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Building knowledge in projects: A practical application of social constructivism to information systems development

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Abstract

Projects are collective, purposeful activities based upon the development of common understandings and interpretations of means and ends. They generate the personal and group knowledge which contribute to their own success. This article describes the development of a knowledge creation and sharing process model based upon social constructivist theory and the integration into the model of heuristics for effective knowledge construction. The intent of this is to help project managers create an optimal environment for the creation and maintenance of shared knowledge. We use the example of information systems development to demonstrate the application of this model. We use published literature and case studies to identify heuristics associated with each process in the model and test the model and heuristics by operationalizing them in a simply survey tool which was subjected to expert opinion and an initial field test. We conclude that the proposed model of knowledge construction, with the associated heuristics, offers a promising avenue toward improving project outcomes through giving project managers insight and tools for enhancing a project's knowledge-environment.

Keywords: Project management; Information systems development; Social constructivism; Knowledge heuristics; Knowledge management; Managing teams

1. The practical challenge and the research problem

This research is directed towards improving communications and understanding in large or distributed projects. Projects are becoming the major delivery vehicle for products and services in a global economy, characterised by hyper competition and radically shrinking life cycles [20]. Furthermore, the projects are becoming more complex, requiring the integration of diffuse partners who are often physically separated and from different cultural and linguistic backgrounds [27,42]. Precision, timeliness and congruence of communicated meanings become increasingly important and challenging. This article takes the view that, for project communication to succeed, greater attention must be paid to ensuring that shared meanings are established to guide project decisions and actions [29]. This is not to say that instrumental strategies such as critical success factors (CSF) or "early warning signs" [25] are not vital to project success, but a common understanding of what a CSF means or even a shared perception that a warning sign exists is a prerequisite for being able to act upon it. Deliberate strategies to establish common contexts and shared meanings should be built upon a sound theory of knowledge in social groups, whether they are teams, organizations or any form of social collective.

Our first intention in this article is to engage project managers with the notion that knowledge is not the discovery and inscription of predetermined facts, but is a process of continual sense-making, in which people build, communicate, verify and commit to mutually agreed views of the world. This process is essentially social not cognitive. Our second intention is a corollary of this view; if knowledge

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is "socially constructed" then managers of projects need to attend to the elements of an environment which influence the *construction* of the knowledge required to get things done in projects.

We take information systems development (ISD) projects as our object of study, as they continue to disappoint and fail at an alarming rate, in spite of great gains in technology, programming tools, methodologies and management techniques [28]. Further they epitomize the project situation in which multiple stakeholders, with widely diverse worldviews and objectives, must work together to construct new visions of work activity, values, processes and methods. Wastell noted "*the continuing prevalence of information systems failure*" [47, p. 581] and called for new organizing principles for projects, drawn from other areas of research such as management science. A Standish report in 2001 reported that twenty-eight percent of the studied projects were successful and 23% were abandoned, the rest (49%) remaining "challenged", albeit with lower cost overruns than measured in previous reports. The major reason for improvement is attributed to the halving of the average project size. The riddle of large systems development had been solved in the style of the Gordian knot: cut but not untangled.

Given such wide-scale failure, it might be argued that our existing "organizing principles" for ISD projects are inadequate. The approach we take to the substantial and enduring conundrum has its origin in the philosophy and sociology of knowledge, and specifically, in a view that the software development process essentially involves the formation, emergence and movement of knowledge as a social construct. The degree to which new understandings are created or emerge, and the difficulty in achieving this, may vary between project types and industry sectors, but the basic principle of shared understanding remains a critical success factor for all projects.

2. Knowledge

The view of "knowledge" that pervades information systems development and other engineering disciplines is positivist, the Platonic view that knowledge is "justified true belief". According to this view, knowledge is expressed in propositions and truth is the correspondence of these propositions to a reality that exists independently of human perception and interpretation. In this century however, philosophers such as Ryle [37], Polanyi [33] and Wittgenstein [51], cultural anthropologists such as Whorf [49] and Sapir [38], sociologists such as Berger and Luckmann [3], and Goffmann [19], and more recently knowledge management researchers such as Nonaka and Takeuchi [31], von Krogh and Roos [46] and Davenport and Prusak [13], have influenced our thinking to appreciate that knowledge is not absolute, but relative to cultures and contexts. Our concept of knowledge has moved from a Cartesian subject, standing in a static, cognitive relationship of certainty to propositions stating facts about the empirical world, to social beings who behave in certain ways to exhibit knowledge and achieve certain ends within systems of thought and action.

The *social constructivist* paradigm characterizes knowledge as the sets of beliefs or mental models people use to interpret actions and events in the world. A shaman's knowledge of the spirit world allows him to interpret naturally occurring phenomena as portents or signs. Moral knowledge allows us to assess behavior as right or wrong, criminal, unethical or fair. Knowledge of invoice processing allows a programmer to generate automatic reminder letters. Social constructivism does not judge whether or not there are actually such things as "spirits" or "right and wrong" or even "invoices". "What is 'real' to a Tibetan monk may not be 'real' to an American businessman" [3, p. 3]. The shared reality of shaman or business managers or programmers and users is constructed by individuals within social groups over periods of time, mostly in conversation and through social rituals.

Berger and Luckmann [3] are amongst the most influential proponents of social constructivism. They propose a series of iterative processes and concepts to describe how the "intersubjective" gap between the personal consciousnesses of individuals is overcome and how socially constructed realities, which comprise the knowledge of any social group, are shared and achieve day-to-day objectivity, acceptance and persistence. They show how language, artifacts and symbolic behavior embody a group's collective, permanent solutions to its ongoing problems.

3. The problem of knowledge in ISD

ISD projects are intensive exercises in constructing social reality through process and data modeling. These models are informed with the particular world view of systems designers [22,48,50] and use their particular formal representations [16,36]. In ISD projects, this operational reality is new and explicitly constructed and becomes understood and accepted through negotiated agreement between participants from the "two cultures" of business and IT [1,7].

Therefore the knowledge embodied in information systems *emerges* as we proceed in the analysis and design of a business system [5,7,41]. However, most contemporary design methodologies do not use the conceptual tools or language of social construction: they use the language of engineering, a discipline that builds lasting structures of steel and concrete from pre-existing elements. ISD methodologies exist as structured approaches to systems development that "tell us what steps to take, in what order and how to perform those steps..." [24]. The knowledge paradigm behind these methodologies has been overwhelmingly based upon a correspondence theory of truth and geared towards the discovery and description of a reality which can be achieved by applying the tools provided by modeling conventions and programming languages [32].

Perhaps the social constructivist paradigm offers an insight into continuing failure, namely that what is happening in an ISD project is far more complex than the simple translation of a description of an external reality into instructions for a computer. It is the emergence and articulation of multiple, indeterminate, sometimes unconscious, sometimes ineffable realities and the negotiated achievement of a consensus of a new, agreed reality in an explicit form, such as a business or data model, which is amenable to computerization.

In the following sections, we draw specifically on social constructivist theories to develop and test a model to address the source of these errors. First we represent Berger and Luckmann's theory of social constructivism in the form of a knowledge process model. Then heuristics (management principles or rules of thumb) which influence the performance of each process are identified from research literature and case studies, and associated with individual processes. These heuristics are phrased as survey-type questions and the process model is operationalized as a survey application. For validation, this application is assessed by experts, and then applied by a project manager in a field test.

4. The knowledge sharing model

The process model in Fig. 1 seeks to capture the core elements of social constructivism according to Berger and Luckmann's seminal work, *The social construction of reality* [3]. The terms in the boxes in the model are those used by Berger and Luckmann, while those outside each box are our translation into more everyday expressions. We explain these in more detail below.

- Personal knowledge, what an individual knows, consists of "typificatory schemes", which are the frameworks used to interpret and make sense of the actions of other people and the physical world (Senge and Argyris, call these "mental models" or "theories in use") and recipe knowledge, which is "know–how", or "knowledge limited to pragmatic competence in routine performance" (p. 56).

This personal knowledge is constructed through a number of processes, the major ones being:

- *Internalization*, which describes the absorption of knowledge by a recipient.
- *Personal knowledge creation*, which can be done through habituation (the development of knowledge into useful routines through repetition of work or tasks) or transformations (radically changing subjective reality and creating new ideas) (p. 176).
- *Externalization*, which is the expression of knowledge in a symbolic form such as speech, artifacts or gestures into the physical world, such that others can perceive and internalize it.
- *Objectivation* is the creation of shared, *social* constructs that represents a group's, rather than an individual's, understanding of the world. This objective knowledge is "stored" in physical symbols such as language, behavior or artifacts which are endowed with social significance and which can be shared.
- *Legitimation* is a process whereby knowledge is authorized by people or groups who have power, and meanings are validated and accepted as "correct" or "standard" by others (p. 111).
- *Reification* is "the apprehension of human phenomena ... as if they were things." (p. 106). It is a process in which concepts (such as witchcraft, incest taboos or loan approval) harden in the minds of the group and attain an existence, apparently independent of human beings, which can no longer be challenged.

4.1. Implications for project managers

Reality construction in ISD projects is evident in the face-to-face interviews, conversations, design workshops,

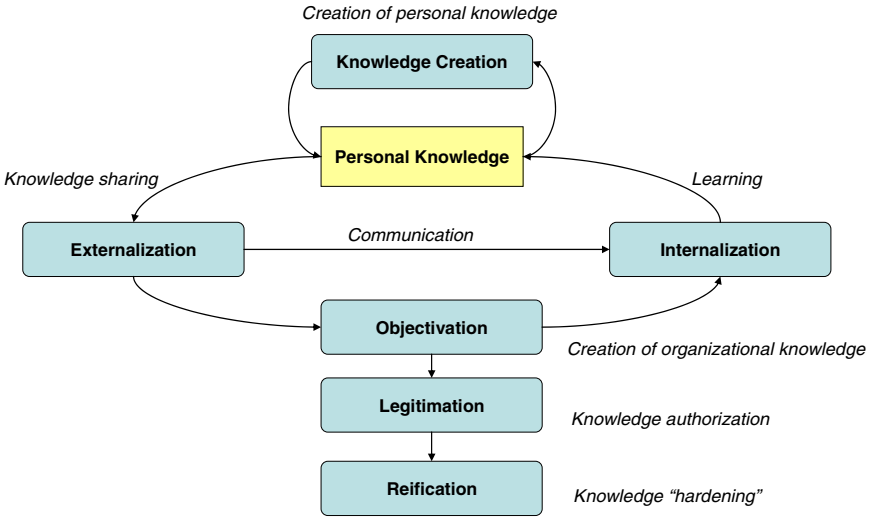


Fig. 1. The knowledge sharing model.

prototyping, model development and joint application development sessions which characterize the relationship between business representatives and the IS function in modern systems development. By describing social constructivism in this way, we hope to have achieved our first objective and engaged the interest of project managers. This way of looking at knowledge differs from standard project communications or information management described in project management texts or the PMBOK [34], in that it introduces the idea that knowledge is a social phenomenon that is continually built and re-built and emerges in interpersonal and group processes, processes which themselves can potentially be enhanced through certain management interventions.

5. Methodology for operationalizing the model

We operationalized the model in several steps. First, we identified knowledge sharing heuristics in the management literature and sorted them by the processes in the model. We then tested the face validity of the model by mapping ISD case study writers' explanations of project success and failure against the processes in the model. Next, we used MS Excel to develop a survey tool for project managers. The tool guides managers to evaluate knowledge sharing in a project using the heuristics identified for each process. Four experienced project managers were then trained in use of the tool and asked to evaluate it. Finally, the tool was used by a project manager working in the field, who reported to us his experience with and assessment of the tool. The steps of identifying heuristics, testing face validity with case studies, expert evaluation, and field test, and the outcomes of these steps, are described in the following sections.

6. Knowledge sharing heuristics

We used the knowledge sharing model as an organizing framework for principles, maxims, and research results associated with effective knowledge sharing. This approach assumes that optimizing the functioning of each process will improve knowledge sharing by facilitating the creation and maintenance of shared conceptions of the world between diverse project stakeholders and minimizing misunderstandings. In order to identify factors which influence the effectiveness of each process, we drew on the considerable existing body of literature in the area of knowledge sharing, organizational learning and social communication. By expressing the knowledge sharing principles that the authors of these works present as guidelines for good practice, we would have the basis of a practical tool.

6.1. Method

We classified principles from the above literature and integrated them into the model under each of the processes in the model. For each process we asked: "*from this literature or research, what factors may influence the capability or the motivation or a staff member to* (for example) *externalize knowledge?*" Two researchers independently reviewed the sorting of the principles under the process headings and the "fit" in most cases seemed natural, although not always unequivocal, as several heuristics applied to more than one process. A manageable set of heuristics was drawn from widely cited work, so that they were representative of commonly held beliefs about good knowledge sharing practice, or were drawn from published empirical studies, or both.

6.2. Implications for project managers

Over 130 heuristics were derived from the reviewed literature and phrased as survey questions. Each heuristic was assigned to a process in the model. Each knowledge process can work well or badly and the heuristics offer some guidance into how to improve the performance of a process. The example of knowledge externalization *capability* is given along with the sources (see Table 1).

The ease with which the heuristics could be associated with processes in the model suggested that the model provided a simple, clear, and comprehensive structure by which to organize and present the complex and voluminous research into knowledge creation and sharing. It allowed us to summarize and sort the research, making it accessible and useful to project managers.

Table 1
Heuristics affecting externalization capability

Externalization capability	Source
We have standard documentation and modeling tools which make business requirements easy to understand	[12,40,41,43]
There is a strong tradition of close cooperation between information service providers and the business	[35,2,18]
We use a mixture of diagrams and words to convey information between stakeholders and information services staff	[12,40,41,43]
We simulate physical processes if necessary to get a better picture of the requirements	[44]
Stakeholders and information systems staff communicate through direct face–face contact	[2,9,45]
Information exchange is conducted with a consistent group of stakeholders from a single point of view	[39]
Our designers/analysts can present requirements specifications and clear solutions to the stakeholders for review	[21]
We use prototypes	[45,31]
It is easy to find someone who can give the right advice	[2,11]
The number of departments in the organization other than my own which need to work together to achieve my group's goals is small	[52]
Our office or working environment allows us to exchange information easily and directly	[23,10]
We have staff whose job it is to assist in knowledge sharing	[6]
Our technology infrastructure and software tools support our information sharing well	[12]
Tacit knowledge and routine skills comprises a small portion of the requirements to be computerized	[44,45]
There is regular sharing of ideas and improvements between departments within the organization	[8]

7. Review of published case studies

While the first application of the model used the generic literature of knowledge management, information systems and organizational studies, the primary purpose of using historical published case studies for this research was to test the face validity of the model in the ISD project domain: is there a relationship between project failure and problems in the respective knowledge processes or, conversely, between project success and the presence of positive indicators?

7.1. Method

Twenty widely cited ISD case studies were reviewed. For each case study, the symptoms and the case writers' suggested causes of failure and success were sorted into the conceptual framework of the knowledge sharing model. One well-known case study [4,17] will be presented to demonstrate the approach, before discussing the overall outcomes of the review. The London Ambulance Service (LAS) is the largest ambulance service in the world and provides accident and emergency and patient transport services to a resident population of nearly seven million people. Their ISD project was intended to produce an automated system for the dispatch of ambulances to emergencies. The existing manual system was poor, cumbersome, inefficient and relatively unreliable. The goal of the new system was to provide an efficient command and control process to overcome these deficiencies. Furthermore, the system was seen by management as an opportunity to resolve perceived issues in poor industrial relations, outmoded work practices and low resource utilization. A tender was let for development of system components including computer aided dispatch, automatic vehicle location, radio interfacing and mobile data terminals to update the status of any call-out. The tender was let to a company inexperienced in large systems delivery. Whilst the project had profound implications for work practices, personnel were hardly involved in the design of the system. Upon implementation, there were many errors in the software and infrastructure, which led to critical operational shortcomings such as the failure of calls to reach ambulances. The system lasted only a week before it was necessary to revert to the manual system. We sorted the salient factors of the case into our model as "lessons learned" (we take the examples of personal knowledge, externalization and reification, page numbers refer to [17]).

7.2. Personal knowledge

There was a comprehensive lack of project management knowledge (p. 84), no involvement of practical ambulance dispatch knowledge (p. 62) and the supplier selected by the LAS was inexperienced in large projects of this kind (p. 58). A management culture of fear of failure led to bids from experienced vendors who did not conform to the timetable being rejected, leaving only an inexperienced vendor to win the work (p. 58).

7.3. Externalization

The study concluded that "a fear based culture is not likely to produce an atmosphere in which doubts can be mentioned and problems discussed" (p. 79). Further, recovery from error situations was very difficult as divisional teams had been separated from the control room and it was more difficult to communicate and override incorrect decisions (p. 73).

7.4. Reification

Deeply held assumptions about the role of personnel and management led to lack of consultation and consequent hostility (p. 55) and an inability to think beyond the existing mindset made the project a "victim of groupthink". This maintained the status quo and rendered problems invisible (p. 64).

Of particular interest across all cases is the degree of failure associated with corrosive or mismatching 'theories in use' [14,26,30] such as "*management are out to get us*" or "*real men do not use functions like that*" or "*we cannot trust the workers*". These beliefs are often "reified", such that project members cannot think beyond them. Lack of competence (i.e. knowledge) by both users and developers is also often cited by case study authors, as is lack of authority (to legitimate goals, actions and solutions).

7.5. Implications for project managers

The case studies demonstrate that there can be no "silver bullet" over such a wide ranging and complex set of factors within what are essentially "open" systems. But the consistent ability of the model to accommodate these factors under headings of *legitimation* or *reification*, or lack of *knowledge* and *motivation* to *externalize* suggests not only a powerful explanatory framework but also potentially a pre-emptive one. The implication is that a tool or method for getting early management control over decisive socio-environmental factors would be of benefit. It seems likely that, had strategies to improve a knowledge sharing environment been implemented, the problems discussed in the case studies may have been avoided. The model thus also seems to provide a structure for integrating past experience in the form of heuristics and strategies which work for a particular organization.

8. Expert opinion

8.1. Method

Following the case study analyses, the research continued in the field, and sought to test the theoretical model by examining user response to the model as operationalized

in a software tool. The model was developed into a series of MS Excel spreadsheets and macros and the knowledge sharing heuristics paraphrased as survey questions that enable assessment of the conditions for effective performance of the overall knowledge sharing process, which we called "capabilities". Terms used in the sociology of knowledge were translated into approximate everyday equivalents. Externalization was converted to "knowledge sharing", internalization to "learning", and objectivation to "creating organizational knowledge" and reification to "knowledge hardening", as shown in Fig. 2.

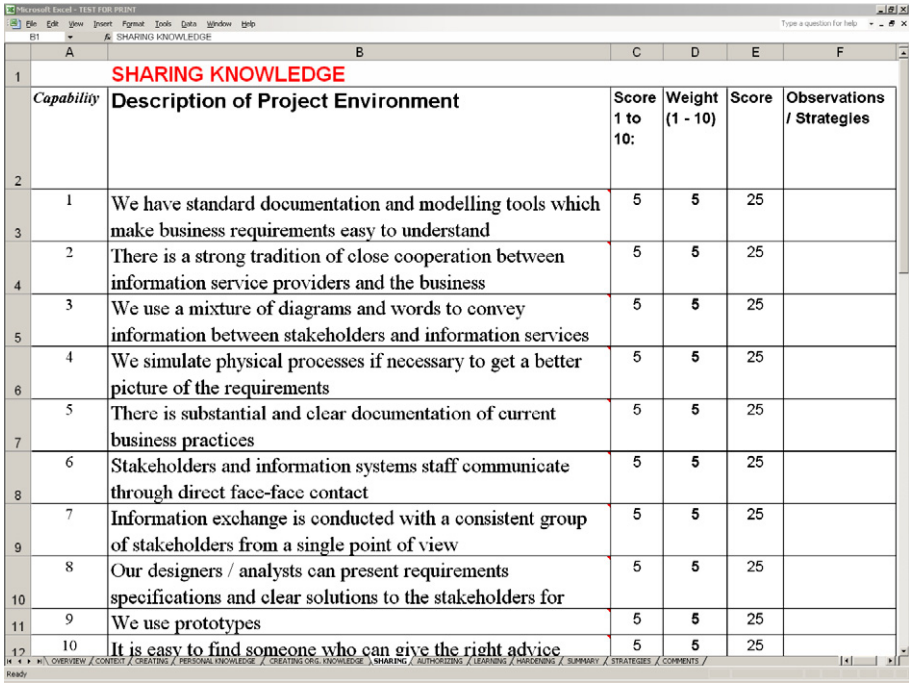
Users of the survey tool were guided to rate the extent to which their project had each capability using a scale from 1 (not true at all) to 10 (very much the case). They were also asked to rate the importance of each capability for their project. These scores were multiplied to get a score for each item. Items with low scores triggered suggested strategies from the literature to address problems: for example, for the survey question "tacit or unarticulated knowledge and routine skills comprise a substantial portion of the requirements to be computerized", the tool suggested strategies such as direct observation (master–apprentice relationships), direct observation plus narration (observation plus explanation from the doer), imitation (group members copy the actions of the expert), and moving experienced staff to the area where the knowledge is needed for the project.

The first prototype of the tool was tested by four participants from the information systems field. All were project managers with an average of twenty years of IT and industry experience, two were senior information systems consultants with experience across many organizations and long-term members of the country's national computer society, while the other two were organizational managers engaged from the business side of ISD projects. Following an individual training session, each member of this panel experimented with the software tool in their projects for four–six weeks. Each expert was interviewed at the end of this period. Through content analysis of the responses, the participants' problems and requirements were subsequently matched to the design intent of the model.

8.2. Implications for project managers

Members of the expert panel gave consistent descriptions of the applicability, simplicity and relevance of the model to themselves as users within a problem domain. For example, one project manager said that "*designers must pick up stuff quickly*" (meaning rapid knowledge transfer was required) and that he needs means of ensuring this. Another said that a major problem was that designers had "*no understanding of how users really work and would use the application*". A major skill of analysts and designers was "*playing an intermediating role between the business, who have no idea of computer systems, and the developers, using translating or bridging language so both parties know exactly what they should be doing*". Such statements support the contention that the tool addresses a real need of project managers, namely to construct a common domain of discourse and build new meanings. All the processes of the model were viewed by panel members as very important to achieving the objectives of requirements gathering in ISD projects.

Content analysis using information systems success criteria [15] showed that the participants were very positive about the potential individual and organizational impact



SHARING KNOWLEDGE

Capability	Description of Project Environment	Score 1 to 10:	Weight (1 - 10)	Score	Observations / Strategies
1	We have standard documentation and modelling tools which make business requirements easy to understand	5	5	25	
2	There is a strong tradition of close cooperation between information service providers and the business	5	5	25	
3	We use a mixture of diagrams and words to convey information between stakeholders and information services	5	5	25	
4	We simulate physical processes if necessary to get a better picture of the requirements	5	5	25	
5	There is substantial and clear documentation of current business practices	5	5	25	
6	Stakeholders and information systems staff communicate through direct face-face contact	5	5	25	
7	Information exchange is conducted with a consistent group of stakeholders from a single point of view	5	5	25	
8	Our designers / analysts can present requirements specifications and clear solutions to the stakeholders for	5	5	25	
9	We use prototypes	5	5	25	
10	It is easy to find someone who can give the right advice	5	5	25	

Fig. 2. Sample assessment survey for knowledge sharing.

of the tool. In particular, they commented that, by using the tool, individual task performance could be improved and specific problems addressed, leading to better outcomes for a project. One participant noted that the tool would also usefully support a project audit or "health check" to be performed on in-flight projects, to identify emergent risks and threats. The general implication is that such a tool need not be particularly sophisticated or complex, but should contain pointers to potential problems and good advice on how to address them.

9. Field test

Having established the face validity of the model, the next step was to ascertain its usefulness in a low-impact "live" environment by performing a knowledge process assessment for a project. An expert involved in the previous test spontaneously approached the researchers, requesting permission to use the tool. He was managing a project to implement a large, sophisticated application with a small but geographically dispersed, mixed user group from diverse external organizations. Some users occupied administrative and analytical functions within the agency, while those external to it were obliged to enter information that demonstrated their firms' progress in infrastructure construction and maintenance. The project manager needed to ascertain, through a systematic assessment, where knowledge sharing practices could be improved to assist implementation, support and best-practice exploitation of the new software package, without the cost of interviewing a wide range of stakeholders. The tool was used to analyze knowledge sharing conditions and develop improvement strategies. Although this was an initial test in a single project, the results of the test had wider-ranging effects than we had anticipated. We describe those effects here, while acknowledging that further applications in different organizations and different projects are needed to better understand if the tool is more effective in specific situations than others.

9.1. Method

The project manager entered his own evaluation of the knowledge sharing environment into the knowledge sharing tool. To address the identified weak points, he used strategies suggested by the tool, augmented these with his own ideas and developed an action plan, using the processes of the model as headings under which to sort the action items. To the researchers, he provided the completed tool and the action plan. He also participated in six half-hour interviews prior to, during and after the project.

9.2. Implications for project managers

The evaluation conducted using the tool highlighted several low scoring factors in three knowledge processes clustered around: (1) lack of personal knowledge, (2) ineffective externalization and (3) inadequate standardization (*objectivation*). A solution for several of these problems emerged as an intranet portal with bulletin boards, expert forums and best-practice solutions providing tools and contexts for dialogues, education and information access. This portal was implemented and now plays a major role in knowledge sharing. The implication for project managers is that technology can be implemented to actively support knowledge sharing and standardization, not just information storage.

A second solution suggested by the tool was to conduct role-playing workshops to externalize how certain work processes really worked (i.e. to uncover tacit knowledge). These role-playing strategies and brainstorming workshops were used to increase the understanding of the stakeholders of complex business processes and the impact of actions upon others. The implication for project managers is that attending explicitly to how knowledge can be expressed pays dividends and that these interventions can energise and educate participants.

Lack of authority and resources prevented the realization of some improvements by the project manager and limited the usefulness of the model at a project level. Nonetheless, it appears to be an interesting side effect that just performing the "health check" changed the behavior of participants. Knowledge sharing appears to be raised to a conscious and reflective level, not just for the individual project manager but also for those with whom he shared his insights and ideas. In this case, some of the participant's colleagues actually began using the terminology of the model (as adapted for the tool) although they had not formally been introduced to it.

10. Conclusions

In the face of the continuing and substantial cost and impact of failure in ISD projects, we have taken up the challenge to use established theory from other fields to discover a new, and potentially fruitful, approach to improving project success. We have argued that the theoretical framework of social constructivism has the potential to improve understanding of knowledge processes in ISD projects. This is potentially transferable to other types of projects and industries.

The social constructivist model we developed appears to be comprehensive and sensible, describing the necessary and sufficient activities for knowledge creation and transfer. It is intuitive, easy to understand and may give project managers a new perspective on how to enhance project performance. The processes of the model appear to offer a useful sorting mechanism by which to integrate the knowledge sharing heuristics of research from a variety of disciplines and make them available to project managers who have otherwise no time to trawl through research literature. They also appear to offer a useful sorting principle by which to present the results of a knowledge-environment health check as well as the strategies

that address issues arising from the health check. The individuals and organizations participating in this research actively requested participation, reflecting a felt need for such a method.

What, in particular, is new about this approach, and how might it help project managers? At a conceptual level, the model clarifies the difference between the approach taken by modern writers about knowledge management and the knowledge activities often undertaken in projects: the modern conception of knowledge management is founded on principles of *social* or collective human understanding of organizations and their processes, but most organizations continue to attempt to implement systems which ignore these social constructions, attempting to engineer solutions as if organizations and processes were constructed of components or objects which exist outside their social context. Until now, this social conception of organizational knowledge has been associated more with philosophical argument than practical tools. The model described here, however, allows a transition from the complex concept of social construction of knowledge to a simple model that reveals the hidden processes of knowledge construction to project managers and a practical tool that can be used to assess the knowledge management health of an ISD, and possibly any, project.

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