Addressing Failure Factors in Knowledge Management*

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Abstract. This article describes a knowledge management (KM) approach conceived from countermeasures targeted at failure factors suggested in the literature. In order to counteract failure factors, the approach combines the technology of knowledge-based knowledge management systems, with the flexibility and understanding of knowledge workers, and the processes of the target community. In the KM system, the approach uses knowledge engineering concepts to represent knowledge artifacts and to enforce managerial responsibilities. By imposing a strict representation format, the approach guides and helps users by determining what knowledge to contribute, by enabling knowledge collection, and by representing knowledge. The purpose of knowledge workers is to complement the limitations of the computer-based component by motivating members to adopt the system and by verifying the quality of submitted artifacts. Identifying the processes of the target community and the level of specificity where they are useful guide design and operation of the approach. The importance of this contribution is on offering guidelines to design a KM approach that relies on conclusions from published literature and provides the means to validate knowledge sharing. One main conclusion of this work is that it may be easier to address failure factors of KM approaches when all members of the target community have the same technical goals, are motivated by a common interest, are organized on a flat hierarchy, and are receptive to innovation, such as in a grant. Other conclusion is that the KM approach can offer side products to compensate for the time contributors allocate to knowledge sharing, such as the drafting of reports. The use of a representation of the community's processes helps standardize capture, guide contributors, and associate existing with new artifacts. This association of artifacts can be used to validate knowledge sharing.

Keywords: Architectures for knowledge management systems, Case-based reasoning, Community of science, Knowledge management systems, Knowledge repository, Validation.

1 Introduction

Knowledge management (KM) refers to the allocation of knowledge assets as a means to improve organizational processes. KM approaches include the resources, methods, and instruments to deliver KM goals. KM goals are usually described in terms of knowledge assets. Due to the nature of knowledge assets, organizational processes tend to improve as knowledge assets are shared and leveraged among organizational members.

In this article, we focus on repository-based KM approaches, one of the main categories of KM initiatives according to Davenport and Prusak (1998). Although this type of approach has been around for decades, e.g. lessons-learned systems, best practices (Weber, Becerra and Aha, 2001), many of its implementations have failed to demonstrate success. For this reason, several authors (e.g., Quinn et al., 1996; Fahey and Prusak, 1998; Disterer, 2001; Atwood 2002) have investigated causes for those failures, suggesting failure factors for KM approaches. We examined this literature and summarized it through fifteen failure factors in Section 2.

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This article's intended contribution is to extend the previous work on failure factors to identify countermeasures, which establish guidelines a KM approach should follow in order to remedy those factors. The guidelines are the basis of our proposed KM approach. They may recommend additional or alternative resources or methods, or may designate constraints.

In Section 4, we describe an ongoing implementation of our approach to manage knowledge for a community of scientists. We conclude in Section 5.

2 Why Do KM Systems Fail?

Literature indicates many potential reasons causing KM approaches to fail. Next, we list and briefly summarize several reasons that cause KM approaches to fail. Rather than an exhaustive review of the literature, we highlight the main areas where failure factors have been suggested and justified.

1. *KM approaches may fail when they do not integrate humans, processes, and technology* (Abecker, Decker and Maurer, 2000). This is justified by the limitations and importance of each of these components. Humans alone are slow and have limited capacities. Processes are the main component in delivering organizational goals; therefore, any approach that is not associated with processes will tend to fail or to be perceived as failures. Technology alone is limited to support humans because of variable accuracy levels when performing simple mundane human tasks.

2. *KM approaches may fail when they target a monolithic organizational memory*. The goal of developing a monolithic organizational memory for an entire organization has failed (Ackerman and Halverson, 2000). Among other reasons, they are distributed and may have conflicting goals.

3. *KM approaches may fail when they are not able to measure their benefits* (Alavi and Leidner, 1999). Unfortunately, many KM systems fail to demonstrate their effectiveness, which is a requirement for any business (Ahn and Chang, 2002). In some cases, the problems originate in the organizations, in others in the technology.

4. *KM approaches may fail when they do not promote collaboration*. Collaboration is an important means for learning and sharing. Therefore, any KM approach that does not promote collaboration is likely to fail.

5. *KM approaches may fail when they store knowledge in textual representations* (Weber and Aha, 2003). Knowledge artifacts stored in textual format may be long and difficult to interpret making the recognition of usefulness of the knowledge artifact a time consuming and maybe impossible task. Textual formats may also lack social and process context (Atwood, 2002).

6. *KM approaches may fail due to lack of leadership support* (Disterer, 2001). Sometimes community leaders are not convinced of the benefits of knowledge sharing (Nonaka and Konno, 1998), potentially spreading their skepticism to the community.

7. *KM approaches may fail when they do not enforce managerial responsibilities* (Weber, Breslow and Sandhu, 2001). Marshall, Prusak and Shpilberg (1996) list these responsibilities as being to determine knowledge, enable knowledge collection, represent knowledge, embed knowledge in targeted processes, verify and validate knowledge, oversee knowledge reuse, monitor knowledge transfer, and create infrastructure for the preceding responsibilities. It is easy to envision how an organization that does not enforce these responsibilities has no control over knowledge being shared or reused, and chances are that individuals may not be contributing to organizational goals. Ignoring these responsibilities may also promote incoherent paradigms (Disterer, 2001) which may leave contributors using knowledge that does not contribute to organizational goals.
8. *KM approaches may fail when contributors do not know the ideal specificity of knowledge*. There is a level of specificity that makes knowledge worth transferring. Contributors may not know the level of generality that would make knowledge useful (Disterer, 2001), causing them to submit useless artifacts or not submit anything at all.
9. *KM approaches may fail when they do not properly oversee the quality of stored knowledge*. This is also related to representation because well-verified artifacts may be perceived as junk if they are hidden in dense texts that are hard to interpret.
10. *KM approaches may fail because users do not perceive value in contributing.* KM approaches do not typically offer any reciprocal value to compensate by the time allotted for knowledge sharing; hence, contributors may not perceive value to them or others (Disterer, 2001).
11. *KM approaches may fail when users are afraid of the consequences of their contributions*. This cause is related to job security. Contributions from a member may be subject to criticism (Disterer, 2001) or evaluation (Weber, Aha and Becerra, 2001); they may oppose contents already captured (Atwood 2002); and users may feel that holding on to their knowledge may be a way to secure influence (Disterer, 2001).
12. *KM approaches may fail when they are designed without input from all stakeholders*. This happens when systems analysis and design ignore the community processes and organizational culture. This is very likely to increase resistance in adoption of the approach. This is considered a failure factor in the development of any systematic approach.
13. *KM approaches may fail when they are standalone solutions outside the process context*. Weber and Aha (2003) attributed failure in the dissemination role of repository-based systems to their standalone design housed outside the environment of the target processes where users are to reuse knowledge artifacts. The authors claim that there are various implications to the user. The users have to know the repository exists; to have time to open and search it; to have the skills to open and use it; to know where to access it; to believe that the repository contains useful knowledge; to believe that knowledge reuse is beneficial. Another problem with standalone tools outside the process context is that they force the user to divert from their normal activities (Atwood 2002).

14. *KM approaches may fail when they rely on inadequate technology*. Davenport and Prusak (1998) describe how repository-based KM initiatives started when many companies bought text databases. The limitation of this technology to support KM has been discussed by McDermott (1999) and explained by Nissen (2002), who stated this problem originates because these tools only deal with data and information, they do not manipulate knowledge as required in KM approaches. Another example of limited technology is in the interfacing between system and users. Humans use natural language to submit knowledge artifacts when interacting with a computer tool that is limited in its ability to understand the captured artifact. Therefore, if the submitted artifact is not correct, the tool may not be able to determine that and guide the user. The verification of knowledge artifacts requires interpretation, what is neither precise nor easy.
15. *KM approaches may fail when they ignore impediments for knowledge transfer*. Szulanski (1996) has studied impediments to the transfer of best practices that also suggest failure factors. One of the impediments is that knowledge to be transferred typically lacks the teaching of the factors that make a strategy applicable to different situations; consequently, potential reusers do not know how to extend it to different contexts. Transfer may also be hindered when knowledge does not include a description of how it was learned (*unprovenness*). Potential users may also lack *absorptive* and *retentive capacities*, which may originate from the lack of understanding of the subject matter.

3 Guidelines for KM Approach

The many causes of failure of KM approaches appointed in the literature can be used as a basis to guide an approach with better chances of success. In this section, we discuss countermeasures to address failure factors discussed in Section 2. These countermeasures may represent functions of the approach, which can be delivered either through a technological component or through knowledge workers, or it may be a restriction imposed in the selection of the target community. Each countermeasure indicates guidelines for a potentially successful KM approach.

1. *KM approaches should integrate three components: Humans, processes, and technology*. The human component should consist of knowledge workers, who work with users, understand their processes, and master the technology. The processes that are relevant to the target community should be identified and incorporated into the main steps of design and development of the KM approach. The technological component should incorporate the community's processes and be designed with user's input.
2. *KM approaches should be designed to support communities of practice.* The goals of the target community should be assessed in order to determine if it represents a community of practice or if it should be subdivided into sub-communities. Being a community of practice implies that its members share the same professional interests. This concept may also be extended to a community of science, where its users share the same scientific goals.

3. *KM approaches should allow the measure of their effectiveness* (Ahn and Chang, 2002). The effectiveness of a KM approach should reflect its ability to share and leverage knowledge. For example, requesting that users associate repository artifacts requires their understanding of those artifacts; thus, it is a way to presume knowledge sharing. Analogously, showing that a member has created a knowledge artifact with the use of an existing one would be a way to presume knowledge leveraging. Surveys asking users about their usage is also a way to measure effectiveness.

4. *KM approaches should include measures to promote collaboration*. Collaboration is intrinsic in knowledge sharing because it is how humans share and learn knowledge in groups. Therefore, understanding the mechanisms that promote collaboration and computer-supported collaboration and incorporating them into a KM approach will increase its chances of promoting knowledge sharing. The essential element to foster collaboration is transparency (Stahl, 2005).

5. *KM approaches should adopt representations that are easy to interpret*. Short and focused representations will make it easier to recognize an artifact's usefulness and applicability. To facilitate this, KM approaches should represent knowledge artifacts in association with processes. An industry conceived knowledge artifact that identifies the process where it can be applied is lessons-learned (Weber, Aha and Becerra, 2001). In order to meet all requirements imposed by its definition, a representation for lessons-learned should highlight the community's process it impacts, its validation, applicability, and the lesson it teaches (Weber, Aha and Becerra, 2001). Representations that are easy to interpret also facilitate transparency.

6. *KM approaches should be adopted by communities with strong leadership support*. If the targeted community does not count with strong leadership support, knowledge workers should educate its leaders on the expected benefits of the KM approach. Management should contribute financially (Whiting, 1999) and understand it as an investment; promoting the success of the approach as return on the investment. Once they understand the benefits, leaders should be role models in knowledge sharing (Quinn et al., 1996). The need of leadership support suggests better results when implementing the KM approach in a community with a flat hierarchy, whose leadership is at a level that is not too different from its members.

7. *KM approaches should incorporate means of enforcing managerial responsibilities*. Actions to enforce managerial responsibilities should be incorporated into the design, training, and operation of the KM approach. The design of the approach should contemplate the knowledge that is relevant to the processes of the target community, collection, verification, and monitoring. Knowledge workers should deliver responsibilities that involve mundane activities while the system design should impose restrictions that reflect managerial directives. For example, an interface to capture knowledge artifacts should be restricted to the essential elements of knowledge sharing (e.g., reusable strategy, conditions that make it applicable).

The overall approach is the infrastructure for the responsibilities. Knowledge relevant to the community should be analyzed and structured in a process network. Knowledge workers should create tutorials and workshops to train users on how to submit artifacts using the knowledge capture method tailored to enforce an adequate representation to the community. Knowledge workers should review and approve new submitted artifacts when they conform to the representation and are associated to community processes. Methods to measure knowledge sharing are an additional way of monitoring the approach.

8. *KM approaches should identify an adequate level of specificity*. The adopted level should be considered useful by the majority of the users. Identifying a useful level should be part of the analysis of the domain. The level of specificity should be constantly monitored by the choice of tasks during knowledge capture.

9. *KM approaches should include verification methods*. The methods should verify knowledge artifacts for correctness, completeness, legitimacy, relevance, adequate specificity, and clarity of knowledge artifacts. It is important that knowledge workers, not supervisors, review submitted artifacts. This opportunity of review by knowledge workers also allow them to contact contributors for any clarifications that may be required and to discuss necessary corrections so that authors are in agreement and have a chance to learn what should have been the best way to submit the artifact in the first place. KM approaches should also include maintenance methods so that stored knowledge remains relevant across time. For example, clustering methods can automatically identify redundant knowledge. Records of usage of artifacts can indicate obsoletism. A committee of members must agree with deletions of artifacts.

10. *KM approaches should demonstrate how contributors can benefit from KM*. Once contributors understand how they will benefit, they are more likely to be motivated to contribute (Atwood, 2002). They should also understand the value of the approach to others. Knowledge workers should emphasize the benefits of the approach to the contributors and to their community in tutorials and workshops. One motivating argument is to offer a benefit that compensates for the time spent on contributing to the KM approach. For example, contents of knowledge artifacts and the process network indicating where artifacts have been submitted can be used to help draft reports and illustrate contributor's performance. On the other hand, knowledge workers should educate and train users in order to minimize the time dedicated to submit artifacts.

11. *KM approaches should be adopted by communities that encourage innovation*. Communities that encourage innovation and positive criticism, where competition or job insecurity does not prevent sharing are ideal for successful KM approaches. However, if criticism is a strong element in organizational culture, then a KM approach should attempt to limit the scope to a community or to a set of processes where innovation and criticism are justifiable and used to commend, rather than to eliminate members. Knowledge workers should discuss with

leadership how support to innovation and positive criticism can motivate contributions and how the opposite will render their investment useless.

12. *KM approaches should be designed in collaboration with stakeholders of the system*. Designers and stakeholders together can guarantee a thorough analysis that takes into account the context of the processes of the target community. Analysis and design should be initially based on the elements derived from this study of countermeasures. Once they are explained to stakeholders and they understand the main principles of the basic design, other aspects should be discussed in the context of the processes that are relevant to the target community. Particular importance should be given to perform analysis and design within their organizational context (Atwood, 2002).

13. *KM approaches should be integrated into the context of target organizational processes*. The context where members deliver organizational processes is where knowledge artifacts are to be shared and are potentially reusable. When knowledge artifacts are to be reused in the context of a computer system, then the *monitored distribution approach* can be implemented for proactive distribution (i.e., a process-based push method) of knowledge artifacts in the context of organizational processes (Weber and Aha, 2003). Proactive distribution requires the use of a computer tool (e.g., ERP systems) for delivering user's activities. When this is not the case, then active casting can be used to push knowledge artifacts based on user's areas of interest. Pull methods should always be available to all users.

14. *KM approaches should adopt technology only when it is reliable for a task*. When technology is not well suited for a task, it should be left for humans. Information management tools that deal with data and information should not be used to represent knowledge artifacts. Knowledge engineering is the field dedicated to the study of knowledge-based methods where knowledge formalisms are used to represent and reasoning with knowledge (not data or information). Due to limited capability of natural-language understanding, knowledge workers should be responsible for verifying the quality of submitted knowledge. Weber and Kaplan (2003) categorized KM approaches based on the type of technology, referring to approaches that rely on knowledge-based methodologies as knowledge-based knowledge management. They explain why knowledge transfer is facilitated when proper knowledge-based methodologies are adopted. The recommended knowledge-based technology for implementing KM systems, according to several authors (e.g., Althoff and Weber, 2006; Watson, 2003), is case-based reasoning (CBR). In CBR, knowledge is experiential and it is represented in a case. Cases include indexing and reusable components. Weber and Aha (2003) recommended a representation for lessons-learned based on cases. The indexing components include an activity or process and information about the context. The activity is where the lesson is applicable, while context provides the circumstances in which the lesson was learned. These two indexing components help retrieve artifacts that are applicable to a task when similar circumstances are present. The reusable components include the central strategy taught by the lesson and a lesson rationale that explains how the lesson was

learned. This knowledge representation incorporates all the elements necessary for applying a strategy and reasoning; it does not simply manipulate data and information.

15. *KM approaches should include methods to overcome impediments for knowledge transfer*. Implementing effective methods to counteract Szulanki's (1996) impediments in his terms may not always be possible. For example, it may be too much to expect that contributors describe a knowledge artifact including the factors that associate the strategy with the original context and how the strategy should change when applied to different contexts. The inclusion of these additional contents would be more easily captured as additional artifacts. Therefore, KM approaches may target at building comprehensive repositories with a dense coverage of strategies and contents. Some maintenance methods defined for CBR (Smyth and McKenna, 1999) utilize techniques to estimate coverage that can be used to determine which additional artifacts should be added to create a dense repository. Unprovenness can be addressed by including in the artifact representation the evidence or description of how the strategy was learned. In order to address both absorptive and retentive capacity, users of the system should be knowledgeable of the processes so they understand how to absorb and retain new knowledge.

4 Implementing the Knowledge Management Approach

We are currently implementing a KM approach based on the guidelines in Section 3. In this section, we describe the target community, its process network, the knowledge workers, the knowledge-based KM system, and the approach's expected benefits.

4.1 The Community: CAMRA

The Center for Advancing Microbial Risk Assessment is a community established through a joint funding from the Environmental Protection Agency and the Department of Homeland Security. CAMRA will advance the science related to threats originating from microbial agents of concern.

The community is composed of research scientists and their students. Therefore, all CAMRA members share the same interests in advancing science and the success of the center, representing a *community of science*. This is a community that has innovation as its main goal. Peer criticism is considered one of their instruments. All members are knowledgeable of the field and able to absorb and retain new knowledge. Given that all members are researchers in the project, CAMRA is also an example of a flat hierarchical community.

The members include researchers who specialize in four aspects of microbial agents. Project I focuses on detection, fate and transport of agents; Project II on transmission and infection; Project III on dose response of contagious diseases in populations; and Project IV links technical research with study of public perception and compliance to governmental actions. A fifth project is dedicated to KM, what reveals the strong leadership support given to KM in this community.

Although seemingly representing different sub-areas, these projects share scientific activities such as the design and testing of models to represent behaviors in microbial risk assessment. Therefore, we can envision the center as being one community that focuses on a variety of contexts.

4.2 CAMRA's Process Network

The CAMRA's network of processes should represent activities in the four projects described above. Building the network itself is a process, which is delivered by knowledge workers and the KM system. A preliminary process network is built based on the initial analysis of the domain and collection of example activities (Figure 1).

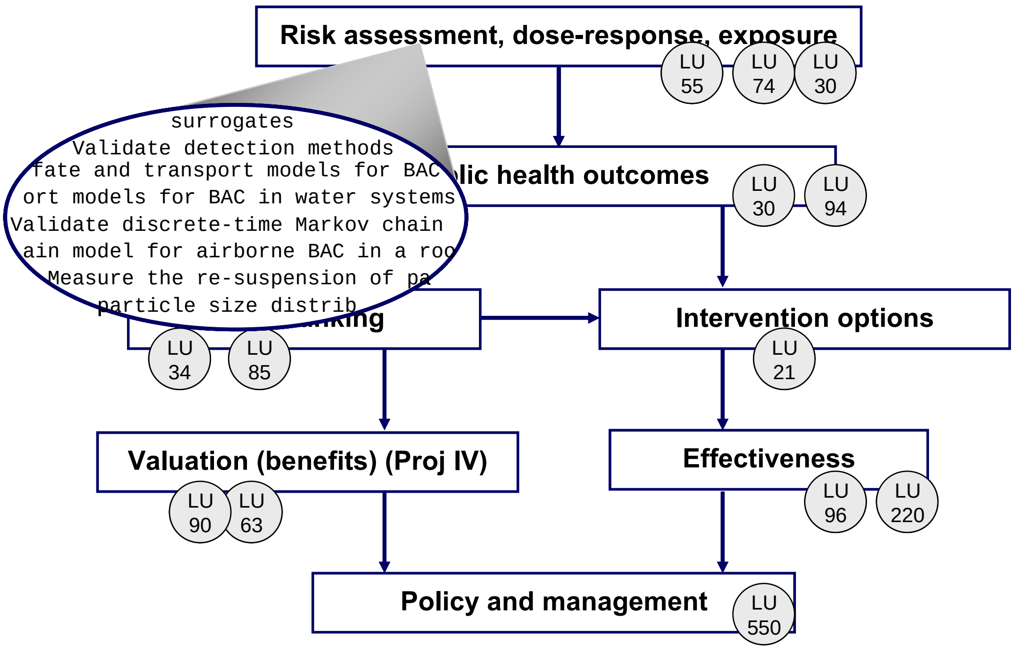

Figure 1. The initial network for CAMRA[1].

During submission of a knowledge artifact, contributors are asked associate it with the preliminary process network. Once the repository is populated with some knowledge artifacts, a second process network is built in the KM system using visualization tools that gather activities from the artifacts. The idea is to receive feedback from users and target a definitive set of processes when these two domain networks have the same activities.

4.3 Knowledge Workers

Knowledge workers are experts in KM issues and in repository-oriented KM systems. They are responsible for educating and motivating users to contribute and benefit from the approach. Knowledge workers keep an open contact with all members, visiting them in person and holding workshops and tutorial sessions. The relationship with stakeholders started at the time of conception

[1] This network is based on a diagram created by Charles Haas for CAMRA's grant proposal.

of the approach moving into the design stage, when users communicate the useful processes of the community. During design, the process network was drafted.

Knowledge workers are mainly responsible for enforcing managerial responsibilities with respect to knowledge capture. They elicit useful processes at useful levels of specificity and they review each submitted artifact.

4.4 Knowledge-Based Knowledge Management System

The Knowledge-Based Knowledge Management System (KBKMS) for the CAMRA approach is a repository-based system that relies on the (CBR) methodology. The artifact in the repository is a learning unit.

4.4.1 Learning Units

The knowledge artifacts in CAMRA's KBKMS are called learning units (LUs). Their representation is based on the concept of lessons-learned highlighting four main fields: Activity, Context, Results, and Contribution. These fields were chosen to fit CAMRA's domain. The four fields enforce the important aspects that must be included in LUs. No LU is approved unless it includes these four main fields.

Activity is the task or process where the LU is applicable. Context provides additional circumstances that motivate applicability. Results cover the unprovenness impediment by providing scientific evidence for the Contribution, which explicitly states a new scientific truth.

These four fields are based on case representation, so all methods designed for CBR are useful. Once the repository is populated, automated methods such as those for maintenance can be used. They will allow, for example, identifying a gap in the knowledge base, even suggesting which project should contribute filling this gap.

The four main fields describing learning units highlight the main aspects needed for sharing. They are an attempt to make knowledge transparent, thus promoting collaboration. The assumption is that geographically dispersed researchers will feel comfortable contacting another member when they have this explicit representation of what the other member is doing. We hypothesize this will promote collaboration.

4.4.2 Search

LUs are in the repository with the purpose of being shared. Because research scientists do not use one single computer-based system to deliver their work, proactive delivery is not used. Active casting [2]is used as contributors indicate which projects or members might be interested in a submitted LU, what is asked at time of submission.

Other forms of dissemination use pull methods, which leave the initiative to the user. One of the main benefits of relying on CBR methodology is the use of case retrieval to find LUs of interest to user, because it represents an intelligent search method. In case retrieval, users will enter a query

[2] See Weber and Aha (2003) for a description of pull and push dissemination methods.

and similar units will be retrieved when they are applicable to the similar processes and/or contexts. There are two forms to enter queries, free form and field-based. Figure 2 shows the field-based query form. Other pull methods use relational database functions according to these parameters: Search by project, by task, by data, by author, by network area, by unit's network area.

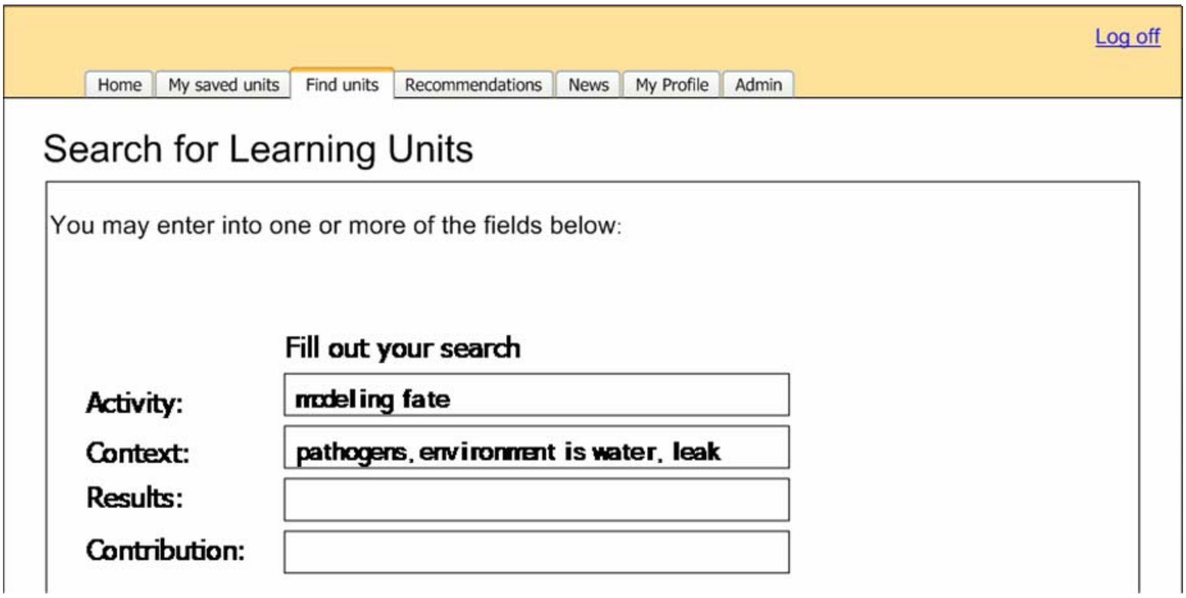

Figure 2. Search for learning units

4.4.3 Validation

The current implementation has different means of measuring knowledge sharing. When submitting learning units, contributors may reference another unit in the fields of the unit. When this referenced unit is not submitted by the same author, then we can deduce that knowledge was shared because to reference a unit, it is necessary the contributor understands it. Contributors are also asked to link the unit being submitted to existing learning units. Again, the same assumption can be done if the author of the existing unit is not the contributor. Then, contributors are asked to associate the new unit to the process network. This aims at identifying additional associations not limited to the unit's activity. Finally, a survey of the usage will be submitted every year the system is in use.

4.5 Benefits of the Approach

In this section, we describe some of the benefits that should help motivate users to contribute that may compensate for the time contributors allocate to the repository. The process network provides a representation of the domain. The process of building it will support a network that is legitimate and representative of the CAMRA domain. Once populated, the repository will provide support and training for newcomers to the project. Because LUs can be retrieved by project, a project leader can use it to control the activities that are being delivered in contrast to what the project is committed to deliver. Government funded projects require annual reports. Retrieving LUs by project, by time, by author, and by activity or context can help users easily draft reports. Automated maintenance methods may help identify gaps in the knowledge base, indicating potential research questions and providing evidence to their importance. The educational component of the project can utilize subsets of LUs to create course curricula.

One of the goals of the center is integration of its members. Integration takes place when knowledge produced by a member becomes part of an integrated whole. Because of the associations between LUs and activities, once a LU is submitted, the knowledge in it becomes integrated to CAMRA's body of knowledge.

In addition to the four main fields, LUs include secondary fields to address additional needs. One is privacy; when submitting a LU, its author is given the choice of keeping it private. Nevertheless, the existence and the activity of the unit are always kept public, so others may contact the author if they want to know about it.

Another benefit to the community is the centralization of information. With such approach, information can be provided using the scientific support in the LUs, preventing different members to understand or communicate inconsistent information. Overall, the approach should enhance awareness of and research experience for all CAMRA members.

5 Concluding Remarks

Our approach extends the concept of a community of practice to a community of science. Rather than a community that shares work practices (Davenport and Prusak, 1998), we focus on a community that shares scientific goals within a field of study. Although its stakeholders can be members of organizational institutions such as government, and even the public in general, the contributors to the system are experts in a field of study.

A community of science seems to meet many of the desired characteristics in a community for a successful KM approach. They encourage innovation, positive criticism, leaders are likely to be role models in knowledge sharing, all members share the same goals, the hierarchy is flat, and all community members tend to be knowledgeable of the subject matters.

In the current implementation, the initial design is being well accepted by community members. At the time this article is being written, knowledge workers have conducted one workshop with the entire community and some individual sessions. In terms of accepting visual diagrams and LUs' contents to draft reports, the majority of members are looking forward to using them but a few remain skeptical.

We anticipate challenges in the coming stages of implementation of the system. Although our approach attacks motivation in different ways, until members can experience the benefits of the system, some will remain skeptical. Then, there is the risk that some members will not be fully satisfied with the reporting products. Anticipating this, we are exploring the incorporation of sophisticated summarization methods that would produce a complete draft of the reports from LUs and would include other necessary items like student information.

The problem with finding the right level of specificity for all activities is another challenge. Whenever new activities are conceived, others may question their level. We are incorporating a drop down list of activities in the interface that captures LUs that includes an option for the contributor to add a new activity. Knowledge workers will keep revising those and assessing the use and acceptance of those new activities. For all anticipated problems, we are devising mitigating actions that would require hiring more knowledge workers. This action would increase our training time and costs, but would not substantially interfere with deadlines.

Within future work, we will investigate the automation of environmental scanning, a librarian's task of investigating all about a topic, which could be used to guide policy makers, intelligence, and strategists. Another potential use of the approach would be to locate experts based on the specific areas they have produced contributions.

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