Abstract

We present an ontological analysis of the problem of fostering knowledge sharing in project management. The ontology has five dimensions derived by parsing the problem statement, namely: (a) fostering methods, (b) fostering factors, (c) fostering functions, (d) knowledge types, and (e) knowledge sharing methods. Each dimension is a taxonomy of discrete categories. The exhaustive set of combinations of categories across the five dimensions, together with appropriate connecting words and phrases, constitutes a closed description of the problem. We map (a) the extant literature on knowledge sharing, and (b) the extensive experience of one of the authors in construction project management, to these combinations to synthesize (a) the current state-of-the-know ledge on the topic, (b) the gaps in it, and (c) an agenda for further research. The method is systematic, logical, repeatable, and extensible.

1. Introduction

Fostering knowledge sharing within projects, across projects, and over time can improve both the efficiency and effectiveness of project management. However, it is not easy to do so. There are many types of knowledge and knowledge sharing methods. Further, many factors can encourage or inhibit sharing. The large number of possible combinations of knowledge types, sharing methods, and affecting factors has to be analyzed and understood, and the right methods deployed.

The literature on knowledge sharing in general, and on sharing in projects in particular, is vast and growing rapidly as indicated by the sample of publications from 2007 and 2008[1-17]. Its size and the rate of growth attest to its importance. However, they also make it difficult to systematically synthesize, interpret, and apply the knowledge about knowledge sharing to project management (and other fields). The difficulty is compounded by a profusion of constructs found to affect or not affect knowledge sharing, each appropriate in the context of the particular paper or study, but difficult to relate across these domains or to translate into practice. The complexity of the topic and the plethora of constructs also make it difficult to determine (a) the gaps in the literature on knowledge sharing, and (b) how to address the gaps.

The proposed ontological analysis [18-22] is a step in addressing the complexity of the problem of knowledge sharing and of the factors affecting it. We propose to address these complexities with an ontological framework derived by parsing the problem statement: fostering knowledge sharing in project management. We systematically synthesize the extant recent literature on knowledge sharing and the extensive field experience of one of the authors in construction projects management in India and the Middle East using the framework. We interpret the literature and the author’s experience in the context of the framework to summarize the conclusions and the gaps in our understanding. Last, we discuss how the interpretation can be applied to fostering knowledge sharing in project management. This method of analysis (parsing), synthesis (of the literature and personal experience), interpretation, and application is systematic, logical, repeatable, and extensible. It is also novel.

2. Ontological analysis

Ontologies are used in information systems design to standardize terminologies, map requirements, organize them systematically, facilitate integration of systems, promote information exchange between systems, etc [18, 19, 21, 23]. Ontologies are related to but different from taxonomies, typologies, concept hierarchies, thesauri, and dictionaries [24]. They are tools for systematizing the description of complex systems. Such systematization, in turn, facilitates analysis and design of these systems.

There is no standard definition of ontology of an information system. We will define it as a logically
constructed n-dimensional natural language description of the system. The dimensions are derived from the system objectives. Each dimension is independent of the other and is a taxonomy of discrete categories. Each taxonomy may be flat or hierarchical. Further, the order of categories in a particular dimension at a particular level of the taxonomy may be nominal (no particular order) or ordinal (based on some parameter). The stages of progression along the dimension, the sequence of evolution, the progressive part-whole relationships, the scale, etc. are some bases for ordering the categories. Last, a dimension may have subdimensions with their own taxonomies. That is, a dimension itself may be hierarchical.

A combination of categories across all the dimensions, with appropriate prepositions and conjunctions, is a natural language descriptor of the system in the form of a sentence. The set of all combinations across all categories – that is all possible sentences – is a closed description of the system. The full set can have a very large number of descriptors (individual combinations). However, many of the combinations may not be interpretable or empirically viable. The uninterpretable or unviable combinations may be discarded from further analysis.

A parsimonious choice of dimensions and taxonomies of dimensions is essential for effective description and analysis. The analysis can be modified or extended by substituting or adding new dimensions, new taxonomies, and new categories and subcategories within taxonomies.

In the following we present an ontological analysis of the problem of fostering knowledge sharing in project management. First, we discuss the choice of the domain of project management. Second, we present an ontological framework derived by parsing the problem. Third, we review and synthesize the recent literature on knowledge sharing in general and such sharing in project management in particular within the ontology. Fourth, based on the review we derive conclusions about the problem and the gaps in our understanding and the literature. Fifth, and last, we propose an agenda for research for the future.

3. Project management

We chose project management as the domain for our inquiry into knowledge sharing for two reasons. First, it is a domain in which one of the authors has extensive experience in India and the Middle East. In fact, the idea for this inquiry arose from his observations about and efforts to foster knowledge sharing among his employees. This paper is a synthesis of his experience and an attempt to address the problems he encounters daily in fostering knowledge sharing among his employees. Second, it is also a domain in which the importance of knowledge sharing has been explicitly recognized and investigated [1, 2, 12, 15, 25-28].

Project management is by definition a structured, albeit complex, domain. It is relatively more structured than a domain like research and development, which too is an object of considerable knowledge sharing research. Projects have well defined tasks, schedules, and goals – all associated with different degrees of uncertainty. Their numbers may be large, spread geographically, and scheduled over a long period of time. Yet, because of the underlying structure they provide a fertile opportunity to share knowledge within projects, across projects, and over time. It is a good starting point for understanding how to foster knowledge sharing using ontological analysis. The analysis can be subsequently extended to other domains which are less structured than project management.

4. Ontology

The proposed ontology for fostering knowledge sharing in project management has five dimensions, namely: (a) fostering methods, (b) fostering factors, (c) fostering functions, (d) knowledge types, and (e) knowledge sharing methods. The logic of the derivation of the dimensions should be intuitively clear. We have deconstructed knowledge sharing into two dimensions: (a) knowledge types, and (b) knowledge sharing methods. Similarly, we have deconstructed fostering into three dimensions: (a) fostering methods, (b) fostering factors, and (c) fostering functions. The five dimensions and their corresponding taxonomies are shown in Figure 1 and discussed below. The fostering functions and knowledge types are connected by the phrase ‘to/for sharing’. The phrase makes the concatenations across dimensions natural and understandable. Three illustrative combinations are shown at the bottom of the figure. The ontology as presented can be expanded into $7 \times 3 \times 2 \times 5 \times 4 = 840$ combinations – it is a concise way of representing them and analyzing them systematically. A listing of all the combinations would take about 12 pages.
4.1 Knowledge types

There are many taxonomies for categorizing knowledge. Any one of them can be used in the ontology. A different taxonomy would naturally yield a different perspective. In keeping with the actuality [25] of the domain of inquiry we have chosen a very simple and practical taxonomy. The five categories in a flat taxonomy refer to the following types of knowledge:

- Problem recognition: Knowledge for recognizing a problem early and correctly. For example – what are the symptoms of potential delay by a supplier?
- Problem formulation: Knowledge for formulating the problem quickly and correctly – to categorize and characterize the problem. For example – is the delay a transportation problem, availability problem, a weather problem, a habitual problem of the supplier, or a combination of these?
- Problem analysis – Knowledge for formulating and analyzing the pros and cons of alternatives to solve the problem. For example – if it is a transportation problem, what are the alternative modes available and their costs, risks, and schedules?
- Problem solution – Knowledge for choosing the best solution from among the alternatives. For example – what would be the best choice in the context of the project to balance the overall costs, benefits, and risks?
- Problem prevention – Knowledge for preventing similar problems in the future. For example – what should be done to prevent or prepare for similar problems in the future in the same project, in a different project, in the same location, or at a different location?

The above five types of knowledge can directly impact the efficiency and effectiveness of project management. They can be seen as part of a repetitive learning cycle in the organization. In that sense there is a natural sequence from problem recognition to problem prevention, with a feedback loop from problem prevention to problem recognition. However, it is not a rigid normative sequence. In certain cases, for example when a problem is a repetition and well known, one may jump directly from problem recognition to solution.

Using the other taxonomies the five types of knowledge in our taxonomy may be substituted by: (a) tacit or explicit (or coded) knowledge, (b) embodied, embodied, enculturated, embedded, or encoded knowledge, (c) declarative or procedural knowledge, (d) personal or social knowledge, or (e) some other defined categories [29, 30]. These categories can coexist and be useful for analysis from different perspectives, or for a different facet or depth of analysis. For our ontological analysis we will focus on the application of knowledge to the recognition, analysis, solution, and prevention of problems in project management.

4.2 Knowledge sharing methods

As with knowledge types we have chosen a very practical taxonomy of knowledge sharing methods. Almost all the knowledge in and about project management is shared either orally or in writing. Very little, if any, is shared through touch, smell, or taste – the other human senses. Both oral and written methods can be informal or formal. Thus, there are four categories in the taxonomy at two levels.

Digressing a little, the formality of sharing could be a separate dimension in the ontology. However, for parsimony we have chosen to make it a sub-dimension of the knowledge sharing methods. Further, the subcategories could be three: formal, semi-formal, and informal. Again, the choice of a dichotomy is sufficient for our purpose and parsimonious. Similarly, the oral-written dichotomy could be further refined into more categories but the dichotomy is adequate for our purpose.

The practice of the four methods of knowledge sharing in project management is shown in Figure 2 below. The left-bottom quadrant illustrates some of the most common oral-informal methods. It includes conversations, phone calls, voice-mail, etc. It also includes skits, jokes, and humor which when used properly can be powerful methods of sharing knowledge effectively. The oral-informal methods are probably the most frequently used in project management.
Figure 2. Knowledge sharing methods

A complement to the oral-informal methods is the written-informal methods – a category which is becoming increasingly popular because of the new electronic media and is shown in the left-top quadrant of Figure 2. These include e-mails, text messages, sketches, etc. It also includes methods like cartoons which when used properly can be very effective in sharing knowledge. The written method, even when it is informal, is likely to carry more value and weight than the oral-informal. It is documented, available for reference in the future, and can have legal consequences. For this reason we have drawn the arrow of progression from the oral-informal to the written-informal. The arrow could be reversed, as is happening in many corporations to avoid potential legal consequences of a physical or virtual ‘paper trail’.

A different path of progression from the oral-informal is to the oral-formal, the right-bottom quadrant in Figure 2. This category includes oral reports, presentations, formal interviews, and meetings. It may also include, in the creative subcategory, stories, slogans, and songs encapsulating the knowledge. The oral-formal methods play an important part in structuring the knowledge and transmitting it to a larger audience than is typically the case with the oral-informal methods which are likely to be restricted to dyads or small groups. As part of the structuring the knowledge is likely to be codified, and through interaction with a larger group of people validated.

The end-point of the progression is the top-right quadrant, the written-formal methods. Very often these are the ultimate repositories of knowledge, either in hard copy or in an electronic format. This category includes written reports, white papers, diagrams, drawings, and presentations. On the creative side it also includes written stories, slogans, songs, etc. These methods have the potential of the largest reach within a project, across projects, and over time. Among all the methods this knowledge is likely to be the most codified. Over a period of time they are likely to be the best vetted, and hence validated.

There are gains and losses associated with moving along the informal-formal and the oral-written axes. The nuances of informality and oral sharing of knowledge can be lost as one moves towards the formal and written methods. Hence there can be a loss of tacit knowledge accompanying the gain of explicit knowledge, or the transformation of tacit knowledge into explicit knowledge. For example, some of the intuitive insights, shortcuts, and adaptations for performing a complex task can be lost when the instructions for performing the task are codified. At the same time there can be a gain in the validation of the knowledge and the scale and scope of its impact.

All four methods of knowledge sharing are necessary and important to foster knowledge sharing. They can be efficient, effective, and timely in different ways for different types of knowledge in different contexts. The overall effectiveness of knowledge sharing will depend upon how the portfolio of the four methods is balanced. Over reliance on the informal oral methods may be ‘quick and dirty’ but at the same time may be error-prone for lack of formal vetting and accessibility, except by the person or people in the know. On the other hand, documenting everything formally in reports may be considered too onerous and bureaucratic. Non-compliance with such report writing requirements may be high. Such a method may be appropriate for critical or core knowledge of the organization which has to be validated, preserved, and accessible over time – but not for ad hoc knowledge whose life cycle is short and reuse value limited.

In the ultimate analysis, a portfolio of these methods will be required to share knowledge effectively and efficiently in project management. Thus, for example, upon encountering the problem there may be an oral-informal exchange between a few people involved with the project. That conversation may lead to an informal written exchange via e-mails or a formal-oral exchange in a meeting of the project where a person knowledgeable about the problem makes an oral presentation. If the problem is important or likely to recur, the informal-written exchanges or the formal-oral exchange may lead to a formal-written report or policy about how to handle such problems. The report or policy will become part of the organization’s knowledge repository.
### 4.3 Fostering factors

Many factors which can foster knowledge sharing have been identified and investigated in a large number of studies [11, 31-36]. These factors have been broadly categorized as individual, organizational, and societal – a taxonomy commonly used in the literature. In terms of the structure of the taxonomy it must be noted that the individuals are a subset of the organization to which they belong, and organizations a subset of the society in which they are. Yet, an organization is more than the sum of its constituent employees, and a society is more than the sum of its constituent organizations. As such the three can exert independent influence on knowledge sharing. They can also interact with each other and affect knowledge sharing.

The individual factors which affect knowledge sharing in project management can be many and varied. We will use Posner and McLeod’s [37, 38] taxonomy of traits, states, strategies, and structures to classify these factors. They individual factors may be a person’s (a) traits such as personality, cognitive style, and learning style, (b) states such as the level of motivation, maturity, language and communication skills, mood, and time pressure, (c) strategies for knowledge sharing such as written, oral, formal, and informal, and (d) structures for knowledge sharing such as conversations, stories, jokes, memos, papers, and presentations. A person’s traits and structures for knowledge sharing tend to be persistent over time, not varying with the context – a detail-oriented person will always be detail oriented, a story-teller will always be a story-teller. His or her states and strategies for knowledge sharing tend to be transient, changing with the context. A person may be more willing to share after the deadline than just before one; he or she may call just before the deadline but write after one. On the other hand, the traits and states of an individual have a broad impact on all aspects of knowledge sharing; the structures and strategies on specific aspects. A person’s detail orientation and deadline time pressure will likely affect all aspects of his or her knowledge sharing; his or her story-telling and medium of communication may affect only specific knowledge types. Thus a person’s cognitive style is likely to affect his or her knowledge sharing in the same way always for all types of knowledge; the effect of his or her anger is likely to be temporary but across all types of knowledge sharing. The written-oral strategies he or she uses may vary with context and content of the knowledge shared, and the person’s use of e-mail or written memos likely to be habitual and associated with specific content and context.

The organizational factors which affect knowledge sharing in project management can also be categorized as an organization’s (a) traits, (b) states, (c) strategies for knowledge sharing, and (d) structures for knowledge sharing. This categorization parallels that of the individual factors but with an organization as the focal unit, with the categories having similar properties. Organizational culture is an example of the trait of an organization, and organizational crisis an example of its state. An organization’s documents security strategy can be part of its knowledge sharing strategy, and the structure of its information system an aspect of its knowledge sharing structure. (In this paper we use information and knowledge interchangeably without distinguishing data, information, knowledge, and wisdom semiotically.)

The societal factors which affect knowledge sharing in project management too can be categorized in the same way as the individual and organizational factors. Societal culture is an example of the trait of a society, and a society in rapid economic transition an example of its state. A society’s policies on freedom of information can be part of its knowledge sharing strategy, and the structure of its mass media an aspect of its knowledge sharing structure.

The individual, organizational, and societal factors can affect knowledge sharing in project management independently, and through interaction with one another. The literature on knowledge sharing has generally focused on the independent effects and not on the interaction effects. Thus for example, an extravert’s propensity to share knowledge may be inhibited by an organizational culture which does not promote knowledge sharing. On the other hand, an individual’s reluctance to share knowledge because of inadequate language skills may be counteracted by language training in the organization or society. Thus the net effect of the fostering factors will depend on the combination of both their independent effects as well as their interaction effects. In their totality they can become facilitators of or barriers to knowledge sharing. Facilitators and barriers are categories within the fourth dimension of our ontology and we discuss it in the following.

### 4.4 Fostering functions

We have chosen two categories of fostering functions in the ontology: facilitators and barriers. The concept of facilitators of and barriers to knowledge sharing is widely used in the literature
Facilitators are generally seen as being functional, desirable for knowledge sharing; barriers as being dysfunctional, undesirable for knowledge sharing. However, sometimes when one considers the second- and higher-order effects of the barriers and facilitators it is possible that the facilitators can have dysfunctional effects and barriers can have functional effects on knowledge sharing. For example, unhindered and unregulated sharing of the experience of a project team may (a) on the one hand be good for others in similar projects to learn, but (b) on the other hand result in information overload and propagation of conflicting and incorrect information. Similarly, organizational protocols for validating white papers through an internal review process may be seen as a barrier to knowledge sharing because of the delay it engenders, but a facilitator of assuring the validity of the knowledge shared thereby increasing the effectiveness of knowledge sharing.

In combination with the three categories of fostering factors discussed earlier, the facilitators and barriers can be (a) individual, (b) organizational, (c) societal, or (d) a combination of the three. Locating the barriers and facilitators in these entities, or a combination of them, is necessary for choosing the right method to foster knowledge sharing. If a dysfunctional barrier is an individual or an organizational trait, persistent and having a broad impact on knowledge sharing, the method has to recognize that the trait is unlikely to be changed but one has to work with it or around it. On the other hand, if the functional facilitator is an organizational strategy, transient and having a specific impact on knowledge sharing, one can take steps to enhance it or embody it in the structure and hence improve knowledge sharing.

The above discussion leads us to the last dimension of our ontology – fostering methods. How to manage the combination of fostering factors and functions to share knowledge in project management?

4.5 Fostering methods

There are many methods of fostering knowledge sharing. As the book-ends of the taxonomy of methods we have chosen identifying and evaluating the combinations of factors and functions discussed earlier for knowledge sharing. To identify is to know the factors which can affect knowledge sharing and the functions they can perform; to evaluate is to determine whether the factors are affecting knowledge sharing and performing the functions as intended. Thus, for example, an individual may be thought to be inhibited from sharing his or her knowledge about a problem solution in a presentation because of poor presentation skills. On evaluation, the barrier may in fact be the introverted personality of the individual, and he or she might be quite effective in writing a short paper on the topic for circulation.

In the middle of the taxonomy is the category of maintaining the combination of factors and functions that are known to work well. To ‘let sleeping dogs lie’ as the saying goes. To decide to maintain a factor obviously requires that the factor must be first identified and also evaluated. Maintenance ensures continuity.

Following the category of maintaining are two other opposing categories – introducing and eliminating. Desirable factors not present, but perhaps known from experience or identified through research, have to be introduced. Undesirable factors, based on evaluation, experience or research, have to be eliminated. Introducing new factors or eliminating existing ones can disrupt continuity and have to be managed carefully.

Thus the seven methods provide very different ways of managing the different combinations of factors and functions to foster the sharing of different types of knowledge through the various methods. It is necessary to deploy a combination of these methods in a particular context. And, as knowledge sharing matures in an organization, the combinations may have to be changed. The taxonomy of methods provides a basic set of alternatives for a knowledge manager to consider.

4.6 Ontological combinations

The categories can be concatenated across the five dimensions with the conjunctive phrase ‘to/for sharing’ to form natural language sentences each of which represents a facet of fostering knowledge sharing in project management. Three illustrative combinations are given at the bottom of Figure 1. As
mentioned earlier 840 combinations are possible with the ontology. The extant research on knowledge sharing is not based on our ontology, or for that matter any particular ontology. Hence, it is not surprising that each piece of research addresses segments of the combinations and not any combination in its entirety, let alone multiple combinations. Thus a paper may address individual, organizational, and societal barriers and facilitators. Or, it may focus on the efficacy of different knowledge sharing methods. In practice too one can observe similar segmentation. Thus one may focus on managing the barriers and facilitators to problem recognition, or fostering written-formal knowledge sharing through intramural whitepapers. However, from these segments we can build a mosaic of the (a) the current state-of-the-knowledge and state-of-the-practice of fostering knowledge sharing in project management, (b) determine the gaps in it, and (c) propose an agenda for further research and recommendations for practice.

Overall, the literature and practice on fostering knowledge sharing in general have focused on identifying individual/organizational/societal barriers/ facilitators for sharing knowledge orally/in writing formally/informally. They have not been discriminating in terms of knowledge types we have proposed and have not explicitly considered the full spectrum of fostering methods. The highest density of research and practice is in identifying individual/organizational/societal facilitators/barriers, and knowledge sharing methods – separately, not linked to each other. This bias in the literature and practice is also true for the knowledge sharing literature which pertains or is related to project management.

In the following section we will elaborate upon the above conclusion and present a synthesis and critique of the literature and practice from the perspective of the five dimensions of the ontology.

5. Synthesis and Critique

There is a considerable amount of literature on knowledge sharing methods, although a significant portion of it may not be labeled as such. The rapid strides in information and communication technology are having a strong impact on the evolution of the research as well as practice. While the researchers try to understand the characteristics and consequences of the technology the practitioners continue to adopt and adapt them to their needs, very often ahead of the research. In addition to improving the efficiency and effectiveness of traditional mores of knowledge sharing the technologies are often having unexpected and unintended consequences, disrupting the traditional mores. And important differences are emerging too across individuals, organizations, and societies. Thus while cell phones have been adopted widely in American (USA), Asian (India, China) and African (Kenya, Nigeria) countries they are used differently for different purposes. Text messaging is not as popular in the USA as it is in India and China; for voice mail it is just the opposite; and in Africa the cell phone has helped leapfrog the traditional telecommunication infrastructure development steps. It is difficult to forecast whether these practices will converge to some equilibrium in the near future or how long they will continue to be disruptive. It is clear, however, that new methods of knowledge sharing are emerging rapidly. The research has to catch up with practice, and the practice may not hew to the research prescriptions.

Simultaneously, the new technology is also reviving many of the old methods of knowledge sharing. The ubiquitous internet provides story tellers, joke writers, stand-up comedians, story writers, poets, singers, song writers, and sloganeers an easier access to a larger audience than was possible in traditional organizations and societies. Unmanaged, the purveyors of knowledge can be dysfunctional and damaging in knowledge sharing; well managed, they can be functional and useful for knowledge sharing. Humor can be used to ease the tension following a mistake and to ensure that the person remembers not to commit the same mistake again; incorrectly used humor can also ricochet as a sexist or racist statement.

In summary there is a vast body of research and practice on knowledge sharing – historical, current, and emerging. The challenge will be to extract the essence of these and apply it to fostering knowledge sharing in project management.

Are knowledge sharing methods different for the five types of knowledge in the ontology? Should they be different? We chose the five types instead of the other possible types because they are particularly applicable to project management. This taxonomy has not been used in the knowledge sharing or knowledge management research. Similar categories, although not called a taxonomy, have however been used in problem solving and clinical decision making research. There is a considerable amount of literature on each category.

Conceptually one could argue that the optimal knowledge sharing methods could be different for different knowledge types. Their underlying individual and organizational cognitive processes are different and may require different methods. They also draw upon different procedural and substantive
knowledge. Problem recognition entails the synthesis of often disparate cues spread over locations and time, separating the sometimes weak signals in them from the noise, and making a conjecture. Problem formulation entails validating the conjecture with additional data about the problem itself and its context, to categorize it in one’s repertoire of problem formulations. Problem analysis requires both logical analysis as well as the application of prior knowledge about the same or similar problem to validate the problem formulation and design the alternatives for its solution. Problem solution requires the evaluation of alternatives intuitively, heuristically, or systematically based on appropriately chosen criteria and making a choice. Problem prevention requires extracting the key parameters and the core logic of the problem and proactively correcting them to prevent a recurrence of the problem.

It would be reasonable to conjecture that different knowledge sharing methods would be appropriate for different knowledge types, given the differences in their procedural and substantive content. Some sharing methods may be more suitable for problem formulation and some for problem analysis. The best matches are not known from present research. It is possible that there is no relationship. If so, then the knowledge type dimension could be eliminated from the ontology, thus simplifying it.

In practice, the problem recognition through prevention cycle is distributed over time, across people, and possibly also across locations. It is usually not an individual activity but a team activity. Thus there is not only a need to share knowledge among people involved within a category but also across people involved in different categories. The people who recognize a problem have to share their knowledge with those to formulate the problem, and they in turn with those to analyze the problem, and so on. The sharing, except in the simplest cases, is likely to (a) be iterative, and (b) use multiple methods. How the sharing is managed in its entirety will affect the efficiency and effectiveness of project management.

The highest density of literature in knowledge sharing is focused on the combinations of factors and functions which foster knowledge sharing. Most of this research is focused on identifying the combinations which with or in the context of particular methods can be effective. As mentioned earlier the taxonomy of barriers and facilitators or their synonyms, and the taxonomy of individual, organizational, and societal factors are widely used. But, there is little organization of the three categories of fostering factors at the next level of detail. We have categorized them as traits, states, structures, and strategies – a categorization that can be used across the individual, organizational, and societal units. We have not assigned the factors in the literature to these categories for a more extensive analysis.

In practice the attribution of a barrier to or a facilitator of a knowledge sharing method to the individual, organizational, societal, or to an interaction of these factors is based on the experience, interaction, and intuition of the project manager. The attribution is validated by interaction with those involved or experimentation with different solutions. It is unlikely that a practitioner would discuss the factors in terms of the traits, states, structures, and strategies. However corresponding to those categories he or she may say: (a) it is her personality to share; (b) his willingness to help with a problem will depend upon his mood; (c) she writes long detailed memos; or (d) send a text message if you want to find out.

Last, among fostering methods the emphasis in the literature has been almost exclusively on identification and evaluation. There has been very little, if any, study of the other methods, namely: introducing, eliminating, maintaining, strengthening, and weakening.

6. Conclusions

The rapidly growing body of literature on fostering knowledge sharing in general and in project management in particular is vast but uneven. Based on our analysis using the five-dimensional ontology we conclude as follows:

- The highest concentration of literature is on individual, organizational, and societal facilitators of and barriers to knowledge sharing.
- However, there is no second level taxonomy of the above factors. They can be categorized as traits, states, structures, and strategies of the individual, the organization, and the society.
- There is a considerable body of literature on formal and informal oral and written communication, especially mediated by information and communication technology. The findings from this literature can be applied to knowledge sharing.
- The practice of knowledge sharing through formal and informal oral and written communication is being transformed rapidly because of the developments in information and communication technology. Knowledge of the state-of-the-practice is as important as that of the state-of-the-theory to foster knowledge sharing.
• Knowledge sharing, in theory and practice, is not distinguished by its role in problem recognition, formulation, analysis, solution, or prevention.
• Apart from identifying and evaluating the factors which can be facilitators of or barriers to knowledge sharing, the literature is silent on introducing, eliminating, maintaining, strengthening, or weakening them.

The application of the ontology can be illustrated through the following anecdotes:

**Fear of failure:** The prevailing education system in the country is ‘pass’ oriented and ‘failure’ is stigmatized by society. The stigma carries over to project management. Consequently, ‘failure’ in a project is not openly discussed among team members; even though they can learn from them and avoid repeating the same mistakes in future. Analysis: Societal trait (stigma of failure) affects individual strategy (hide failures). Solution: Introduce organizational trait (respect for failure) to affect individual strategy (discuss failures) and shield from societal trait.

**Language skills:** One of the engineers often questions the statements of another with supporting data – but in private with the superior immediately after a meeting. The target of his criticism is fluent in English and articulate in meetings; the critic is fluent only in his mother tongue (Kannada) and hence bashful of speaking in public. Every time this happens it is a lost opportunity for them to discuss their differences and share their knowledge. Analysis: Individual state (oral language inadequacy) and organizational structure (face to face meetings in English) affects individual strategy (private conversation instead of public discussion). Solution: Change individual state through communication training and possibly organizational structure for knowledge sharing – permit written exchanges (if the critic’s written English is better). However, written notes may have the undesirable second-order effect of formalizing and documenting the differences prematurely, and escalating the tension between the two.

**Broadcasting knowledge:** Sometimes there are similar projects simultaneously in multiple cities using the same construction technology and the same technology vendor. These projects are not synchronized. Hence their activities lag or lead each other. It would benefit the project managers and the organization if they shared their knowledge of (a) the problems in and solutions for using the technology, and (b) working with the vendor, daily or weekly. Lack of time and the fear of losing the ‘power’ of their knowledge prevent them from doing so. Analysis: The state of the project managers (time stress), their trait (competitive), and the organization’s structure for sharing (time consuming) inhibit the sharing of knowledge. Solution: Develop an organizational structure (IT infrastructure) for broadcasting with little effort, demonstrate the value of the knowledge to reduce the time stress (state) of the project mangers, and foster an organizational trait of cooperation and competition.

**Sharing local knowledge:** During the monsoons every evening it rains for a couple of hours and disrupts outdoor work. While this is general local knowledge, the managers do not use it in planning outdoor tasks such as plastering or painting external walls. By starting a few hours earlier the tasks could be completed before the rains. Yet, they do not use their knowledge to prevent the rain delay. Analysis: The results of prevention are often hidden because their outcomes are not visible. ‘Prevention inertia’ is a common societal, organizational, and individual trait. Solution: Slowly modify the organizational trait to recognize and reward prevention.

The ontology we have used is one of many possible for the problem of fostering knowledge sharing in project management. The problem can be analyzed from other perspectives by developing new ontologies. From these analyses it should be possible to construct an ontology which is parsimonious yet complete for research and practice.

7. References


