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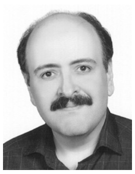

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Abstract

Purpose – *This paper aims to provide a criteria-based evaluation framework for assessing knowledge management system (KMS) development methodologies.*

Design/methodology/approach – *The evaluation criteria have been elicited based on the features expected from a successful KMS. Furthermore, a number of prominent KMS development methodologies have been scrutinized based on the proposed evaluation framework.*

Findings – *It was demonstrated that the proposed evaluation framework is detailed and comprehensive enough to reveal the strengths and weaknesses of KMS development methodologies. It was also revealed that even though the evaluated methodologies possess certain strong features, they suffer from several shortcomings that need to be addressed.*

Research limitations/implications – *The evaluation framework has not been applied to all existing KMS development methodologies; however, the evaluation does cover the most comprehensive methodologies which exist in the research context.*

Practical implications – *The results of this research can be used for the following purposes: organizational goal-based selection of KMS development methodologies, evolution of existing KMS development methodologies and engineering of tailored-to-fit KMS development methodologies.*

Originality/value – *The proposed evaluation framework provides a comprehensive and detailed set of criteria for assessing general, area-specific and context-specific features of KMS development methodologies. KMS developers can select the methodology which best fits their requirements based on the evaluation results. Furthermore, method engineers can extend existing methodologies or engineer new ones so as to satisfy the specific requirements of the project at hand.*

Keywords *Knowledge management, Criteria-based evaluation, Evaluation framework, Knowledge management system development methodology*

Paper type *Research paper*

1. Introduction

Dealing with complicated organizational situations requires managing the organizational knowledge flow so as to achieve organizational goals. A knowledge management system (KMS) is commonly considered as an information system which supports different phases of the knowledge management (KM) process (Alavi and Leidner, 2001). Thus, using an appropriate KMS can manage the complexity inherent in the competitive market by maintaining and managing the relevant organizational knowledge.

Most research in the area of KMS success has focused on surveying the success factors already known, identifying new success factors and assessing the relationships among the factors. Research efforts which have focused on providing methods/techniques for choosing and using the success factors are few and far in between; a recent example is Cricelli *et al.* (2014), which has proposed a framework to help developers identify the KMSs that are most important to achieving organizational goals.

A KMS development methodology is defined as a framework for applying KMS development practices and, like all methodologies, consists of two parts: process and

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> **“Dealing with complicated organizational situations requires managing the organizational knowledge flow so as to achieve organizational goals.”**

modeling language (ML) (Ramsin and Paige, 2010). The process part defines the phases of system development along with the proper sequence for applying them, the roles which are responsible for performing the phases, the products of each phase and guidelines and metrics for progress monitoring and quality assurance. The ML part of the methodology defines notational and semantic rules for expressing the products which are produced during the enactment of the process.

Although existing methodologies strongly support a number of KMS development aspects, a comprehensive, all-encompassing and general-purpose KMS development methodology does not exist; hence, in many cases, KMS development methodologies should be custom-built (by applying methodology engineering approaches) to be capable of addressing the special KMS development needs of the organization.

Providing new KMS development methodologies or reusing existing ones requires a precise analysis of the strengths and weaknesses of existing methodologies. Unfortunately, the research in this area has been rather scattered and high-level. Past research efforts on analyzing KMS development methodologies can be divided into two main categories:

1. *Analysis of development process*: This category is itself divided into following subcategories:
   - *Comparison-based analysis*: No comprehensive and detailed comparison has so far been reported; however, the limited research efforts which have been conducted, such as Rubenstein-Montano *et al.* (2001a), have used certain KM dimensions, principles, foundations and building blocks as comparison criteria.
   - *Feature-based analysis*: Research efforts in this category have focused on analyzing specific KM features in processes, e.g. Chang *et al.* (2012) has focused on analyzing the knowledge creation approaches applied.
   - *Infrastructure-based analysis*: Research efforts in this category, such as Perez-Soltero *et al.* (2006), have focused on analyzing the infrastructure required for successful development of KMSs.
2. *Analysis of ML*: Research efforts in this category, such as Abdullah *et al.* (2002), have focused on analyzing KM MLs and techniques.

This paper targets the following shortcomings in the context of KMS development methodologies:

- lack of a comprehensive evaluation framework for goal-based selection/engineering of KMS development methodologies, which we address through eliciting the essential features of an efficient KMS development methodology and thereby evaluating a number of prominent methodologies; and
- neglect towards the relationship between KM/KMS success and the efficiency of KMS development methodologies, which we address through illustrating the influence of the elicited evaluation criteria on KM performance metrics.

The research reported herein was conducted in four major stages: domain investigation, criteria elicitation, criteria-based evaluation and analysis of the results. The first stage involved high-level investigation of existing KMS development methodologies and selection of KMS development methodologies which satisfy the requirements of this research as to prominence, rigor, comprehensiveness and innovation. In the second stage, evaluation criteria were extracted through an iterative process of *exploration* and *evaluation*; in the *exploration* step, the suitability criteria (expected characteristics and capabilities) for an efficient KMS development methodology were elicited; in the *evaluation* step, the elicited criteria were evaluated and completed through applying a set of meta-criteria (criteria for evaluating the criteria themselves) to determine their deficiencies. The criteria were refined and improved through further iterations of the exploration–evaluation process. In the third stage, the selected methodologies were evaluated based on the criteria extracted in the previous stage. In the last stage, the evaluation results were analyzed to identify the strengths and weaknesses of the studied methodologies, and also to identify the improvements and refinements that should be made to the evaluation criteria.

The rest of this paper is organized as follows: A process-centered review of the selected methodologies is presented in Section 2. Section 3 introduces the evaluation criteria and reports the results of criteria-based evaluation of the selected methodologies. Section 4 analyzes the evaluation results. Section 5 discusses the implications of this research, and Section 6 discusses the conclusions and suggests ways to further this research.

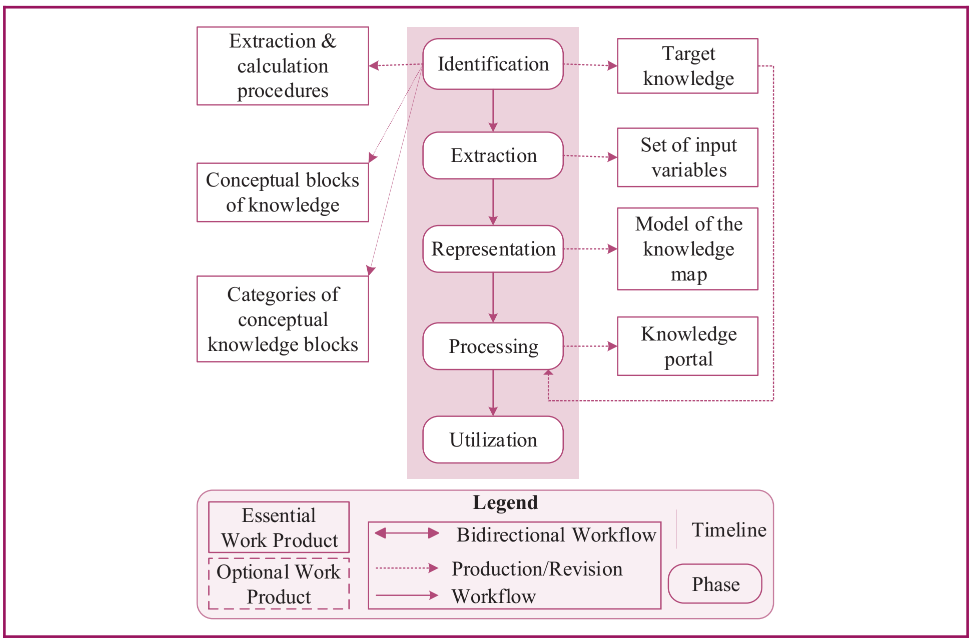
2. Review of selected KMS development methodologies

This section provides a review of seven methodologies by using the process-centered approach introduced in Ramsin and Paige (2008). These methodologies were selected based on the following criteria: prominence in the field, concreteness and comprehensiveness, high degree of innovation and availability of adequate documentation on the methodology’s process and ML.

2.1 Chalmeta and Grangel

This model-driven development (MDD) methodology provides high-level activities and techniques with the aim of applicability to diverse organizations (Chalmeta and Grangel, 2008). The phases of the methodology are as follows (Figure 1):

Figure 1 Chalmeta and Grangel’s process



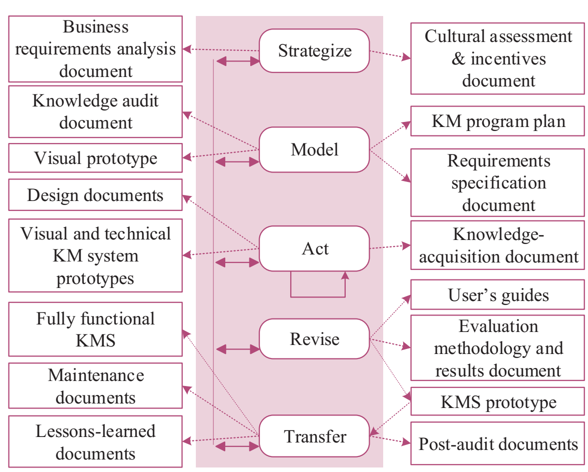
- *Identification*: Identifies and classifies the organizational knowledge blocks. Knowledge blocks are high-level knowledge elements which, unlike knowledge sources, may not be singly and directly used to extract knowledge.
- *Extraction*: Aims at specifying procedures for knowledge extraction. To this aim, it first identifies the inputs of the procedures (explicit/implicit knowledge variables and the knowledge produced by the KMS itself). Then, the resources with the ability to produce these inputs are identified. Procedures are then identified by investigating the way that the sources can be used to produce the inputs.
- *Representation*: Designs the organizational knowledge map through modeling at platform-independent model (PIM) and platform-specific model (PSM) levels. The following items are modeled at the PIM level: organizational knowledge blocks, recognized knowledge extraction procedures, inputs to knowledge extraction procedures and organizational knowledge sites. PSM-level models are produced by automatic transformation of PIM-level models.
- *Processing*: Implements an operational KMS through modeling at the computation-independent model (CIM) level. The system will be a knowledge portal which provides the organizational knowledge map and the tools to access it.
- *Utilization*: The system is used and maintained. Also, learning and continuous improvement mechanisms are determined.

2.2 Rubenstein-Montano et al.

This methodology is specifically intended to overcome the weaknesses of a number of older KMS development methodologies (Rubenstein-Montano *et al.*, 2001a). The base framework for this methodology was proposed in Rubenstein-Montano *et al.* (2001b). The phases of this methodology are as follows (Figure 2):

- *Strategize*: Covers strategic planning, business requirements elicitation, cultural assessment and planning and specification of criteria for KM process evaluation.
- *Model*: Covers logical and physical modeling through specifying the strengths and weaknesses of the organizational KM process, planning to achieve KM goals, developing the organizational knowledge map, determining the required software and hardware and designing the outline of the system.

Figure 2 Rubenstein-Montano *et al.*'s process



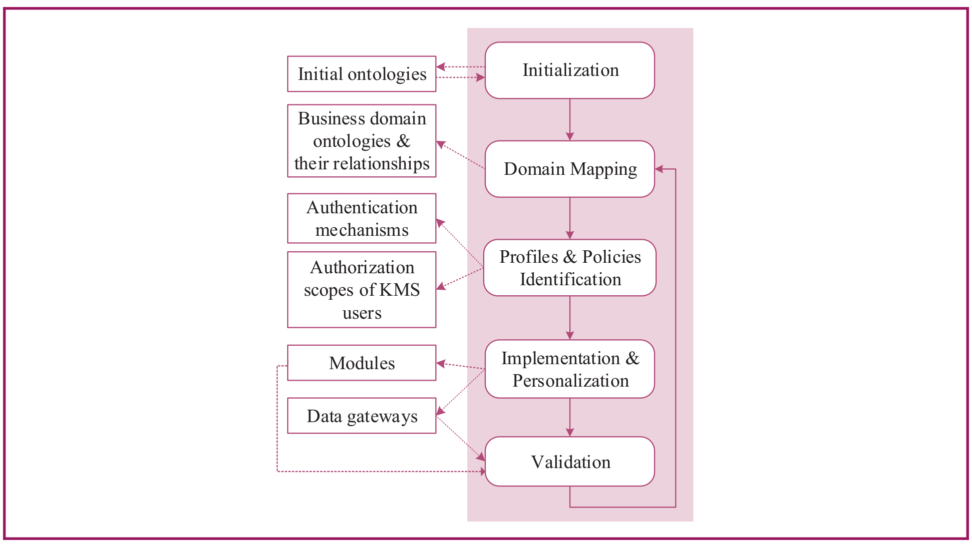
- *Act*: Aims at supporting the KM process through collecting and structuring organizational knowledge, and developing the KMS prototype which supports knowledge storage, integration, creation and sharing.
- *Revise*: Produces training documents for users and verifies and validates the KMS through practical usage of the system. Also, the knowledge acquired is investigated to assess its accuracy, precision and appropriateness regarding the organizational requirements.
- *Transfer*: Aims at deploying and maintaining the KMS through KMS usage and verification, and also by monitoring KM activities. Based on the feedbacks and the weaknesses uncovered, returning to previous phases might become necessary.

2.3 Amine and Ahmed-Nacer

This ontology-based agile methodology aims at developing a KMS to reduce the risks of component-based development through managing the knowledge needed for component selection, update and maintenance (Amine and Ahmed-Nacer, 2011). The phases, shown in Figure 3, are as follows (the last four phases are iterative):

- *Initialization*: Aims at understanding the problem domain ontologies through communicating with the customers and specifying the business/knowledge/cultural sources in the organization. Selecting the most appropriate tool for ontology modeling is also carried out in this phase.
- *Domain mapping*: Continuously refines the problem domain ontologies into system domain concepts through constant communication with end-users and customers.
- *Profiles and policies identification*: Specifies the authentication mechanisms and the level of system access allowed for each user.
- *Implementation and personalization*: Implements and tests three items: the modules required to implement the concepts which were derived in previous phases, data gateways to bring in the data from external sources in the right format for the KMS and appropriate views for different users.
- *Validation*: Verifies and validates the system.

Figure 3 Amine and Ahmed-Nacer's process

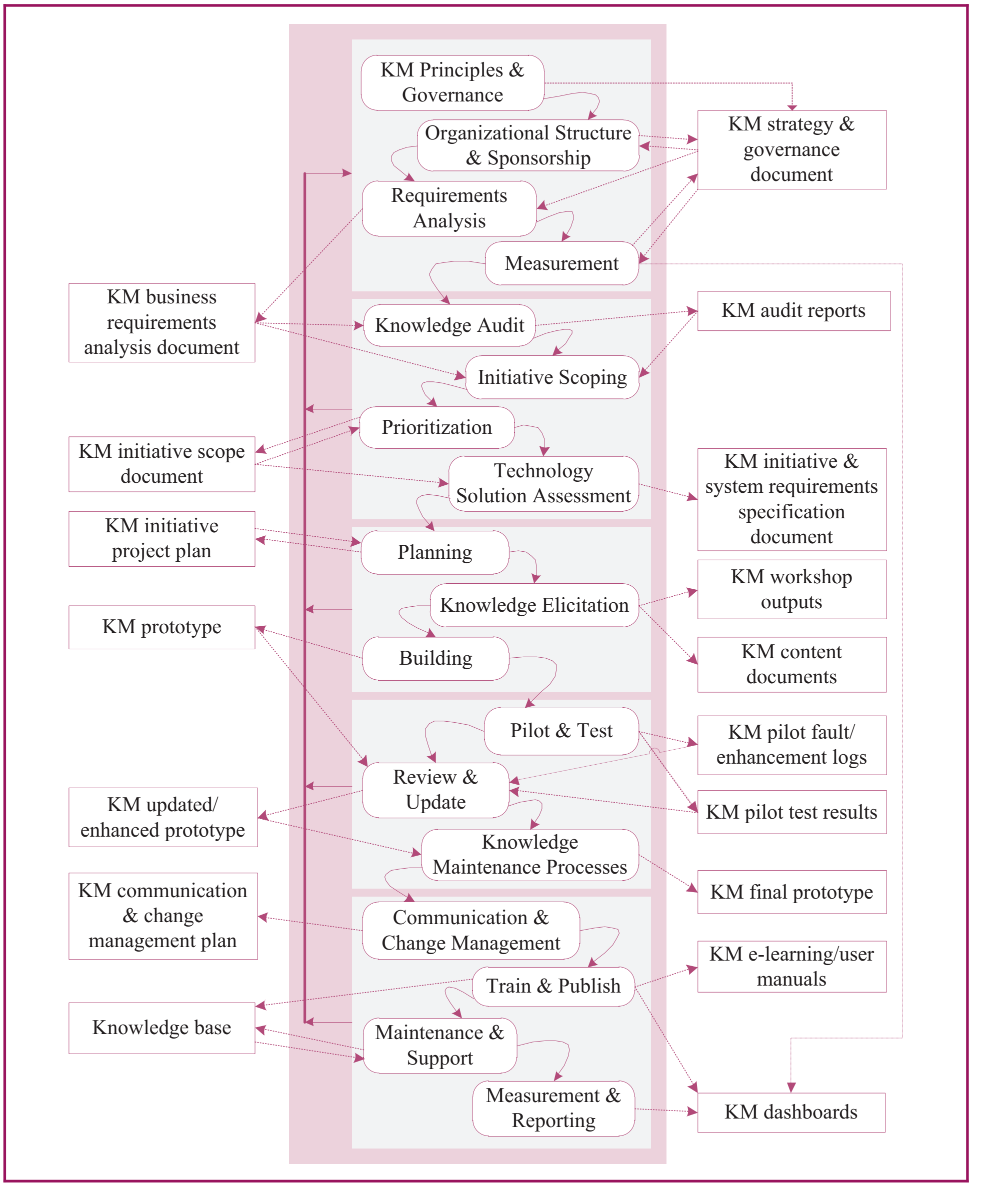


2.4 *Smuts* et al.

This methodology aims at expounding the KMS development process presented in Calabrese and Orlando (2006). The basis of the proposed methodology is a framework based on five principles: strategizing, evaluation, development, validation and implementation (Smuts *et al.*, 2009). As shown in Figure 4, the methodology consists of 18 phases, which collectively cover the five mentioned principles:

1. *KM principles and governance*: Specifies the goals, strategies, dimensions of the knowledge to be managed, organizational knowledge taxonomy and methods for evaluating goals.
2. *Organizational structure and sponsorship*: Determines the roles/responsibilities necessary for implementing and supporting the KMS.
3. *Requirements analysis*: Determines which areas of the organization are in need of KM, and which are knowledge sources.

Figure 4 Smuts *et al.*'s process



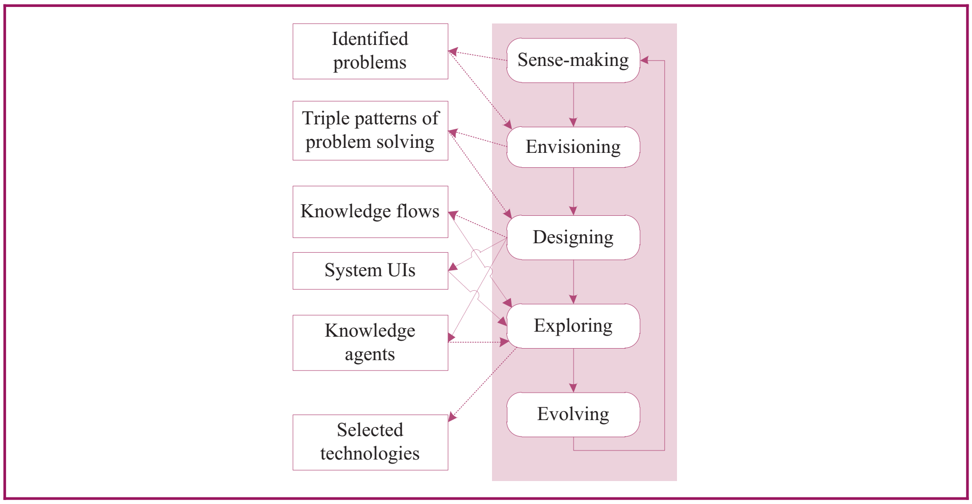
4. *Measurement*: Assesses the KM process through a dashboard and specifies the activities needed to overcome the weaknesses.
5. *Knowledge audit*: Specifies the experts who are the sources of tacit knowledge. Also, knowledge bases in line with satisfying the requirements are determined.
6. *Initiative scoping*: Envisions and improvises the KM solution based on the requirements and audit reports.
7. *Prioritization*: Prioritizes the visions presented in the previous phase.
8. *Technology solution assessment*: Specifies the tools and technologies which best fit the requirements of the KMS.
9. *Planning*: Plans and schedules the development of the KMS.
10. *Knowledge elicitation*: Covers extracting, categorizing, validating and encoding organizational knowledge.
11. *Building*: Focuses on KM process definition, and building the initial version of the KMS; also, the community of practice (COP) is formed.
12. *Pilot and test*: Verifies and validates the KMS.
13. *Review and update*: Updates the KMS.
14. *Knowledge maintenance processes*: Updates the KM process, completes the KMS prototype and stabilizes the responsibilities.
15. *Communication and change management*: Aims at enhancing knowledge sharing and maintenance processes.
16. *Train and publish*: Launches the system and trains the COP.
17. *Maintenance and support*: Covers the maintenance phase through using COP comments and user support.
18. *Measurement and reporting*: Monitors the development process according to the goals and strategies, and reports on the benefits gained.

2.5 *Moteleb* et al.

This methodology aims at using practical experiences for developing KMSs in small organizations (Moteleb *et al.*, 2009). The most significant strength of this methodology lies in the smooth logical-to-physical progression of the phases (Figure 5). The general lifecycle of the methodology, the phases of which are listed below, is iterative-incremental:

- *Sense-making*: Aims at investigating whether KMS development is a conceivable solution for the organizational problems. To this aim, it determines whether the problems can be mapped to the following three categories of problems: locating knowledge, communicating knowledge and interacting with knowledge.
- *Envisioning*: Categorizes the conceivable solutions (in the three categories mentioned in the previous phase) through communicating with the stakeholders. The solutions will specify which knowledge types should be located, and also the time and way to access and transfer the knowledge. Also, it determines which changes are required in the business processes.
- *Designing*: Determines the organizational knowledge agents (sources), flows and interfaces. The system will then be designed based on the solutions presented in the previous phase and the agents, flows and interfaces identified.
- *Exploring*: Specifies the appropriate technologies based on the technical, social and organizational features of the KMS, and also according to availability and cost.

Figure 5 Moteleb *et al.*'s process



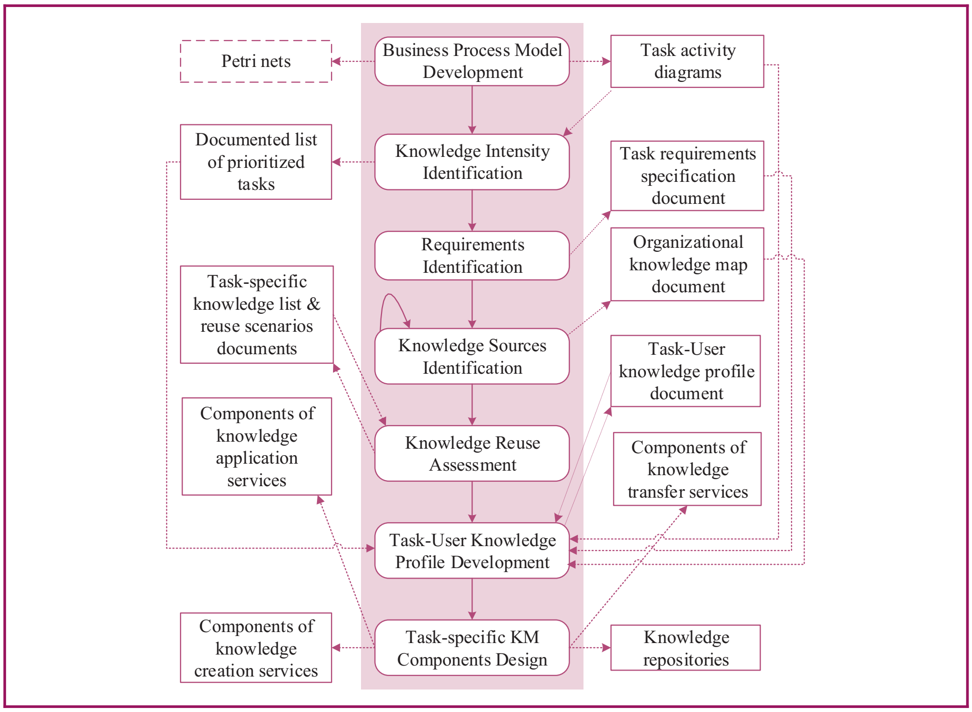
- *Evolving*: Monitors and maintains the KMS through investigating organizational and environmental changes, and also through detecting new requirements.

2.6 Sarnikar and Deokar

This methodology directs the development process based on the workflows within the organization (Sarnikar and Deokar, 2010). The phases of the methodology are as follows (Figure 6):

- *Business process model development*: Investigates the organizational business process and specifies the business process tasks, their relationships and the individuals responsible for them.

Figure 6 Sarnikar and Deokar's process



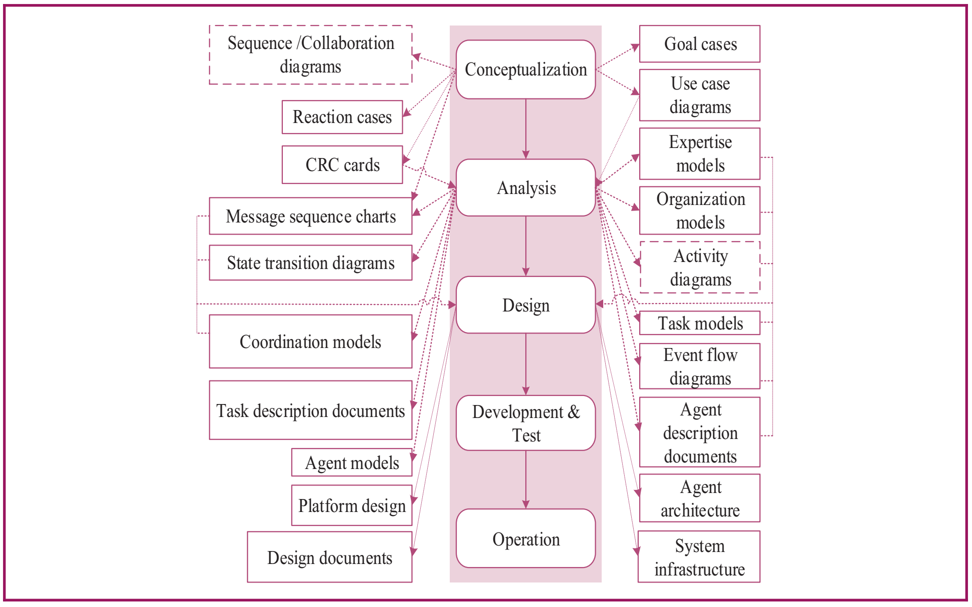
- *Knowledge intensity identification*: Prioritizes the tasks based on their knowledge intensity. The knowledge intensity of each task is determined based on the factors provided in Eppler *et al.* (2008).
- *Requirements identification*: Aims at facilitating the detection of knowledge sources and sharing scenarios through investigating the knowledge required to perform the tasks. To this aim, knowledge requirements are examined from three perspectives: tacit/implicit, procedural/declarative and general/contextually-specific/technically-specific.
- *Knowledge sources identification*: Develops the knowledge map which includes the internal and external knowledge sources. For this purpose, knowledge sources are classified using the classifications presented in Holsapple and Joshi (2004) or Becerra-Fernandez and Sabherwal (2001).
- *Knowledge reuse assessment*: Reveals the knowledge flows by specifying knowledge creation and reuse scenarios (using the framework proposed in Markus (2001)).
- *Task-user knowledge profile development*: Describes the knowledge-intensive tasks using the sample proposed in Abecker *et al.* (2000). This description can be used to determine, for each task, which knowledge should be transmitted to the user responsible for that task.
- *Task-specific KM components design*: Designs the system components to support the tasks investigated in previous phases.

2.7 Iglesias and Garijo

A KMS can be considered as a multi-agent system in which knowledge is hidden in agents and their relationships. This agent-oriented methodology is not specifically targeted at developing a KMS, but can be effectively used for this purpose (Iglesias and Garijo, 2005). The phases of the methodology are as follows (Figure 7):

- *Conceptualization*: Obtains the initial view of the problem domain. To this aim, two techniques can be used: class-responsibility-collaboration (CRC) (analyzing the agents' goals, plans, knowledge and collaborators) and user-environment-responsibility (UER) (analyzing the users, their environment and their collaborators).
- *Analysis*: discovers system requirements through five steps: Detecting and analyzing the features of system agents, identifying and describing the tasks

Figure 7 Iglesias and Garijo's process



required to achieve the goals, analyzing the static relationships and the interactions among the agents and analyzing the knowledge required for evaluating the performance of knowledge-intensive tasks.

- *Design*: Designs the system in three steps: agent network design, agent design and platform design.
- *Development and test*: Develops the system code and tests the system.
- *Operation*: The system is operated and maintained.

3. Criteria-based evaluation framework

In this section, our proposed criteria-based evaluation framework is first defined (in Section 3.1), and then the methodologies reviewed in the previous section are evaluated based on the evaluation framework (in Section 3.2).

3.1 Elicitation of evaluation criteria

The criteria which constitute the target evaluation framework are elicited in an iterative manner, that is through repetitive extraction and evaluation. The elicitation process starts with extracting a core set of criteria which are then evaluated based on a predefined set of meta-criteria; this process is repeated until all the meta-criteria are reasonably satisfied. The criteria are elicited based on the features that a KMS should satisfy.

As the extracted criteria are intended to be measureable, we have classified them in two classes: simple-form (binary) and scale-form (multilevel). The result of applying a simple-form criterion denotes the satisfaction or non-satisfaction of the criterion, whereas the result of applying a scale-form criterion is selected from among multiple predefined discrete levels. Unless indicated otherwise, the symbols that we use by default for denoting the two possible values of simple-form criteria are as follows: "+" denotes satisfaction of the criterion, and '−' denotes non-satisfaction. The extracted criteria fall into three categories:

1. *General evaluation criteria*: These criteria assess the general characteristics of a system's development methodology, regardless of paradigm, context and application scope (Ramsin and Paige, 2010). This set of criteria is divided into following subsets:
   - criteria which assess the high-level features that a methodology should satisfy (Table I); and
   - criteria which assess the features related to the three main constituents of a methodology: process, people and products (Table II).
2. *KMS development evaluation criteria*: These criteria assess the features and characteristics of a KMS development methodology by considering the capabilities and characteristics of an efficient KMS. The extraction method for this set of criteria is based on two assumptions: the KMS should be capable to upgrade the organizational KM process, so the KMS development methodology should enforce the incorporation of this feature into the produced KMS; and the output of a KMS development methodology should be practicable and practical in satisfying organizational KM goals. The criteria pertaining to the first assumption have been extracted based on the

"Although existing methodologies strongly support a number of KMS development aspects, a comprehensive, all-encompassing and general-purpose KMS development methodology does not exist."

Table I Criteria for evaluation of general features of systems development methodologies–based on high-level features

Name		Type	Possible Values
Scalability		Binary	+/-
Basis in Requirements		Multilevel	A: All phases and prescribed products are based on requirements; B: Some phases and prescribed products are not based on requirements; C: None of the phases and products are based on requirements.
Application Scope	Scope Specification		A: Application scope of the methodology is specified explicitly; B: Application scope can be indirectly inferred from the goals of the methodology; C: Application scope is not specified.
	Practical Usage History		A: The whole scope of the methodology has been empirically explored; B: Parts of the scope have been explored; C: No usage history exists.
Configurability & Flexibility (Is the methodology configurable based on project characteristics? Is it tunable–flexible–during the development process?)			A: Both configurability and flexibility are addressed; B: Only configurability is addressed; C: Only flexibility is addressed; D: Neither configurability nor flexibility is addressed.
Methodology Definition	Process Phases		A: All stages and activities are defined; B: Some stages and activities are not defined; C: No stages or activities are defined.
	Modeling Language (ML)		A: A new ML is defined; B: Models of an existing ML are prescribed and explained; C: Models of an existing ML are just prescribed; D: No ML is prescribed, yet modeling is mandatory; E: Modeling is not mandatory.
	Products		A: All products are precisely defined; B: All products are generally defined; C: Some products are precisely defined; D: No products are prescribed.
	Techniques		A: All techniques are described; B: All techniques are just named; C: Some techniques are described; D: Some techniques are named; E: Techniques are not specified.

Source: Ramsin and Paige (2010)

Table II Criteria for evaluation of general features of systems development methodologies–based on methodology constituents

Constituent Part	Name			Type	Possible Values
Process	Coverage of Umbrella Activities	Project Management	Planning	Multilevel	The methodology: A: comprehensively covers the activity; B: partially covers the activity; C: does not cover the activity.
			Scheduling		
			Control		
		Risk Management			
		Quality Assurance			
	Seamlessness and Smoothness of Transition				Transitions between phases are: A: seamless and smooth; B: just seamless; C: just smooth; D: neither seamless nor smooth.
	Life Cycle Coverage	Requirements Engineering			The methodology: A: provides full coverage for the phase; B: provides partial coverage for the phase; C: does not cover the phase.
		Analysis			
		Design			
		Implementation			
		Test			
		Deployment			
		Maintenance			
	Practicability & Practicality	Feasibility Study	Technical		The methodology: A: explicitly prescribes a feasibility study; B: just prescribes obtaining a high-level view of the system; C: does not prescribe a feasibility study or a high-level view.
			Financial		
		Lack of Redundant Activities and Tasks		Binary	+/-
People	User Involvement			Multilevel	User Participation is: A: mandatory in all phases; B: mandatory in some phases; C: not prescribed at all.
Products	Testability & Tangibility	Understandability of Products	For Developers	Binary	+: The products used by the developers are essential in the development process, and specific guidelines have been provided for producing them; -: Some of the products used by the developers are non-essential, or guidelines have not been provided for producing them.
			For Users	Multilevel	A: The products used by the users can convey the intended concept; B: The products used by the users cannot convey the intended concept; C: No products are produced for the users.
		Specifying Product Dependencies		Multilevel	A: Products produced in one phase are evolved or reused in other phases, as specified by the methodology; B: Some products are evolved or reused in other phases, as specified by the methodology; C: Product dependencies are not specified by the methodology; D: Products are not interdependent.
	Modeling Viewpoints	Structural		Multilevel	Prescribed models: A: cover this viewpoint comprehensively; B: cover some aspects of this viewpoint; C: do not cover this viewpoint.
		Behavioral			
		Functional			
	Modeling Levels	Logical (Is the problem domain modeled?)			A: Comprehensively; B: Partially; C: Not modeled.
		Physical (Is the system domain modeled?)			

Source: Ramsin and Paige (2010)

features defined at different levels of the capability maturity model (CMM) (Khatibian and Jafari, 2010) (Table III); the logic behind this is that in CMM, organizations are categorized based on their capabilities in managing organizational knowledge, so the methodology should produce the KMS so that the organization's CMM level is elevated. To extract the criteria pertaining to the second assumption, KMS success and failure factors have been extracted from Alavi and Leidner (2001), Tiwana (2000), Davenport *et al.* (1998), Wong (2005), Al-Alawi *et al.* (2007), Alazmi and Zairi (2003), Akhavan *et al.* (2006), Wong and Aspinwall (2005), Abeljaber *et al.* (1998), Lehner and Haas (2010), Ajmal *et al.* (2010), Riege (2005), Mathi (2004), and have then been mapped to evaluation criteria. These criteria are in turn divided into following categories:

- criteria which are extracted based on the success/failure factors relevant to the *preparation* activities of the KMS development process (Table IV); and
- criteria which are extracted based on the success/failure factors relevant to the *main* activities of the KMS development process (Table V).

Table III Criteria for evaluation of special features of KMS development methodologies–based on CMM levels

CMM Level		Name	Type	Possible Values
1. Initial		Planning for Organizational KM Process	Binary	+/-
2. Managed		Managerial Responsibilities Specification and Assignment	Multilevel	A: Both specification and assignment activities are prescribed; B: Only specification is prescribed; C: Specification is not prescribed.
		Exploring Organizational Knowledge Sources		Knowledge-source exploration activities are: A: prescribed; B: just recommended; C: not addressed.
		Specifying the Methods of Access to the Organizational Knowledge Sources		+/-
		Specification of Policies		+/-
		Legal Feasibility Study		+/-
	Specification of Strategies	Training		
		Communicational		
		Motivational	Binary	+/-
		Human Resources' Empowerment and Retirement		
		General		
	Support for Training Activities	Training for System Usage		+/-
		Support for Learning		
3. Defined	Requirements Change Management	Continuous Update of Requirements	Binary	+/-
		Documentation of Policies and Standards		+/-
		Documentation of Utilized Tools and Technologies		+/-
		Specification of Organizational Structure		+/-
		Benchmarking to Assess Fulfillment of Requirements	Multilevel	A: Definition of easily measurable criteria (Taromirad and Ramsin, 2008) is enforced; B: Criteria definition is recommended; C: Criteria definition is neglected.
		Continuous Revision of Business Processes		Continuous improvement of business processes is: A: enforced; B: recommended; C: not addressed.
		Embedding Knowledge Sharing Capabilities in KMS	Binary	+/-
4. Quantitatively Managed	Embedding Commune Features in KMS	Face-to-face Communication		+/-
		Remote Communication	Binary	
		Attention to Cultural Issues		+/-
		Periodical Verification		+/-
		Specification of Users' Supervision Level in KMS		+/-
5. Optimized	Support for Change Management Activities	Embedding Document Management Features in KMS		
		Periodical Notification (of Failures/Successes)		+/-
		Embedding Motivational Features in KMS		
	Existence of Honesty and Confidence Culture	Embedding Features for Measuring the Amount of Knowledge Sharing in KMS		
		Embedding Knowledge Abuse Detection Features in KMS	Binary	+/-
		Giving Ownership Rights to Knowledge Owners		
	Support for Innovation Cycle Activities	Updating Utilized Technologies		
		Financial Resource Management		+/-
		Identification and Obviation of Reasons for Rejection of KMS		
		Embedding KM Process in Organizational Processes		+/-

Table IV Criteria for evaluation of special features of KMS development methodologies– based on success/failure factors (preparation-related factors)

Name	Type	Possible Values
Conformance of Organizational Occupational Hierarchy with System Users' Hierarchy	Multilevel	Users hierarchy is: A: specified based on organizational occupational hierarchy; B: not based on occupational hierarchy; C: not specified at all.
Scheduling Feasibility Study	Binary	+/-
Human-Factor Feasibility Study		+/-
Operational Feasibility Study		+/-
Knowledge Management Feasibility Study		+/-
Specification of Long-Term Goals, and Corresponding Plans		+/-
Specification of Responsibilities and Power at Different Levels of KMS Users		+/-
Specification of the Intended Definition of Knowledge		+/-
Cultural Feasibility Study (According to the cultural features of the organization, is it feasible to develop the KMS?)	Multilevel	Cultural Feasibility Study is: A: explicitly prescribed; B: indirectly prescribed (an overview of cultural situation is obtained); C: not addressed.
Convincing Users about the Position and Importance of the KMS	Binary	+/-
Gaining Managerial Support		+/-
Explanation of Features Distinguishing KMS from Technology-Driven Systems		+/-

Table V Criteria for evaluation of special features of KMS development methodologies– based on success/failure factors (development-related factors)

Name		Type	Possible Values
Determination of Appropriate Tools & Technologies		Multilevel	Selection of tools and technology is A: enforced, and usable tools and technologies are provided; B: just enforced; C: not enforced, but using specific tools and technologies is advised; D: not addressed.
Support for KM Process	Embedding Knowledge-Source Detection Features like Knowledge Map	Binary	+/-
	Periodical Evaluation of Knowledge Content		+/-
	Embedding Knowledge Storage Features		+/-
	Monitoring the KM Process		+/-
Prototyping		Binary	+/-
Embedding Diverse Channels for Knowledge Transition			+/-
Embedding Required Features to Access the Knowledge at any Time and Place			+/-
Specification of the Requirements at Different Levels of Users			+/-
Specification of the Appropriate Time to Obtain the Knowledge			+/-
Documenting the Problem and System Domain Definition Concepts		Binary	+/-
Specification of Appropriate Architecture			+/-
Specification of Organizational Knowledge Taxonomy			+/-
Identification and Encoding of Expert Knowledge			+/-
Prioritization			+/-
Providing Documents for Development and Maintenance Phases		Binary	+/-
Embedding Features to Receive/Request Knowledge by Users			+/-
Embedding Features for Monitoring Justice-Based Efficiency of KMS			+/-
Support for Management of Human Resources			+/-
Gathering Knowledge based on Knowledge Requirements			+/-
Compatibility Check of Selected Technologies			+/-
Formation of Maintenance Team(s)		Multilevel	The methodology has: A: addressed the formation of maintenance team(s) and has provided criteria for selecting team members; B: only addressed the formation of team(s); C: not addressed this issue.
Checking Compatibility with other Organizational Systems		Binary	+/-
Embedding the Features for Monitoring Knowledge Flows			+/-
Provision of Methods to Extract Hidden Knowledge of Experts			+/-
User-Friendly UI Design			+/-
Basis in Practical Experiences			+/-
Periodical Validation			+/-
Embedding Knowledge-Sources Search Features			+/-
Prevention of Invalid Knowledge Encoding			+/-
Determination of Characteristics of Organizational Knowledge	Determining Security Levels of Organizational Knowledge	Binary	+/-
	Determining obstacles to Achieving Organizational Knowledge		
Attention to Distinctive Characteristics of Tacit and Explicit Knowledge			+/-
Planning for Tacit KM		Multilevel	Planning for tacit KM is: A: specifically enforced; B: generally enforced; C: not enforced.
Detection of Organizational Knowledge Flows			A: activities are specified for knowledge flow discovery; B: only guidelines are provided for this task; C: not addressed.

Each criterion in Table III is traceable to one or more features of CMM levels. For example, the "Planning for KM process" criterion is elicited based on the "Lack of planning for organizational KM process" feature of organizations which are classified in the first level of CMM. Also, each criterion in Tables IV and V is traceable to one or more proven success/failure factors of KMSs. For example, the "Scheduling feasibility study" criterion is elicited based on the "Shortage of time" failure factor for developing KMSs. For sake of brevity, we have left out the related CMM features and also the success/failure factors of KMSs from the tables.

3. *Context-specific evaluation criteria*: These criteria assess the features and characteristics which are related to the core paradigm, domain or approach of the methodology; for example, a methodology that claims to be agile should exhibit the features expected from an agile methodology and should therefore satisfy the relevant agile criteria. Tables VI-VIII provide context-specific evaluation criteria for model-driven, agile and agent-oriented methodologies, respectively. We have elicited context-specific criteria for these contexts, as they are most relevant to KMS development; obviously, criteria for other contexts can be added as required. It should be noted that the criteria for evaluating the minimum agility characteristics of a methodology (Table VII) are elicited based on a minimal set of the agile software development principles presented in Beck *et al.* (2001); however, the complete set can be used if required.

Each of the above categories is further divided into subcategories to provide a simple structure for the criteria and thereby enhance their understandability. It should be noted, however, that some criteria can be classified under more than one category, as they satisfy more than one feature; to avoid repetition, such criteria have been classified under the category to which they are most relevant. It should be noted that in addition to the above categorization, we have also categorized the criteria using the well-known goal-question-metric method so as to extract the features/stages/activities of an efficient KMS development methodology (Dehghani and Ramsin, 2014); this categorization provides a more precise insight into the elicited criteria through specifying the questions

Table VI Criteria for evaluation of model-driven characteristics

Name	Type	Possible Values
Providing Tools for PIM-to-PSM Transformation	Binary	+: The methodology has presented the appropriate tools. -: Tool selection is devolved to the developers.
Providing Tools for PSM-to-Code Transformation		
Metadata Management		
Automatic Test		
Traceability between Models		
Use of UML Profiles		+/-
Extension of Rules	Multilevel	A: Guidelines and techniques for performing the activity are provided; B: Only a high-level definition has been provided for the activity; C: The activity is devolved to the developers.
Round-Trip Engineering		
Source Model and Target Model Synchronization		
Tool Selection/Implementation		The methodology: A: has provided the appropriate toolset, or guidelines for tool selection; B: has provided some of the appropriate tools, or high-level guidelines for tool selection; C: does not support this criterion.
CIM Creation		The methodology: A: describes steps and techniques for model creation; B: provides general guidelines for model creation; C: does not support this criterion.
PIM Creation		
PSM Creation		

Source: Asadi and Ramsin (2008)

Table VII Criteria for evaluation of agility characteristics

Agile Software Development Principle	Name	Type	Possible Values
Early and Continuous Delivery and Progress Measurement based on Working Software	Early Delivery	Binary	+/-
Collaboration among Developers	Daily Collaboration		+/-
Face-to-Face Conversations	Face –to-f ace Interaction		+/-
Existence of Self-Organizing Teams	Formation of Self-Organizing Teams		+/-

Source: Beck *et al.* (2001)

Table VIII Criteria for evaluation of agent-oriented characteristics

Comparison Aspect		Name	Type	Possible Values
Concepts		Definition of the Agent Concept	Binary	+/-
		Determining the Agents' Characteristics		+/-
Modeling Language		Using Appropriate Agent-Oriented Modelling Language		+/-
Process		Support for Agent-Oriented Process		+/-
Agent-Oriented	Technical	Support for Agent-Oriented Tools and Technologies		+/-
	Managerial	Support for Complexity Management		+/-

Source: Dam and Winikoff (2004)

> **“Using a low-quality KMS development methodology will most likely lead to developing an inferior KMS which does not satisfy all organizational goals.”**

that are addressed in assessing the efficiency of a KMS development methodology from different aspects.

To evaluate and complete the criteria, a set of meta-criteria is required. We have used the meta-criteria provided by Taromirad and Ramsin (2008) for this purpose. In addition, a special meta-criterion has been defined (by the name of “Conformance with KM Foundations”) to ensure the consistency and comprehensiveness of the elicited criteria in accordance with KM principles, dimensions, foundations and building blocks. The criteria proposed herein satisfy the set of meta-criteria, as explained below:

- *Conformance with KM foundations*: The proposed criteria are consistent and complete with regard to KM foundations.
- *Comprehensiveness*: The criteria cover the important aspects of KMS development methodologies.
- *Accuracy*: The criteria accurately express the details and goals of the intended evaluation and precisely define the possible values of the evaluation results.
- *Simplicity*: The criteria are understandable and measurable.
- *Consistency*: All inconsistencies have been identified and eliminated.
- *Minimal overlap*: Independence of the criteria has been strictly observed.
- *Generality*: The criteria are applicable to all KMS development methodologies, regardless of context.
- *Balance*: Suitable criteria are provided to evaluate the major aspects of KMS development methodologies (technical, managerial and usage).

3.2 Criteria-based evaluation of selected methodologies

We have evaluated the methodologies reviewed in Section 2 based on general criteria, KMS development criteria and context-specific criteria; the results are shown in Appendix 1 (Table AI), Appendix 2 (Tables AII and AIII), and Appendix 3 (Table AIV), respectively. To ensure a realistic and fair evaluation of the methodologies, we have conducted the following activities in a period of approximately five months:

- conducting the evaluation based on the descriptions provided for each methodology in the corresponding resource(s), documenting the evaluation results (as provided in Tables AI-AIV of Appendix 1, 2, 3) and recording the reasons for assigning a specific value (satisfaction level) to each criterion for each of the methodologies (these reasons have been provided in Dehghani (2014));
- deselecting poorly described methodologies;
- iteratively evolving the evaluation criteria so as to ensure that the evaluation criteria can reveal all of the strong/weak points of the evaluated methodologies; and
- reaching a consensus on the evaluation results through investigating the various symptoms that lead to choosing a specific satisfaction level for a criterion.

4. Analysis of evaluation results

The results of the assessment based on general criteria (shown in Table AI) and KMS development criteria (shown in Tables AII and AIII) are discussed throughout the rest of this section. It should be noted that each of the cells in the evaluation tables (Tables AI-AIII) provides an analysis of a specific strength/weakness of a specific methodology. In Subsection 4.1, the strengths and weaknesses of the methodologies have been discussed; due to the large number of evaluation criteria and also limitations in space, we have only included strengths/weaknesses which are not common among the methodologies. Subsection 4.2 explains the prevalent strengths and weaknesses, and Subsection 4.3 provides a high-level overview on the potential effects of the identified strengths/weaknesses on KM performance. As context-specific criteria (provided in Table AIV) are only applicable to methodologies which support a specific development approach, they can just be used to assess support for approach-specific features and are therefore not further discussed herein.

4.1 Methodology-based analysis

A high-level comparative overview of the significant weaknesses/strengths of the reviewed methodologies is provided below:

- *Rubenstein-Montano et al. methodology*: This methodology is superior to other methodologies from the following aspects: providing a more comprehensive coverage of general development phases, enforcement of planning for the organizational KM process and attending to motivational strategies through enforcing the analysis of appropriate motivational methods. Nevertheless, this methodology has failed to determine appropriate tools and technologies, whereas other methodologies have partially or fully addressed this issue.
- *Smuts et al. methodology*: This methodology is superior to other methodologies from the following aspects: providing a more comprehensive coverage of umbrella activities; paying special attention to obtaining managerial support; documenting the strategies, selected technologies and principles; providing features for measuring the amount of knowledge sharing in KMS; and specifying the organizational structure along with the responsibilities necessary for supporting the KMS. Despite these strengths, this methodology has failed to specify the methods of access to the organizational knowledge sources and has neglected logical modeling.
- *Sarnikar and Deokar methodology*: Attending to tacit knowledge, seamless transition between phases and special consideration to knowledge requirements through developing the task-user knowledge profile are the distinctive strengths of this methodology. Nevertheless, this methodology has failed to address user involvement.

> **"The framework is practical in that it facilitates evaluation through providing precise definitions and satisfaction levels for the criteria, and ensures an efficient assessment through covering both general and specific features of KMS development methodologies."**

- *Amine & Ahmed-Nacer methodology*: Superior aspects of this methodology are as follows: attending to compatibility with other organizational systems through developing data gateways and constructing KMSs through adding new features to existing organizational systems, determining security levels for organizational knowledge and taking advantage of agile practices.
- *Moteleb et al. methodology*: Knowledge management feasibility study through assessing KM's potential to address the current problems is the main strength of this methodology; this feature has been neglected in other methodologies.
- *Chalmeta and Grangel methodology*: Distinctive strengths of this methodology are as follows: prescribing useful techniques for each phase, considering the importance of monitoring the KM process and attending to training through specifying training strategies and also by suggesting e-learning techniques. Furthermore, this methodology benefits from certain model-driven development practices.
- *Iglesias and Garijo methodology*: Distinctive strengths of this methodology are as follows: precise description of the products, support for different modeling viewpoints (structural, functional and behavioral), specifying the construction flow of the products based on the requirements, providing seamless and smooth transition between activities and benefiting from agent-oriented development practices. However, this methodology has failed to address user involvement.

4.2 General analysis

To provide a general overview, the prevalent strengths and weaknesses identified among the evaluated methodologies are explained in this section.

4.2.1 Results of evaluation based on general criteria. Most of the methodologies reviewed herein are flexible and configurable: Adjustments can be applied based on the current characteristics of the project at hand. However, the following eight shortcomings are prevalent in satisfying the general criteria:

1. *Lack of a clear and accurate definition for the process part of the methodology*: The reviewed methodologies suffer from the following weaknesses:
   - *Poor process-centered definition*: Most of the evaluated methodologies have failed to specify the finer-grained activities and their execution sequence.
   - *Poor product-centered definition*: The evaluated methodologies have typically failed to adequately describe the artifacts of the methodology and their interdependencies.
   - *Poor role-centered definition*: Specification and assignment of development responsibilities are not enforced.
2. *Poor support for modeling*: Although a methodology is expected to specify syntax and semantic rules for producing the artifacts of the development process, the methodologies reviewed herein have settled for just naming the artifacts. In many instances, the models prescribed do not cover the different modeling viewpoints that are typically expected (structural, functional and behavioral). Furthermore, solution-domain models are not produced based on their problem-domain counterparts.
3. *Poor provision of low-level techniques*: Prescribing an activity without suggesting concrete technique(s) for performing it provides little value to the developers. Most of the reviewed methodologies have just named the techniques at a fairly high level, without even providing adequate guidelines as to their selection and usage.
4. *Poor support for umbrella activities*: These activities support the managerial and monitoring dimensions of the development process, lack of which can lead to the

failure of the project, or at least result in a significant reduction in quality. Planning activities (including the identification of general development strategies) have been neglected in most of the evaluated methodologies, and other activities have only been weakly supported.

5. *Poor coverage of the generic system development lifecycle*: None of the evaluated methodologies have fully covered the basic phases of KMS development (requirements engineering, analysis, design, implementation, test, deployment and maintenance). This can result in non-satisfaction of organizational requirements, disruptions in the development project and problems in the produced KMS as to applicability, reliability and usability.
6. *Lack of seamlessness and smoothness of transition among phases and activities*: None of the evaluated methodologies have provided a fine-grained step-by-step development process; additionally, establishing the relationships among some of the phases/activities has been completely left to the developers. Neglecting the intermediate activities and their interrelationships can lead to semantic seams (e.g. paradigm shifts) among phases/activities, and may adversely affect the smoothness of transition from one phase/activity to the next.
7. *Failure to address practicality and practicability*: This weakness may be traced to the following deficiencies:
   - *Lack of feasibility-study activities*: KMS development methodologies may fail due to the following reasons, all of which can be avoided through studying the different aspects of KMS development feasibility: lack of financial resources, failure to meet technical requirements, violation of rules and regulations, time constraints, inadequacy of human resources, incompatibility of the chosen method with current circumstances (such as business processes), neglecting current cultural characteristics and misunderstandings over the KMS's capabilities in addressing organizational goals.
   - *Inadequate history of practical and successful usage*: Some of the reviewed methodologies have not been used in practice at all, and others have merely been used in a small number of case studies; this sort of usage history is not sufficient for assessing all the different aspects of practicality.
   - *Failure to utilize successful and practical experiences*: Some of the evaluated methodologies are more of a theoretical nature rather than practice-based. Thus, a number of bad symptoms, which adversely affect the applicability of methodologies, are prevalent among the methodologies reviewed; examples include: poor analysis of the characteristics of the project at hand, poor support for project management activities and lack of focusing techniques such as requirements-based development (Ramsin and Paige, 2010).
8. *Poor user involvement*: Unwillingness of the users to participate in the KM process will lead to efficiency problems in the developed KMS. Thus, users should be actively involved in all phases to confirm and promote the quality of the target KMS. In most of the evaluated methodologies, user involvement is restricted to a limited number of activities, such as validation.

4.2.2 Results of evaluation based on KMS development criteria. Most of the methodologies studied herein suffer from the following weaknesses in satisfying the evaluation criteria for KMS development methodologies:

- *Lack of planning for the organizational KM process*: At the fifth level of CMM, an organization has an accurate and clear image of the current status of the organization, sets its goals based on this image and realistically plans the KM process based on its goals; in comparison, at the first CMM level, an organization executes the KM process "in an unconscious way but in a systematic form with no uniformity" (Khatibian and Jafari, 2010). Lack of planning for the organizational KM process means that the users of the methodology (organizations) will be placed at the lowest CMM level.

- *Lack of attention to organizational policies and standards*: Failing to consider organizational policies and standards in setting the goals and strategies, and also in planning the KM process, can reduce the applicability of the produced KMS.
- *Failure to determine managerial responsibilities and their assignment to the right individuals*: There should be managers responsible for monitoring and directing the KM process, otherwise the organization may deviate from its KM goals.
- *Failure to address the training, motivation, preservation and promotion of human resources and the required communicational strategies*: Providing training on the different dimensions of KMS (including cultural, social and usage) and establishing the learning environment, choosing the appropriate method to motivate the individuals to share their knowledge, using suitable methods for preserving and promoting the different levels of experts, and providing an appropriate communicational environment have a significant effect on KMS success.
- *Lack of support for methodology-level training and learning*: The individuals involved in the KM process should be trained on the part of methodology in which they are involved.
- *Poor support for documentation*: Proper transcription and transfer of organizational knowledge and the outputs of the KMS development process is essential due to the gradually evolving nature of organizational knowledge.
- *Failure to support the basic requirements of KMSs*: Although KMS goals may vary across organizations, there are a number of basic requirements that the methodology should incorporate into any KMS; in our proposed set of criteria, the criteria whose name starts with "Embedding" evaluate the degree to which the methodologies enforce the implementation of certain features in the produced KMS. The evaluated methodologies have failed to properly address this issue.
- *Lack of support for continuous and criteria-based evaluation of the satisfaction of system requirements*: The methodology should direct developers on how to determine and use appropriate criteria to continuously evaluate the satisfaction of different kinds of system requirements (technical, strategic, etc.); this motivates the developers and helps attract managerial support.
- *Failure to consider organizational structure*: The KM process is executed by organizational roles and responsibilities. KMS development methodologies are expected to provide means for investigating existing organizational structure, applying the necessary changes (if necessary) and designing the KMS based on the organizational structure.
- *Failure to determine the degree of supervision required on user activities*: The levels of communication and coordination allowed (to share knowledge) may vary based on organizational policies and strategies.
- *Lack of periodical notifications*: To support change management and motivational activities, managers, developers and system users should be periodically notified about the status of the KM process, and everybody should be involved in improvement activities.
- *Failure to properly manage the financial resources*: Due to the dynamic and continually evolving nature of KMSs, KMS development is typically considered a costly process; thus, a KMS development methodology should prescribe proper activities for managing the financial resources.

- *Failure to identify and address the oppositions and obstacles in KMS development*: Identifying and removing potential obstacles should be addressed by any KMS development methodology.
- *Failure to attract managerial support*: KMS development processes are bound to fail without support from the organizations' managers and should therefore include suitable activities for acquiring the required support.
- *Lack of attention to user requirements at different organizational levels*: As all organizational roles should get involved in the KM process, the KMS should satisfy the user requirements at different organizational levels.
- *Failure to specify appropriate technologies and tools*: Developers expect the methodology to guide them on how to choose the tools and technologies which are best suited to the requirements, and which are compatible with other organizational systems; most of the evaluated methodologies have not considered this issue.
- *Failure to provide an appropriate vision on KMS capabilities*: Misconceptions about KMSs (e.g. regarding KMSs as information/expert systems and neglecting the impact of cultural/environmental/human factors) prevent the achievement of KM goals. The methodology should therefore provide appropriate visions for managers, users and even developers.
- *Failure to determine the responsibilities and authorities of the users at various levels*: Establishing appropriate knowledge flows requires that each individual access the right knowledge at the right time (Riege, 2005). The point that the evaluated methodologies have neglected is that the methodology should direct its users on determining and updating the responsibilities and authorities of different users in the knowledge sharing process.
- *Lack of attention to specifying and updating the various knowledge security levels required*: Knowledge is one of the most valuable organizational assets, and its improper distribution can lead to its loss. KMS development methodologies should ensure that proper knowledge security levels are specified and maintained.
- *Lack of attention to distinguishing tacit KM from explicit KM*: In comparison with explicit knowledge, transmission of tacit knowledge is more difficult due to its intangibility and latency. Therefore, the methodology should prescribe appropriate activities and techniques for managing each kind of knowledge.
- *Absence of periodical validation*: Due to the dynamicity of knowledge, the KMS should be continually evolved to satisfy new requirements and maintain acceptability.
- *Failure to gather knowledge based on knowledge requirements*: The main goal of KM is to provide appropriate knowledge flows, not to accumulate organizational knowledge. Achieving this goal requires continuous elicitation of knowledge.
- *Lack of attention to long-term goals*: Long-term organizational goals have a strong impact on KMS development; however, they are not always achieved, mainly due to lack of resources or shortage of time. KMS development methodologies should prescribe the planning and plan-revision activities required for achieving long-term organizational goals.

Their weaknesses, notwithstanding most of the studied methodologies, show the following strengths:

- attention to the discovery of knowledge sources;
- provision of methods for accessing organizational knowledge sources;
- prescription of activities for periodical assessment of knowledge content;

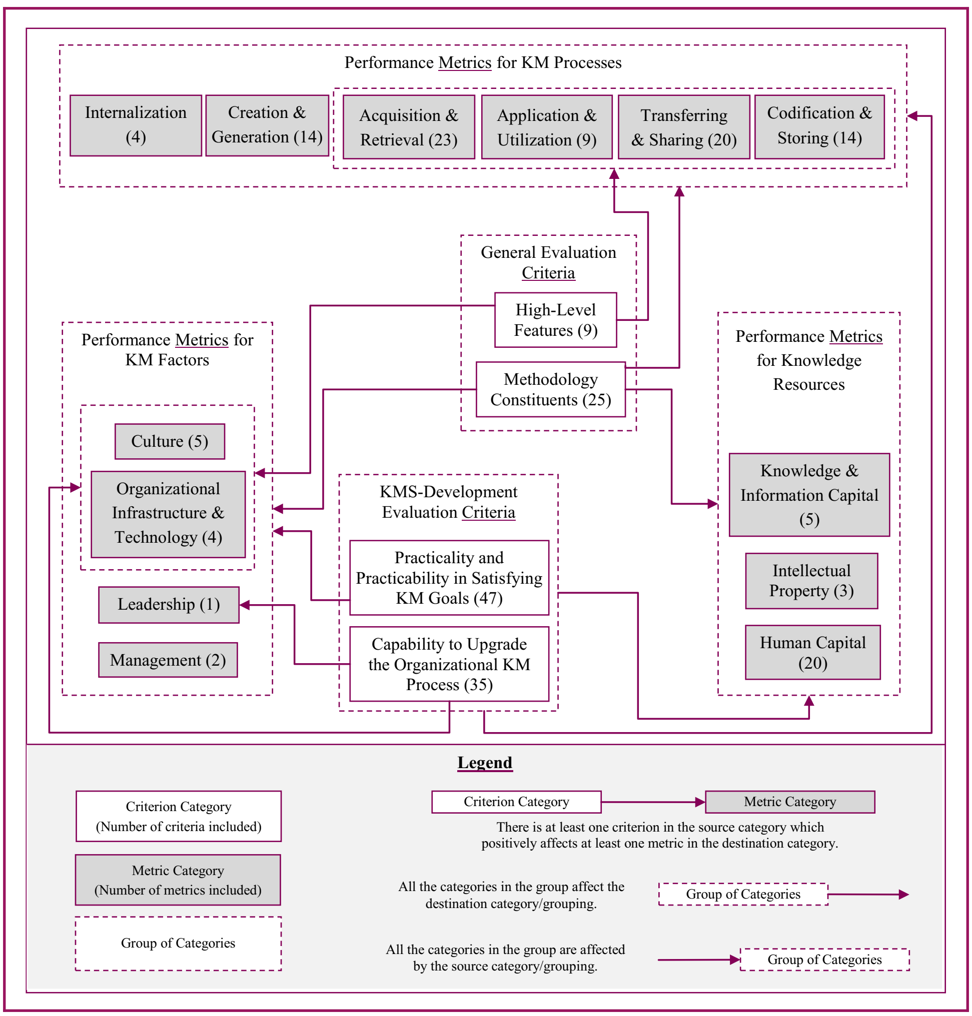
- attention to the discovery of organizational knowledge flows;
- consideration given to the discovery of organizational knowledge taxonomy; and
- attention to the prioritization of requirements.

4.3 Impact of satisfaction of proposed criteria on KM performance

To map the insight gained from the evaluation results to potential improvements in the KM area, we will assess the influence of the elicited criteria on the KM performance metrics surveyed in Wong *et al.* (2015). Figure 8 depicts the positive effects of satisfying the proposed criteria on these metrics. Due to the large number of criteria and metrics, we have only shown the categories; an arrow from a criterion category to a metric category implies that some of the criteria included within the criterion category positively influence some of the metrics within the metric category. For example, as shown in Figure 8, the "Transferring & Sharing" metric category is positively influenced by all criterion categories.

The following example shows how a metric can be influenced by a criterion: if the users know about the advantages of the KMS, they will use it more often to take advantage of its potential benefits; thus, the "Convincing users about the position and importance of the KMS" criterion (within the "Practicality and Practicability in Satisfying KM Goals" criterion category) influences the "Number of frequent KMS users" metric (within the "Transferring &

Figure 8 Positive influence of the proposed evaluation criteria on KM performance metrics



Sharing" metric category). As a result, if a methodology prescribes appropriate activities for convincing the users about the position and importance of the KMS, KM performance would be increased through increasing the number of frequent KMS users. Due to space limitations, the details of how the evaluation criteria influence the KM performance metrics will not be further explained herein.

As deduced from Figure 8, all metric categories are positively affected by one or more criterion categories; in other words, there are some metrics in each metric category that are positively influenced by some criteria in some/all of the criterion categories. This implies that satisfaction of the proposed evaluation criteria would improve KM performance; thus, if a KMS development methodology possesses the features that are assessed by the criteria, we can safely assume that its enactment will have a positive effect on KM performance.

5. Implications

Based on the evaluation results and the observations made on the effects of satisfying the proposed criteria on KM performance, the following implications can be stated for this research:

- *Theoretical implications*: Researchers can use the proposed evaluation framework as a means for assessing various KMS development methodologies and also for proposing better methodologies through reusing the strengths and alleviating the weaknesses identified in existing methodologies. As the quality of a KMS development methodology affects the performance of KMSs and KM, this research can also provide a basis for research on performance issues in the area shared by KM, KMS and KMS development methodologies. Moreover, the criteria within the proposed framework can be evolved to produce more comprehensive evaluation frameworks.
- *Practical implications*: Using a low-quality KMS development methodology will most likely lead to developing an inferior KMS which does not satisfy all organizational goals. Organizational managers and methodology engineers can use the proposed evaluation framework for choosing/developing the KMS development methodology which is best suited to their requirements. The framework is practical in that it facilitates evaluation through providing precise definitions and satisfaction levels for the criteria, and ensures an efficient assessment through covering both general and specific features of KMS development methodologies. Developers and managers can prioritize the proposed evaluation criteria based on their goals for developing KMSs and assess the existing methodologies based on these priorities; in case the current methodology does not satisfy the important criteria which assess the satisfaction of main organizational goals, it can be evolved through adding new features or updating existing ones so that the target criteria are satisfied at the desired level.

6. Conclusions and future work

This research has identified the features which are considered desirable in a KMS development methodology. These features are manifest in our proposed criteria-based framework for evaluating KMS development methodologies. The proposed evaluation framework, and the results of its application to evaluating prominent KMS development methodologies, provides the following two contributions:

1. *Facilitating the selection and evolution of KMS development methodologies (or engineering new methodologies from scratch) through revealing the strengths and weaknesses in the area of KMS development*: Applying the evaluation framework to a select set of prominent KMS development methodologies has shown that:
   - Most of the evaluated methodologies have covered the identification, assessment and classification of organizational knowledge, and have considered the importance of achieving short-term success.

- Despite the need for an accurate and detailed methodology for developing KMSs, most of the evaluated methodologies have provided overly abstract and vague methodology definitions.
- Umbrella activities have not been properly addressed.
- Most KMS development methodologies are not practical over their entire scope of application.
- Analysis and maintenance phases are poorly covered by most of the evaluated methodologies.
- Tacit KM needs to be addressed in its own right, and continuous communication among system users should be emphasized.

Utilization of the above findings can result in the development of more comprehensive and efficient methodologies.

2. *Resulting in KMS development methodologies which improve KM performance*: As satisfying the elicited criteria (constituents of the proposed framework) has a positive effect on KM performance metrics, the methodologies which are selected/developed through the use of the framework will enhance the performance of organizational KM.

We have used the results of this research for proposing an abstract KMS development methodology (Dehghani and Ramsin, 2014). We aim to further this research by proposing an object-oriented KMS development methodology. We also intend to develop a solution-finding model to map organizational KM-performance metrics with lower-than-expected values to corresponding solutions in KMS development methodologies.

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Appendix

Table AI Results of applying general evaluation criteria

Criterion Category	Criterion			Rubenstein-Montano et al.	Smuts et al.	Samikar&Deokar	Amine & Ahmed-Nacer	Moteleb et al.	Chalmeta&Grangel	Iglesias & Garijo
High-Level (General)	Scalability			+	+	+	+	-	+	+
	Basis in Requirements			B	B	B	B	B	B	A
	Application Scope	Scope Specification		B	B	B	A	A	A	A
		Practical Usage History		C	C	B	B	B	B	B
	Configurability & Flexibility			C	C	A	A	C	A	A
	Methodology Definition	Process Phases		B	B	B	B	B	B	B
		Modeling Language (ML)		D	E	D	D	E	C	B
		Products		B	B	B	C	D	B	A
		Techniques		D	D	C	D	C	B	C
Process	Coverage of Umbrella Activities	Project Management	Planning	B	B	C	C	C	C	C
			Scheduling	C	B	C	C	C	C	C
			Control	B	B	C	B	B	C	C
		Risk Management		B	B	B	B	B	B	C
		Quality Assurance		B	B	C	B	B	B	C
	Seamlessness and Smoothness of Transition			B	D	B	D	D	D	A
	Life Cycle Coverage	Requirements Engineering		B	B	B	B	B	B	A
		Analysis		B	B	B	B	B	B	A
		Design		B	C	B	B	B	B	A
		Implementation		A	A	B	A	B	A	C
		Test		A	A	C	A	B	B	C
		Deployment		A	B	C	C	C	C	C
		Maintenance		B	B	C	B	B	B	C
	Practicability & Practicality	Feasibility Study	Financial	B	B	C	C	B	B	C
			Technical	B	B	C	B	B	B	C
		Lack of Redundant Activities and Tasks		+	+	+	+	+	+	+
People	User Involvement			B	B	C	B	B	B	C
Products	Testability & Tangibility	Understandability of Products	for Users	A	A	C	A	C	C	C
			for Developers	+	+	+	+	+	+	+
		Specifying Product Dependencies		B	B	B	B	B	B	B
	Modeling Viewpoints	Structural		B	C	B	B	C	B	A
		Behavioral		B	B	B	C	C	B	A
		Functional		A	A	B	C	C	C	A
	Modeling Levels	Logical		B	C	B	B	B	B	A
		Physical		B	B	A	C	C	B	B

Table AII Results of applying the criteria for evaluation of special features of KMS development methodologies–to assess capability to upgrade the organizational KM process

Criterion \ Methodology		Rubenstein-Montano et al.	Smuts et al.	Samikar&Deokar	Amine & Ahmed-Nacer	Moteleb et al.	Chalmeta&Grangel	Iglesias & Garjo
Planning for Organizational KM Process		+	-	-	-	-	-	-
Specification of Policies		-	-	-	+	-	+	-
Legal Feasibility Study		-	-	-	-	-	-	-
Exploring the Organizational Knowledge Sources		A	A	A	A	A	A	A
Specifying the Methods of Access to the Organizational Knowledge Sources		+	-	+	+	+	+	+
Managerial Responsibilities Specification and Assignment		C	A	C	C	C	A	C
Specification of Strategies	Training	-	-	-	-	-	+	-
	Communicational	-	+	-	-	-	-	-
	Motivational	+	-	-	-	-	-	-
	Human Resources' Empowerment and Retirement	-	+	-	-	-	-	-
	General	+	+	-	-	-	+	-
Training for System Usage		+	+	-	-	-	+	-
Support for Learning		-	+	-	-	-	+	-
Continuous Update of Requirements		-	+	-	+	+	+	-
Documentation of Policies and Standards		-	+	-	-	-	-	-
Documentation of Utilized Tools and Technologies		-	+	-	-	-	-	-
Embedding Knowledge Sharing Capabilities in KMS		-	-	-	-	+	-	-
Benchmarking to Assess Fulfillment of Requirements		A	A	C	C	C	B	C
Continuous Revision of Business Processes		C	C	C	C	C	C	C
Specification of Organizational Structure		-	+	-	-	-	+	-
Embedding Communication Features in KMS	Face-to-face Communication	-	-	-	-	-	-	-
	Remote Communication	-	-	-	+	-	-	-
Periodical Verification		+	+	-	+	+	+	-
Attention to Cultural Issues		-	-	-	-	-	-	-
Specification of Users' Supervision Level in KMS		-	-	-	-	-	-	-
Embedding Document Management Features in KMS		-	-	-	+	-	+	-
Periodical Notification (of Failures/Successes)		+	+	-	-	-	-	-
Embedding Motivational Features in KMS		-	-	-	-	-	-	-
Giving Ownership Rights to Knowledge Owners		-	-	-	-	-	-	-
Embedding Features for Measuring the Amount of Knowledge Sharing in KMS		-	+	-	-	-	-	-
Embedding Knowledge Abuse Detection Features in KMS		-	-	-	-	-	-	-
Updating Utilized Technologies		-	-	-	-	+	+	-
Financial Resource Management		+	+	-	-	+	-	-
Identification and Obviation of Reasons for Rejection of KMS		-	-	-	-	-	-	-
Embedding KM Process in Organizational Processes		-	-	-	-	-	-	-

Table AIII Results of applying the criteria for evaluation of special features of KMS development methodologies–to assess practicability and practicality in satisfying organizational KM goals

Criterion \ Methodology	Rubenstein-Montano et al.	Smuts et al.	Sarnikar&Deokar	Amine & Ahmed-Nacer	Moteleb et al.	Chalmeta& Grangel	Iglesias & Garijo
Monitoring the KM Process	-	-	-	-	-	+	-
Operational Feasibility Study	-	-	-	-	-	-	-
Specification of Long-Term Goals, and Corresponding Plans	-	-	-	-	-	-	-
Providing Documents for Development and Maintenance Phases	+	+	+	-	-	-	-
Provision of Methods to Extract Hidden Knowledge of Experts	-	-	-	-	-	-	-
Embedding Features for Monitoring Justice-Based Efficiency of KMS	-	-	-	-	-	-	-
Embedding the Features for Monitoring Knowledge Flows	-	-	-	-	-	-	-
Compatibility Check of Selected Technologies	-	-	-	-	-	-	-
Checking Compatibility with other Organizational Systems	-	-	-	+	-	-	-
Gaining Managerial Support	-	+	-	-	-	-	-
Cultural Feasibility Study	B	C	C	B	C	C	C
Specification of the Requirements at Different Levels of Users	+	-	-	+	-	-	-
Determination of Appropriate Tools & Technologies	D	B	D	B	B	A	B
Convincing Users about the Position and Importance of the KMS	-	-	-	-	-	-	-
Embedding Knowledge-Source Detection Features like Knowledge Map	+	-	-	-	-	+	-
Periodical Evaluation of Knowledge Content	+	+	-	+	+	+	-
Embedding Knowledge Storage Features	+	+	+	+	-	+	-
Embedding Diverse Channels for Knowledge Transition	-	-	-	-	-	-	-
Embedding Required Features to Access the Knowledge at any Time and Place	-	-	-	-	-	+	+
Embedding Knowledge-Sources Search Features	-	-	-	-	-	-	-
Human-Factor Feasibility Study	-	-	-	-	-	-	-
Prevention of Invalid Knowledge Encoding	+	+	-	-	-	-	-
Specification of the Appropriate Time to Obtain the Knowledge	-	-	-	-	-	-	-
Specification of Responsibilities and Power at Different Levels of KMS Users	-	+	-	+	-	-	-
Knowledge Management Feasibility Study	-	-	-	-	+	-	-
Documenting the Problem and System Domain Definition Concepts	-	-	-	-	-	-	-
Detection of Organizational Knowledge Flows	B	C	A	A	A	A	B
Determining Security Levels of Organizational Knowledge	-	-	-	+	-	-	-
Determining obstacles to Achieving Organizational Knowledge	-	-	-	-	-	-	-
Specification of Appropriate Architecture	+	-	+	+	-	+	+
Specification of Organizational Knowledge Taxonomy	+	+	+	-	-	-	+
Identification and Encoding of Expert Knowledge	-	+	+	+	+	-	+
Specification of the Intended Definition of Knowledge	-	+	-	+	+	+	-
Explanation of Features Distinguishing KMS from Technology-Driven Systems	-	+	+	+	+	+	-
Prioritization	+	+	+	-	-	-	+
Planning for Tacit KM	B	B	C	C	C	C	C
Attention to Distinctive Characteristics of Tacit and Explicit Knowledge	-	+	+	-	-	+	-
User-Friendly UI Design	+	+	-	+	-	-	-
Basis in Practical Experiences	-	+	-	-	+	-	-
Periodical Validation	-	+	-	+	-	+	-
Scheduling Feasibility Study	-	-	-	-	-	-	-
Embedding Features to Receive/Request Knowledge by Users	-	-	-	-	-	-	-
Conformance of Organizational Occupational Hierarchy with System Users' Hierarchy	C	B	C	C	C	C	C
Support for Management of Human Resources	-	-	-	-	-	-	-
Gathering Knowledge based on Knowledge Requirements	-	+	+	-	-	-	-
Formation of Maintenance Team(s)	C	C	C	C	C	C	C
Prototyping	+	+	-	-	-	-	-

Table AIV Results of applying context specific evaluation criteria

Criterion	Evaluation Result
Model-Driven Approach Criteria (Chalmeta&Grangel Methodology)	
Providing Tools for PIM-to-PSM Transformation	+
Providing Tools for PSM-to-Code Transformation	-
Metadata Management	-
Automatic Test	-
Traceability between Models	-
Tool Selection/Implementation	B
CIM Creation	B
PIM Creation	B
PSM Creation	B
Extension of Rules	C
Round-Trip Engineering	C
Source Model and Target Model Synchronization	C
Use of UML Profiles	+
Agile Approach Criteria (Amine & Ahmed-Nacer Methodology)	
Early Delivery	+
Daily Collaboration	-
Face –to-f ace Interaction	-
Formation of Self-Organizing Teams	-
Agent-Oriented Approach Criteria (Iglesias &Garijo Methodology)	
Definition of Agent Concept	+
Determining the Agents’ Characteristics	+
Using Appropriate Agent-Oriented Modeling Language	+
Support for Agent-Oriented Process	+
Support for Agent-Oriented Tools and Technologies	-
Support for Complexity Management	-

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