In addition to these four phases, KM-REM also defines a requirements management process to the entire KM project.

The result of phases 1-3 was the construction of the super method (Hong et al., 1993) of KM-REM, based on the elicitation and adaptation of its components from the existing frameworks and the interconnection of all components within a new, coherent knowledge requirements engineering framework. Table 3 provides a complete overview of the required steps and deliverables in a KM requirements engineering process. It includes the following modeling tools:

OM-1 - Organizational Model, TM (Task Model) (Shreiber, Akkermans, Anjewierden, de Hoog, Shadbolt, van de Velde and Wielinga, 2000)

OTA - Impacts and improvements document for Organization, Task and Agent models (Shreiber et al., 2000)

Customer, Actors, Transformation Process, World-View, Owners and Environmental Constraints (CATWOE) (Checkland and Scholes, 1998)

Rich Picture (Checkland and Scholes, 1998)

Brainstorming and decision matrix (Stratton, 2004)

Project Management Body of Knowledge (PMBOK) (P.M.I, 2004)

A more detailed discussion of KM-REM and its implication is beyond the scope of the current paper and can be found at Aviv, Levy and Hadar (2009).

Phase 4 – KM-REM Collection of Experiences and Analyses of Method Use and Method Refinement

This phase included implementing KM-REM in a case study within a large, international software organization. The company employs approximately 5,300 software developers worldwide, with headquarters in the United States and 150 offices in more than 45 countries. The main purpose of the case study was to apply and validate KM-REM and its modeling tools in a knowledge-intensive organization. Substantiating data was collected in four countries across three continents – the

US, the UK, France, and Israel – with the participation of 16 teams that provide customer support for different products. Data was collected through interviews and field observations of the engineers' work. During the case study, KM-REM was continuously refined and extended to improve its information collection and requirements analysis tools.

Existing Modeling Tools		**Existing Knowledge Audit Methods**					
Engineering	Social	Iazzolino et al. 2005	Levantakis 2008	Perez-Soltero et al. 2006	Bright 2007	Handzic et al. 2008	
Stage 1 – Organizational Analysis							
OM-1			>< 1.1 1.2	< 1.1; 1.3			1.1 Identify areas with knowledge-oriented problems and opportunities
Decision matrix	Brainstorming		< 1.3		= 1		1.2 Prioritize areas and select one
OM-1			< 3.1	= 2.1			1.3 Identify core business processes in the selected area
Decision matrix	Brainstorming			< 3.2	< 2		1.4 Prioritize core processes and select one
Stage 2 – **Define Project's Properties**							
PMBOK			< 1.4				2.1 Establish integrative project team
							2.2 Allocate project's properties
							2.3 Mange project risks
Stage 3 –Knowledge Inventories Analysis							
OM-3, TM-1					< 4		3.1 Define flowchart diagram
OM-4, TM-2			< 5.1	< 5.1	< 5	>< 5	3.2 Analyze formal knowledge inventories within the process
Flow chart diagram	Rich Picture		< 5.3	< 5.2			3.3 Analyze informal knowledge interactions during the process
Stage 4 - KM Infrastructure Analysis							
Analysis of data obtained in Stages 1-3						< 4	4.1 Analyze knowledge related culture
		< 1.2	< 3.4	<5.2	<5	< 4	4.2 Analyze knowledge processes
		> 1.2; 2.1					4.3 Analyze knowledge-related IT
Stage 5 – KM Requirements Specification							
							5.1 Reconstruct business process
OTA							5.2 Create specification report

Stage 6 – KM Requirements Validation							
			< 7.2		< 6		6.1 Receive comments
				< 6.2			6.2 Validate results
							6.3 Prioritize results
							6.4 Final recommendation

Table 3. Outlining of KM-REM

CONCLUSION

In this research we propose a new conceptual methodology for designing IS methods. This methodology encompasses existing IS method engineering methodologies combined with grounded theory tools. We applied the new methodology for developing a KM requirements engineering method (KM-REM) in the context of knowledge-intensive business processes. The contribution of this research is twofold. First, a conceptual methodology for IS method design is proposed, applying grounded theory tools within method engineering for improved method development and validation. Second, KM-REM, developed via the new methodology, is a new and comprehensive method for requirements engineering in the KM domain, which can be used by both researchers and practitioners investigating KM solution requirements in knowledge-intensive organizations. In order to further validate and enable wider generalization of both the conceptual methodology and the specific KM-REM designed in this research, future research will need to apply and examine them in additional contexts.

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