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Research Article

Methodologies for Building a Knowledge Map: A Literature Survey

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Abstract: Nowadays one of the most important phenomenons in organizations is their ability to make the available knowledge internally visible in a formal way. Most organizations are facing difficulty in making important knowledge visible as part of their knowledge management effort. Knowledge maps make it easier to locate this knowledge, capture it and make it visible for the organization. Several methodologies have been proposed and presented for building a knowledge map. Despite this, discussion on those methodologies in the literature is very little. Thus, the goal of this study is to carry out a literature survey to determine all the existing methodologies used for building a knowledge map, then cross-referencing those methodologies with the five types of knowledge map. Practitioners and researchers involved with knowledge maps may find this study useful as it provides a wide description of those methodologies and assesses their degree of contrast. The fact that this study is the first literature survey of methodologies used to build knowledge maps makes it a significant contribution to the Knowledge Management (KM) community.

Keywords: Knowledge management, knowledge maps, methodology, ontology

INTRODUCTION

The knowledge management field has received much attention from many researchers and practitioners over the past several decades. Continuous efforts have been given by researchers and practitioners towards the advancement of the field. In particular, special attention was given to the development of tools which would support or facilitate knowledge management activities. Among those tools, special attention was given to knowledge maps (Mansingh *et al*., 2009a). Knowledge maps can simply be defined as a visual representation of an organization's knowledge (Eppler, 2001; Wexler, 2001; Vail, 1999). It helps to describe how to find, what to find and where to find useful knowledge within the organization (Eppler, 2006; Yun *et al*., 2011; Jafari *et al*., 2009; Driessen *et al*., 2007; Davenport *et al*., 2000; Hansen and Kautz, 2004).

A well-constructed map elucidates knowledge of key ideas besides how these ideas are interrelated within a domain (Novak and Cañas, 2006; Tergan *et al*., 2006; Chung *et al*., 1999; Novak, 1998; Herl *et al*., 1996; Crampes *et al*., 2006).

Several objectives can be acquired when utilizing knowledge mapping. Some organizations view it as an activity to help with their strategic planning, while others may use it as a basis for knowledge transfer (Balaid *et al*., 2014). In other cases knowledge maps have been used to represent the views of participants and their mutual relations to other views, as well as to illustrate the learning path dependencies and serve as the basis for the implementation of a knowledge management program (Ivanov and Cyr, 2006; Einsfeld *et al*., 2009; Dang *et al*., 2011; Kim *et al*., 2003). In all cases, it deals with the problem of how best to visualize knowledge assets in order to perform specific activities, particularly when organizations that value knowledge would like to recognize how, when and where to access knowledge. This is where a knowledge map presents a snapshot of where an organization is at any given time comparative to its competitors (Vail, 1999; Tiwana, 1999). Therefore, it is important for the organizations to create maps of where knowledge, experiences and expertise reside, as well to know which knowledge needs to be shared with whom, how, when and why.

Many different methodologies for constructing knowledge maps have been proposed during the last few decades, with each development team usually following its own set of principles, design criteria and phases during the map development process. Nevertheless, there are still questions around these works: What are the different methodologies available today? Do they meet requirements? Do they cover all important steps? Which methodologies should be chosen for a specific type of knowledge map? We faced these questions, concluding that a general survey of existing methodologies for building knowledge maps is necessary.

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The goal of this study is, therefore, to carry out a literature survey to discover all the available methodologies used for constructing knowledge maps, as well as describing the characteristics of each methodology. Through a comparative analysis of those methodologies, we aim to provide readers with a comprehensive understanding of the knowledge map building process. Practitioners and researchers involved in knowledge maps may find this study useful, since it provides a comprehensive understanding of the map development process. Practitioners can use this study before building their map, employing it as preliminary information that explores the workings of current methodologies. Researchers can also consult the study to discover the main features that a method often includes and to observe how those methods can be implemented according to the purpose of each type of knowledge map.

RESEARCH METHODOLOGY

This research was undertaken as a literature survey, with the goal to summarize existing methodologies used for building knowledge maps and to cross-reference them with the 5 different types of knowledge map. We started this review through a range of related search terms inside relevant and known sources of literature, such as Science direct, IEEE digital library, Google Scholar, etc. These resources were selected since they provide the most important full text journals and conference proceedings that cover the domain of knowledge maps in general. Since we aimed to include all related studies stored in these resources databases over the years, full papers from journals, conference proceedings as well workshops published up to 2013 were considered. Further studies that did not clearly relate to the knowledge map building methodologies were excluded.

In total, the outcome of this search yielded 103 papers. Each paper was arranged and included in a full text search with the aim of identifying the relevant contributions to the knowledge map building domain. By using the keywords of "knowledge map building methodology" and "methodology for building knowledge map", full text searches on the data set were conducted. This was followed by a stage of eliminating search result duplicates (i.e., ensuring that a paper is only counted once when that paper matched both search criteria), which left us with a set of 72 papers. A review of each paper and its contribution was carried out as an extra step to assess appropriate study relevance. This step included analyzing the title, abstract, introduction, as well as conclusions of each research paper. By the end of this stage 57 papers were deemed as not relevant and discarded, reducing the total set of papers from 72 to 15. A second read was then carried out for deeper analysis, leaving us with 9 papers very highly relevant to our domain. Through a comparative analysis of those papers and the careful reading of each paper, we were left with six methodologies, which, according to the literature, have been, or are intended to be used for building knowledge maps. Finally, we cross-referenced them with the 5 types of knowledge map to provide readers with a comprehensive understanding of the knowledge map building methodology. The most common methodologies for building knowledge are detailed in the next section.

Knowledge map implementation methodologies: Different steps are necessary for building knowledge maps. Although these steps can vary according to the selected type of knowledge map, there are many similarities within the approaches. This section presents, in chronological order, the best-known methodologies for building knowledge maps as they are in the knowledge map literature.

Nine-step methodology (Vail, 1999): Vail (1999), suggested a methodology for building knowledge map. This methodology comprises nine steps that have to be taken to create a knowledge map. In this section, the different steps are presented with some details that can be described as follows.

Step 1: Identify the sponsor: This first step is for the sponsor to identify the objectives of building the knowledge map. This is normally done through the Chief Information Officer (CIO) of the organization, manager for training and business managers of the organization.

Step 2: Determine knowledge map objectives: This step is where the knowledge workers will determine the scope of the knowledge map that is the area that the knowledge map will cover in terms of user requirements.

Step 3: Education plan: In this step, the knowledge workers will conduct awareness campaign on the benefit of the knowledge map to the organization. The campaign usually start with the project sponsor and other stakeholders within the organization that their support is regarded as necessary for the successful implementation of the project.

Step 4: Indentify stakeholders: The main goal of this step in the map creation process is to identify the key stakeholders that will be touched directly with the knowledge map by identifying who is endorsing the knowledge mapping activity (sponsor), identify for whom is the map will be designed (users).

Step 5: Create the steering committee: This step involve selecting key people in the organization that will form the steering committee. This committee will represent all the major stakeholders within and outside the

organization. The number of members to form that committee depends on the size of the project, for small knowledge map project 2 to 4 can serve as the committee while for large project large number and specialization are required as well.

Step 6: Create the technical committee: In this step, a technical committee for the corresponding map is created. Typically, the map technical committee and architect control the knowledge map components, definitions, structure and templates.

Step 7: Select evaluation strategy: Choosing which characteristics and capabilities the knowledge mapping tools should offer to fulfill the objectives; as well, the selection process must be established.

Step 8: Identify the custodian and maintenance process: In this step, the custodian of the map is identified. Besides the location of the repositories and process of maintaining it. Through conducting periodical reassessments, update the knowledge map on a regular basis. By keeping the map up-to-date, incorporating the users' updates and corrections knowledge, is continuously accurate, maintaining its real value to them.

Step 9: Create the initial enterprise knowledge map: Start building the first knowledge map and at the same time emphasizing on the breadth of the map other than the depth. This is so because it will allows for making sure the entire dimension for the mapping and the architecture are functionally satisfied. The map can then be extended to more detail level depending on the need for that.

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Eleven-step methodology (Bargent, 2002): Bargent (2002), suggested an approach following a typical life-cycle method to build a knowledge map by using Lotus Discovery Server, in which eleven steps such as identifying requirements, conduction an information audit and etc., are involved (Bargent, 2002). The following section describes these steps in detail.

Step 1: Requirements identification: Before rushing off to create a knowledge map from organization's actual data, the goal of the knowledge map must be clearly define and required to be in line with the objectives of the business. A set of business task typically involves identifying in this step and focusing on the sources of getting accurate data that will at the end addresses this task. In order to identify these tasks, the knowledge map workers has to find out if the members of the organization are having any difficulty in locating a particular resources in the event of their work. This especially possible if the organization has many knowledge banks or repositories located in so many places. This step will also identify the target audience that will be capture in the knowledge map as well as the scope of the work. If the scope is small it is normally easier to have a successful knowledge map development. In sum, the scope and target audience need to decide in this step, the smaller the scope, the easier it is to measure the success of the knowledge map.

Step 2: Conduct an information audit: Information auditing must be conducted before, targeting data sources for inclusion into the knowledge map. All possible sources must identify by subject matter experts. Initially, electronic information used by the target audience should be audited, including: document management system files, databases, internal and external Web sites.

Step 3: Define information sources to use: In this step, subject matter experts, must closely review and refine the generated list from the information that was edited by removing useless sources, duplicate data, information of little value, outdated information and identify the security issues or any access. One of the objectives of this step is to generate new list that will contain sources all data that will be needed for knowledge map development, by prioritizing the most relevant document and their sources, which will be uses in the process.

Step 4: Modify the stopword list: Update the default Lotus Discovery Server (LDS) those words that are removed from the knowledge map. LDS normally is able to maintain its own list of words therefore; this list should be modified to include any industry or organizational specific terms.

Step 5: Configuring the LDS: The LDS server has to be configured before the generation of initial knowledge map. This configuration includes assigning the types of spiders to be used and various rules related to the spiders. This configuration determines the reliability and performance of the knowledge map.

Step 6: Generate people profiles: The process of generating people profiles from a primary source involves; generation of profile from a master sources like light weight directory access protocol and finally updating the files that was been generated from supplementary (such as domino database or spreadsheet).

Step 7: Setting up of data sources for spidering: The moment people profiles is successfully created the next step, is to configure each data source before building the initial knowledge map. This is achieved by setting up the set of data in the

discovery server in order to create the initial knowledge map. Next is to define each all the data set to the lowest level in order to make sure that all questions asked by the spider can be answer. Before you can move on to the next step each source must be processed.

Step 8: Create the knowledge map: When the data source successfully set up and reviewed and the training set have been processed the next phase is to the create knowledge map. To do so, three steps are involving: primarily, add repositories to process; next review the settings of the knowledge map; finally create knowledge map.

Step 9: Train the knowledge map: So even after creation, the knowledge map is not ready for use, LDS does not automatically create a working knowledge map. Therefore, further training of the knowledge map is required. The process of training of the knowledge map is repetitive cycle whereby new data source are added continuously. During the training process, subject matter experts (knowledge map editors) have to teach the systems the right document and category of the taxonomy.

Step 10: Generate affinities: Afterward, the editors have trained the knowledge map, the affinities generated. Affinities (the associations between people and information) correspond to the knowledge of the expert and knowledge map class and are confirm by the managers who can identify the requirement for a particular user.

Step 11: Knowledge map testing: Finally and before releasing knowledge map for usage by the beneficiaries, it is more appropriate to test the map using user acceptance teat. This type of testing evaluate the knowledge map`s effectiveness, affinities and taxonomy as well to ensure that all document placement and categorization has been completed before going into production.

Six-step methodology (Kim *et al*., 2003): In line with development and utilization of knowledge map Kim, explored a technique that can be used for knowledge map representation and consequently proposed guidelines for developing a general knowledge map. The guidelines consist of 6 steps which are: understanding the knowledge within the organization, analysis of the knowledge process map, extracting the knowledge, profiling the knowledge, linking the knowledge map finally validating the proposed knowledge map (Kim *et al*., 2003). Next section will explain the proposed steps of creating a knowledge map in detail.

Step 1: Defining organizational knowledge: This steps involves defining the available knowledge in the organization, by locating knowledge sources and their location (Gruber, 1995). Using ontology in the map development in order to extract all the available knowledge items and represent them in a formally set of concept and their relationship within a domain. Defining baseline taxonomy and knowledge within an organization are as well covered in this step. By using interview and questionnaires techniques, limitation of the knowledge map is identified as to whether it should be limit to only one department or throughout an entire company is determined by the scope. The detail of knowledge analysis is determined after deciding the scope. Operation manuals, project deliverables, meeting minutes, customer contact records and external data can be used to analyze the knowledge sources in that organization in question.

Step 2: Process map analysis: Organizational knowledge is extracted in this phase, based on the business process. Solutions to problems can be founded easily by identifying and capturing the available in the organization. By using the process map technique the business process is analyzed. The process map consist of process, flow and event and external object with their relationship.

Step 3: Knowledge extraction: Knowledge is extracted in this step, through a process map. Three types of knowledge are extracted: prerequisite knowledge, used knowledge and produced knowledge that are used before, during and after execution. In knowledge extraction the following techniques are available: system analysis, document analysis, interviewing and knowledge workshop. Other techniques such as focus groups, brainstorming, task environment analysis and qualitative text analysis, can be used as well to extract knowledge.

Step 4: Knowledge profiling: In this step, knowledge profile of extracted knowledge is produced. Knowledge is described with pre-defined items (attributes) and the corresponding relationship with the process. Profiling the knowledge will help in connecting workers with the required information and workers with workers by providing some attributes such as descriptions and keywords.

Step 5: Linking knowledge: After completing the knowledge profile, then knowledge link is identified. The link is initially indicated when producing knowledge profile. A new links are identifying, beside examine and confirm existing links. This link is usually represented by using arrows in the knowledge map.

Step 6: Validating the knowledge map: The last step in this knowledge map development is validating the map. The validation is achieved by contacting the domain expert and

practitioners. This is to make sure that all the relevant knowledge in the organization is extracted. And the validation will also make sure that all profiles and links are well described and consistent for all the knowledge.

Four-phase methodology (Lecocq, 2006): Lecocq (2006), suggested a novel methodology for building knowledge map. This methodology is divided into four basic phases: planning, collecting, mapping and validating (Lecocq, 2006). Each phase includes a number of steps that can vary according to the approaches that are chosen. In this review, the different phases are presented regardless of the chosen approach or type of map. The phases can be described as follows.

Phase one:

Plan: In this first phase, the objectives, the scope of the project, who will take action in it and the approaches to be used, are determined. Once these steps are fulfilled, the components that will be mapped are identified and a number of deliverables should be produced. The main four steps of this phase are.

Step 1: Identifying objectives, scope and stakeholders: Objectives, scope and stakeholders are tightly linked together and they have a great influence on the whole mapping methodology. The objectives determine the nature and the future use of the knowledge map. To identify the objectives initially, clarify the context for which the knowledge map is created, as well as identify the targeted business value of mapping knowledge assets. In the same way, determining the area or scope on which the map will focus. As a final point for this step, is identifying the key stakeholders by:

- Identify who is endorsing the knowledge mapping activity (sponsor).
- Identify for whom is the map designed (users) what are their specific needs?
- Identify who will be provided support to update the knowledge map.
- Analyze the stakeholders' issues and concerns to ensure the best value from the knowledge map.

Step 2: Selecting the mapping engineering team: Constitute the mapping engineering team is the second step in the map creation process. Their role will be to build the map while ensuring the correctness of the components being represented and to determine the selection of the capabilities offered by the map. Consequently, set up the steering committee of a knowledge map that includes representatives from key sponsors as well as stakeholders. Many employees may not realize how knowledge maps can help them better accomplish their daily tasks, therefore ongoing education process on knowledge mapping benefits, is required starting with the sponsor.

Step 3: Determining right balance between approaches: Knowledge mapping can be classified according to four approaches: social, procedural, competency and conceptual. In this particular step, each approach needs to be reviewed and examined in order to evaluate the degree of importance. This analysis will be performed while always keeping in mind the final objectives of the project.

Step 4: Identifying components: This step supports the determination of knowledge components that need to be mapped. It is important that the selection of components be the result of a number of techniques such as conducting interviews, making observations, reading background documentation etc. To rely on many such techniques will guarantee that important elements will be taken into account:

- The key knowledge assets to be mapped should be identified, their location, sources, recipients, routine/non-routine nature, tacit/explicit nature and the issues they address.
- Identify the pathways through which knowledge flows in the organization, how it is exchanged between systems.
- Validate the choice of components.

Phase two:

Collect: In this phase, the ontology must be built and all the information on the components to be represented on the map is gathered. The main deliverables are inventory of components, standardized terminology and ontology.

Step 5: Compiling ontology: The ontological framework will need to be defined before the gathering or inventory actually takes place, in order for the knowledge map to be relevant to the end-users. At this step, it is important to specify the common concepts and their links to make sure that all knowledge objects will be adequately organized and structured. A good ontology will improve communication and allow a better reuse and interoperability.

Step 6: Conducting inventory: The content of the map will be established by a knowledge inventory. However, the way this inventory is conducted, for example, through questionnaires, interviews, focus groups or observations will differ according to the culture and characteristics of the organization. It will also

differ depending on the components that one wishes to represent on the map.

Phase three:

Map: In phase three, the initial map is draft by analyzed the collection results. The map has to be built by using the selected tools and method accordingly to the objectives.

Step 7: Defining and selecting the tools: In this step, the characteristics and capabilities of the tools are determined to fulfill the objectives. As well, the selected tools should be tested and validated.

Step 8: Crafting the knowledge map: Here, a template, a model and a legend have to elaborated to represent the knowledge artifacts, knowledge flows and the links to people:

- Map the content and knowledge sources and owners against the process map
- **Map the processes:** Identify key decision points and determining routine/non-routine tasks
- **Map the knowledge against the process:** For every particular steps of the process, the important knowledge needed must be identified
- **Map the social network:** Interactions

Phase four:

Validate and use: In this final phase, the feedback from the users, includes an evaluation of the usage and consists of regular updating and enhancement, all leading to the following deliverables: an electronic system made available to all users, a final report, a training and communications plan, as well as evolution and maintenance plan.

Step 9: Validating the knowledge map: Validation can be made by a walkthrough with actual users and people who contributed to its production such as: business managers, domain experts and knowledge map producers. During this walkthrough the following questions could be asked (Kim *et al*., 2003):

- Is all knowledge represented?
- Is any knowledge redundant? If it is, evaluate if that redundancy is necessary or not.
- Are profiles (in the case of competency based for example) and links fully described?
- Are the symbols used significant enough?

Step 10: Exploiting the knowledge map: Start using the map according to the objectives. Hence, educate people to better understanding the components and use the map, communicate the good news, identify gaps and lack of connectivity for a better use of knowledge map components. This will contribute to the next concurrent step for the evolution of the map.

Step 11: Revising, maintaining and enhancing the knowledge map: Throughout this last step, measure the results by comparing the initial objectives of the sponsor and users with the outcome. The map should serve its purpose and bring some impacts that can be appraised by the sponsor either in a qualitative and/or quantitative ways. For users objectives the map should fulfill their expectations and help them perform their tasks in a more efficient and time-effective manner.

Three-stage methodology (Mansingh *et al*., 2009b): The process of building the map in this methodology is divided into three basic phases includes creation of ontology, identification of the processes involved and bringing out the instances of the processes and as a final point all the available kind of knowing are then extracted and presented as the final knowledge map (Mansingh *et al*., 2009a). The following sections will describe the details in development process.

Stage 1: Ontology development: Ontology is aims at describing who does or know what in an organization. An ontology deficit the embedded knowledge in organization by visualizing the available knowledge in the organization. The most important component in knowledge map development is developing the ontology of the knowledge domain. In order to develop a good ontology there are some stages to follows which includes: ontology feasibility, kick up, refinement and evaluations (Sure *et al*., 2002). For the feasibility studies the aims is to consider the possibility of using ontology for building knowledge map. In addition, for the kick up and refinement the researcher should analysis the organizational knowledge by interviewing administrators in order to understand the relationship and concepts.

Stage 2: Process map: This is a useful tool for understanding the existing business process in an organization. The maps are intended to give clearer picture of the existing process by representing their different links. There are many standards for process map representations like flowcharts and petri nets (Curtis *et al*., 1992; Harvey, 2005). Expert will later help in validating the process in the map.

Stage 3: Extraction of the knowledge map and evaluation process: The instances are then extracted by using an ontology, which gives a needed vocabulary and gives the details relationship between the concepts. By analyzing all these instances, a lot of knowledge can be generated from various knowledge holders in that organization.

Evaluation process: The evaluation is based on ontology focused and user-focused evaluation (Sure *et al*., 2002). During the developing of the knowledge map will be ensured the ontology is used and also refined so as to facilitate future valuation of the ontology. Applying the concept of ontology during the extraction of information from various experts in the organization ensures there is consistencies and completeness in the process extractions and the relationships.

In the user-focused perspectives, the concern is to make sure that, the end users are satisfied with the maps and are able to apply the maps during their work process. Usability and usefulness are the main factors used in evaluating the knowledge map for representing some aspect of knowledge.

Seven-step methodology by Pei and Wang (2009): In this methodology, the author focuses on knowledge management network for matrix organization. In matrix organization, the experts are not readily available, as they may be not staying around the organization at any point in time. Therefore, without adequate tools for knowledge transfer from expert to the various actors in the organization, there will be a serious danger to the general organizational performance (Yasin and Egbu, 2010; Pei and Wang, 2009). Here, the author suggests seven steps for developing knowledge map.

Step 1: Setting up of project team: The first step, in developing a quality knowledge map in especially matrix organization is the setting up of the project team. This including looking at the key players in the organization that can contribute to the knowledge management process. These players involves the top management that plays the role of decision makers, the technical staff, the knows the operations of the organization and then finally the end users.

Step 2: Analyzing the knowledge resources: This step involves defining and analyzing the knowledge requirement of the major players in the group. This means the team has to know what kind of knowledge the top management needs and what the technical staff require in order to achieve a certain objectives in the knowledge map development.

Step 3: Setting of knowledge boundaries: This step involves defining the boundaries of business knowledge domain so as to enable the team determine the knowledge distribution in the organization.

Step 4: Determine the structure: In this step, the team has to determine the structures, constituent of the elements and after that define the relationship between the nodes and between a node and a specific person, the types of storage methods. With knowledge extraction and sharing the relationship among items like correlations, logics and ranks can be revealed.

Step 5: Evaluation process: After the team determines the structures and their relationship, the next step is to and evaluates the knowledge map and select appropriate development tools. One of the best way to evaluate the knowledge map is by testing it in a case study and there by getting practitioners feedback on the possible area where there is need for improvement.

Step 6: Knowing the knowledge enterprise locations: This one of the fundamental step where by the team identifies the locations of knowledge within and inside the organization. This also will guide the team in strategizing on how to find required information in the organization. This will act as the navigation map that locates both external and internal knowledge resources of the organization.

Step 7: Constant update: The last step in knowledge map development is constantly updating the contents of the knowledge map and continuously evaluation it until the desired scenario is achieved. The update can come as a result of changes in actor-resources relationship in the knowledge map, for example if the skill requirement of a particular actor changes or the location of a particular knowledge changes then this has to also reflect in the final knowledge map.

METHODOLOGIES AND KNOWLEDGE MAPPING TYPES REFERENCED

The way an organization chooses a knowledge map type is determined by many factors. One of the main reasons that motivate organizations to undertake a specific type of map depends largely on the expectations they place on the activity. To bring tangible results, knowledge mapping must concentrate on specific areas, processes or activities of the organization. According to the literature, there are a numerous types of knowledge maps useful for different aims. Eppler (2001), structured diverse kinds of knowledge maps and underscored that the procedure of building the maps is challenging when contrasted with utilizing engineering to execute them. The five knowledge maps include source maps, asset maps, structure maps, application maps and development maps (Eppler, 2001).

Knowledge source maps define the location of an expert in an organization. For example, ‘where can I found somebody who knows how to do something?’

Table 1: Knowledge maps and their objective

Types of knowledge map	Directories	Purpose
Knowledge source maps	Expert	Organizational knowledge assets; how to locate knowledge?
Knowledge asset maps	Core competencies	Organizational knowledge assets; how many x consultants are there in the company?
Knowledge structure maps	Skills domains	What types of skills or expertise is needed and what is their relationship?
Knowledge application maps	Specific context	Where and how to locate more specific knowledge within the organization?
Knowledge development maps	Learning paths	Learning maps

Table 2: Cross-referencing of knowledge map types and methodologies

Mapping types/methodology	K. source map	K. asset map	K. structure map	K. application map	K. development map
Nine-step methodology (Vail, 1999)	✓			✓	✓
Eleven-step methodology (Bargent, 2002)	✓		✓	✓	✓
Six-step methodology (Kim *et al*., 2003)			✓	✓	
Four-phase methodology (Lecocq, 2006)	✓	✓	✓	✓	✓
Three-stage methodology (Rao *et al*., 2012)	✓		✓		
Seven-steps methodology (Pei and Wang, 2009)			✓	✓	

Knowledge asset maps provide a simplified graphic 'balance sheet' of a company's intellectual capital. It answers questions such as 'how many x consultants do we have?' Knowledge structure maps describe the general architecture of the environment. For example, 'what skills are needed to undertake a particular task?' Knowledge application maps describe how a certain skill is applied in solving a particular problem. Lastly, a knowledge development map describes a roadmap for developing a particular skill, thus illustrating the organizational vision strategy. All these types of maps can be merged together to form a single and bigger knowledge map. A good example is that we can use a knowledge structure map to capture different roles that come together to perform common tasks, thereby identifying the know-what and know-how. Table 1 explores the 5 types of knowledge maps and the aspect of organizational knowledge they represent.

The methodologies of building a knowledge map, detailed in the previous section, can be cross-referenced with the 5 types of knowledge map (source, asset, structure, application and development) outlined above. Table 2 shows the cross-referencing of the 6 methodologies and knowledge map types.

RESULTS AND DISCUSSION

This section tries to analyze the result of literature reviews for the six methodologies. The analysis was based on Eppler`s classification of knowledge map types. Six different types of methodology for developing knowledge maps from 6 different authors were summarized in Table 3. The first methodology from Vail (1999) has nine steps, from the first step of identifying the sponsor to the final step of developing the knowledge map. This type of methodology focused more on the process of development but did not give adequate attention to the core competencies in an organization. The issue of the actors-role interaction is greatly missed. The methodology therefore did not meet the requirements for the two classes of knowledge map by Eppler (2001), which are knowledge asset map and knowledge structure map. By lacking in these two types of mapping technique, it means the opportunity of locating the core competencies and skills in the organization is missed. It is therefore difficult to know who has particular skills for solving a particular problem and how to appropriately locate knowledge in the organization.

The second methodology by Bargent (2002) has eleven steps. The author employs the strategy of software development lifecycle stages by using the Lotus Discovery Server (LDS) software, from identifying the requirement and finally to testing the knowledge map. One of the advantages of this method is the strength of the validation stage by using usability tests to evaluate the effectiveness of the knowledge map and its affinities and taxonomy, as well as to ensure that all document placement and categorization has been completed before going into production. Unlike the methodology by Vail (1999) this method fails to meet the requirement of Eppler's classification of knowledge maps, which is the knowledge asset map, but satisfies the remaining three. Therefore the method is relatively more effective than Vail`s. The disadvantage is that the process requires the use of LDS, a specific software which makes it difficult for employees with little or no experience in software application to contribute. Also by not fulfilling the knowledge asset map it means there is no good interactions between the core competencies and their corresponding role in the organization. It is therefore difficult to know who knows what in that organization.

Third is the 6 stages methodology developed by Kim *et al*. (2003). This method employs the use of ontology in the development process which is a good concept for formally representing knowledge based on a conceptualization; the objects, concepts and other entities that are assumed to exist in some area of interest and the relationships that hold among them. Amid the advantages of using ontology in developing knowledge maps are clarity and minimal encoding biases. Clarity means, the ontology should be able to correctly communicate the actual meaning of the symbol-level encoding terms. The definition should be objectively motivated so that while defining a concept

Table 3: Summaries of methodologies identified for knowledge map building, from different resources

Methodology	Methodology details			
Nine-step methodology (Vail, 1999)	Step 1 Identify the sponsor and his or her objectives	Step 2 Determine what the K-map is intended for, the scope of the map and the specific K-map user requirements	Step 3 Begin an ongoing education process on mapping's benefits and requirements, starting with the sponsor	Step 4 Identify the key stakeholders (key users or people who will be impacted by the creation of the K-map)
	Step 5 Create a K-map steering committee with direct representatives of the key sponsors and stakeholders	Steps 6 and 7 Create corresponding K-map technical committee and develop a tool evaluation and selection process	Step 8 Identify the custodian of the map, the repository location and the maintenance process	Step 9 Create the initial enterprise K-map and build the mapping team
Eleven-step methodology (Bargent, 2002)	Step 1 Identify requirements: define the goal of the K-map, define a set of business pains, define the targeting data sources	Step 2 Information audit: define a list of detailed of every data source used including: electronic information document, management system files and databases	Step 3 Define information sources to use: refine the list generated from step 2, generating a new list and then define a list of a prioritized known as the training set	Step 4 Modify the stop-word list: update the list of words of LDS that are already excluded from the map to include any industry or organizational specific terms
	Step 5 Configure the LDS: type and numbers of used spiders and the various rules must be configured against each of the spiders on the first time of using LDS	Step 6 Generate people profiles: from the master source, the profile should be generated as well updating the generated profiles from supplementary or a secondary source	Step 7 Set up data sources for spidering: in the discovery server, setting up the training set of data and defining each data source to its lowest	Step 8 Create the map: three steps are involving primarily, add repositories to process, review the settings of the knowledge map, create knowledge map
	Step 9 Train the K-map: Teach the system correct document placement and category labels of the taxonomy and ensure that meaningful category labels appear	Step 10 Generate affinities: affinities for specific users identify by the managers; automatic discovery based on documents that a person has edited, read and/or authored	Step 11 Test the K-map: finally, undergo a level of end user tests to evaluate the effectiveness of the knowledge map as well as to ensure that all document placement and categorization has been completed	
Six-step methodology (Kim *et al*., 2003)	Step 1 Defining organizational knowledge: define ontology; define scope and level of detail	Step 2 Process map analysis: extract organisational knowledge based on the business process, experience	Step 3 Knowledge extraction: through a process map identify prerequisite, used and produced knowledge	Step 4 Knowledge profiling: give attributes to the extracted knowledge; derive relationships with process
	Step 5 Knowledge linking: examine profile made in preceding step, confirm existing links, identify new ones	Step 6 K-Map validation: walk through with users, subject matter experts, business managers and K-Map producers		
Four-phase methodology (Lecocq, 2006)	Phase 1: Plan Step 1 Identifying K-map objectives, scope and stakeholders	Step 2 Set up a K-Map steering committee that includes representatives from key sponsors and stakeholders	Step 3 Determining right balance between K-map approaches	Step 4 Identifying components, validate the choice of components, Identify the pathway through which K-map flows
	Phase 2: Collect Step 5 Define ontological framework to specify the common concepts and their links	Step 6 Conducting inventory, develop a plan for collecting, reviewing, storing and sharing information and knowledge	Phase 3: Map Step 7 Defining and selecting the tools. Test and validate the selected tools	Step 8 Crafting the K-map: In this step, a template and a legend must be elaborated to represent the flow's knowledge, as well as the links to people

Table 3: (Continue)

	Phase 4: Validate and use			
	Step 9 Validating the K-map by a walkthrough with actual users and people who contributed to its production	Step 10 Exploiting the K-map: educate people to better understand the components and use the map	Step 11 Revising, maintaining and enhancing the K -map; conduct periodical reassessments by examining log files	
Three-stage methodology (Mansingh *et al*., 2009b)	Stage 1 Developing the ontology of the knowledge domain through ontology feasibility, kick up, refinement and evaluations	Stage 2 Creating the process map representations by using standards such as flowcharts or petri nets	Stage 3 Extracting the K-map by extracting the instances using an ontology and gives the relationship between the concepts	
Seven-step methodology (Pei and Wang, 2009)	Step 1 Set up a project team that comprises of managers, technical staff and users.	Step 2 Analyze the knowledge resources requirement of the main user group	Step 3 Define the business knowledge domain and the map distribution	Step 4 Determine the basic structure and relationship between the nodes
	Step 5 Select and evaluate development tools	Step 6 Confirm knowledge-classification, their relationship and then draw initial map	Step 7 Update the K-map and continue evaluating it iteratively	

even though motivation may arise from social context, but that will not be dependant of the social context.

Therefore, by using ontology, this method reduces drastically the tendencies for inconsistencies and bias. This method was tested in the manufacturing industry but not in other contexts. The limitations are that this method may not be applicable to other institutions such as service industries, education or healthcare organizations. Secondly the roadmap concentrates on the business process in developing the knowledge map without paying good attention to the people profiles in that organization. As such, the workers might not be opportune to give adequate contribution in the process of building the knowledge map. The method also do not satisfy three of the knowledge map types proposed by Eppler (2006), including the knowledge source map, knowledge asset map and knowledge development map. However, it does fulfill the remaining two, knowledge structure map and knowledge application map and thus the roles and actors relationship is missed in the building process. This makes it unsuitable for knowledge intensive organizations such as in the service industry.

The fourth method is the four phases methodology developed by Lecocq (2006). The steps involve planning, collecting, mapping and validating. This method, like Kim`s, also employs the use of Ontology in the process and is hence relatively consistent. The method has four phases that are decomposed into eleven steps and therefore has so much detail compared to the three previous methods discussed above. The author deploys the use of continuous reassessment of the knowledge map and validates it based on iterative testing. The map should serve its purpose and cause effects that can be appraised by the sponsor either in qualitative and/or quantitative ways. For user objectives the map should fulfill their expectations and help them perform their tasks in a more efficient and time-effective manner. The method satisfies all the classes of knowledge map proposed by Eppler (2001), hence it is easy for the team developing the knowledge map to locate organizational knowledge assets. It also helps organizations know how many experts are available and what their area of expertise is. This is very important for locating more specific problem-solving knowledge in an organization. Lecocq's method is the only one among the six that meets all five types of knowledge map, making it more effective and reliable, especially as it involves an organization's people during the map building process.

The fifth type of methodology was by Mansingh *et al*. (2009b). The methodology involves creation of ontology, identification of the processes involved and bringing out the instances of the processes. All the available kind of knowing are then extracted and presented as the final knowledge map. Usability and usefulness were the main factors used in evaluating the knowledge map for representing some aspect of knowledge. Since there are only a few methods for developing knowledge maps, the authors argue that this ontology-driven method will improve the consistency of the development process. The methodology however does not meet the knowledge asset map, knowledge application, or knowledge development map of Eppler`s classification. Even though the author uses ontology in the knowledge map building process, it is inefficient because he does not focus on the core competencies or experts in an organization. The method was tested in a healthcare organization and was found to be suitable despite the process of validation not adequately detailed.

The last methodology was proposed by Pei and Wang (2009). The author focuses on a knowledge management network for matrix organization. This methodology does not meet the 3 classes of knowledge map by Eppler (2006). Even though the methodology

describes the structure and application map, the extended detail of description was inadequate. The author only mentions the case study area as matrix organization, which was quite too broad given a matrix can include any organizations with known organizational structures and relationships. Even though the methodology is more recent than that of Vail (1999), the map development process was not as detailed and therefore not as consistent as the remaining five methodologies.

CONCLUSION

This study puts forward the methodologies for building knowledge maps and focuses on six detailed methodologies as the core of building knowledge maps for an enterprise. These include: Nine-Step Methodology (Vail, 1999); Eleven-Step Methodology (Bargent, 2002); Six-Step Methodology (Kim *et al*., 2003); Four-Phase Methodology (Lecocq, 2006); Three-Stage Methodology (Mansingh *et al*., 2009b); Seven-Steps Methodology (Pei and Wang, 2009). In this study, we describe these methodologies and cross-referenced them with the five types of knowledge map (source, asset, structure, application and development) outlined above. Even though we believe this review can provide a valuable contribution in both academic and practical settings, for academic purposes researchers can consult the paper to discover the main features that methodologies often include. Further, they can observe how those methodologies can be implemented according to the purpose of each type of knowledge map. Practitioners can use this paper before building their maps and employ it as preliminary information regarding what methodologies exist and what their features are. However, as noted in the survey, there are few papers available on this topic. Out of the 103 relevant papers we collected during the database search, only 9 scientific papers were directly related to our research context. Furthermore, all current methodologies for building knowledge maps do not have the same degree of maturity and thus there is no standard methodology yet.

REFERENCES

Balaid, A., M.Z.A. Rozan and S.N. Abdullah, 2014. Conceptual model for examining knowledge maps adoption in software development organizations. Asian Soc. Sci., 10(15): 118.

Bargent, J., 2002. 11 Steps to Building a Knowledge Map. Retrieved from: http://www.providersedge.com/docs/km_articles/11_Steps_to_Building_a_K_Map.pdf.

Chung, G.K.W.K., H.F. O'Neil Jr. and H.E. Herl, 1999. The use of computer-based collaborative knowledge mapping to measure team processes and team outcomes. Comput. Hum. Behav., 15(3-4): 463-494.

Crampes, M., S. Ranwez, J. Villerd, F. Velickovski, C. Mooney, A. Emery and N. Mille, 2006. Concept maps for designing adaptive knowledge maps. Inform. Visual., 5(3): 211-224.

Curtis, B., M.I. Kellner and J. Over, 1992. Process modeling. Commun. ACM, 35(9): 75-90.

Dang, Y., Y. Zhang, P.J.H. Hu, S.A. Brown and H. Chen, 2011. Knowledge mapping for rapidly evolving domains: A design science approach. Decis. Support Syst., 50(2): 415-427.

Davenport, B.T.H., L. Prusak and A. Webber, 2000. Working Knowledge: How Organizations Manage What they Know. Harvard Business Press, Boston, Mass, pp: 199.

Driessen, S., W.O. Huijsen and M. Grootveld, 2007. A framework for evaluating knowledge-mapping tools. J. Knowl. Manage., 11(2): 109-117.

Einsfeld, K., A. Ebert, A. Kerren and M. Deller, 2009. Knowledge generation through human-centered information visualization. Inform. Visual., 8(3): 180-196.

Eppler, M.J., 2001. Making knowledge visible through intranet knowledge maps: Concepts, elements, cases. Proceeding of the 34th Hawaii International Conference on System Sciences, pp: 1-10.

Eppler, M.J., 2006. A comparison between concept maps, mind maps, conceptual diagrams and visual metaphors as complementary tools for knowledge construction and sharing. Inform. Visual., 5(3): 202-210.

Gruber, T.R., 1995. Toward principles for the design of ontologies used for knowledge sharing. Int. J. Hum. Comput. Stud., 43(5-6): 907-928.

Hansen, B.H. and K. Kautz, 2004. Knowledge mapping: A technique for identifying knowledge flows in software organisations. In: Dingsoyr, T. (Ed.), EuroSPI, 2004. LNCS 3281, Springer-Verlag, Berlin, Heidelberg, pp: 126-137.

Harvey, 2005. Essential Business Process Modeling. O'Reilly, Cambridge, MA.

Herl, H.E., E.L. Baker and D. Niemi, 1996. Construct validation of an approach to modeling cognitive structure of U.S. history knowledge. J. Educ. Res., 89: 206-219.

Ivanov, A. and D. Cyr, 2006. The concept plot: A concept mapping visualization tool for asynchronous web-based brainstorming sessions. Inform. Visual., 5(3): 185-191.

Jafari, M., P. Akhavan, A. Bourouni and H.A. Roozbeh, 2009. framework for the selection of knowledge mapping techniques. J. Knowl. Manage. Pract., 10(1): 1-13.

Kim, S., E. Suh and H. Hwang, 2003. Building the knowledge map: An industrial case study. J. Knowl. Manage., 7(2): 34-45.

Lecocq, R., 2006. Knowledge mapping: A conceptual model. Technical Report, DRDC-RDDC Valcartier TR2006-118, pp: 1-96.

Mansingh, G., K.M. Osei-Bryson and H. Reichgelt, 2009b. Building ontology-based knowledge maps to assist knowledge process outsourcing decisions. Knowl. Manage. Res. Pract., 7(1): 37-51.

Mansingh, G., K.M. Osei-Bryson and T. Hirata, 2009a. Building ontology-based knowledge maps to assist knowledge process outsourcing decisions. Knowl. Manag. Res. Pract., 7(1): 37-51.

Novak, J., 1998. Learning, Creating and Using Knowledge: Concept Maps as Facilitative Tools in Schools and Corporations. Lawrence Erlbaum, Mahwah, NJ.

Novak, J.D. and A.J. Cañas, 2006. The origins of the concept mapping tool and the continuing evolution of the tool. Inform. Visual., 5(3): 175-184.

Pei, X. and C. Wang, 2009. A study on the construction of knowledge map in matrix organizations. Proceeding of the International Conference on Management and Service Science, pp: 1-5.

Rao, L., G. Mansingh and K.M. Osei-Bryson, 2012. Building ontology based knowledge maps to assist business process re-engineering. Decis. Support Syst., 52(3): 577-589.

Sure, Y., S. Staab and R. Studer, 2002. Methodology for development and employment of ontology based knowledge management applications. SIGMOD Rec., 31(4): 18-23.

Tergan, S.O., T. Keller and R.A. Burkhard, 2006. Integrating knowledge and information: Digital concept maps as a bridging technology. Inform. Visual., 5(3): 167-174.

Tiwana, A., 1999. Knowledge Management Toolkit. 1st Edn., Prentice Hall PTR, Upper Saddle River, NJ, pp: 482.

Vail, E.F., 1999. Knowledge mapping: Getting started with knowledge management. Inform. Syst. Manage., 16(4): 37-41.

Wexler, M.N., 2001. The who, what and why of knowledge mapping. J. Knowl. Manage., 5(3): 249-264.

Yasin, F. and C. Egbu, 2010. Exploitation of knowledge mapping benefits in the facilities performance evaluation process: A conceptual framework. Proceeding of 26th Annual Association of Researchers in Construction Management ARCOM Conference, pp: 799-808.

Yun, G., D. Shin, H. Kim and S. Lee, 2011. Knowledge-mapping model for construction project organizations. J. Knowl. Manage., 15(3): 528-548.