Dynamic Knowledge Support for Decision-making and Problem-solving

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Abstract: An effective knowledge approach requires that existing and created tacit and explicit knowledge are mobilised and integrated, and made available to support collaboration between team members. The paper presents a model validated during a longitudinal case study conducted at one of the world's leading software organisations that addresses the need to make dynamic tacit and explicit knowledge available and accessible for effective decision-making and problem-solving.

Keywords: Knowledge creation, integration, decision-making, problem-solving, collaboration, interaction, feedback

Introduction

Organisations function in rapidly changing and evolving environments characterised by high levels of uncertainty and ambiguity. Unpredictable and ill-structured operating conditions require dynamic resolution approaches supported by the sharing and application of tacit and explicit knowledge for creative problem solving. As organisations lay greater emphasis on people and interactions over processes and tools, knowledge increasingly underpins collaborative activities. Managing knowledge effectively allows organisations to develop a long-term and continuous perspective, and improve their decision-making and problem-solving processes.

Most work practices are increasingly being standardised to leverage existing knowledge for decision-making and problem-solving, but some situations require more flexibility than can be addressed by standardised processes. Rubinstein and Pfeiffer (1980) argue the problem-solving ability of an organisation can be hindered by repeatedly attempting to solve problems using approaches that have been performed successfully in the past. Previously tried methods of problem-solving may be effective sometimes, but certain fast changing and complex situations require new approaches. Simon (1977) distinguishes between structured and non-structured situations, where repetitive and routine structured situations are addressed by standardised processes and operating procedures, while unstructured situations require human judgement, insight and intuition for meaningful resolution. The complexities and unpredictability of unstructured situations require insights and tacit knowledge of individuals for effective decision-making and creative problem-solving. Standardised processes identify good practices and reduce mistakes and rework, but also reduce an organisation's ability and flexibility to adopt new approaches for problem-solving which may result in vital learning. Tacit knowledge must be available in a dynamic form to ensure that relevant shared contexts and interpretations create common knowledge and understanding in such situations. The interaction and flow of dynamic knowledge, including tacit knowledge, is required within an organisation's core work practices to provide feedback and facilitate collaboration for decision-making, problem-solving and innovation.

The flow of knowledge requires an effective knowledge management (KM) strategy and the mobilisation, integration, sharing, and application of tacit and explicit knowledge in a dynamic manner. However, most knowledge management (KM) frameworks lay an emphasis on managing explicit knowledge by focussing on the processes of capture, storage, retrieval, transfer and application (Argote and Ingram 2000, Sunassee and Sewry 2002, Dyba 2003, Arling and Chun 2011). Tacit knowledge, on the other hand, needs the key mechanisms of interaction and feedback for effective sharing and use (Polanyi 1967, Nonaka and Takeuchi 1995, Kreiner 2002. Xue et al 2011, and Margaryan et al 2011). Within a dynamic and holistic knowledge approach, the existing and created tacit and explicit knowledge are mobilised and integrated, and made available to collaborative team members. The need therefore exists for a knowledge management framework which addresses the requirements to facilitate the exchange and application of tacit knowledge, in addition to explicit knowledge. The paper presents a model which addresses this need to make dynamic, tacit and

explicit knowledge available and accessible for effective decision-making and problem-solving. The model was validated during a longitudinal case study conducted at one of the world's leading software and consultancy organisation which currently employs more than 245,000 individuals (Sandhawalia and Dalcher 2010).

The paper is organised as follows: the next section discusses the theoretical concepts of KM processes and knowledge flows, and how they influence the decision-making and problem-solving processes; Section 3 presents the research methodology and provides details of the case study and the methods of data collection and analysis; Section 4 presents the research findings and analyses how dynamic knowledge identified in the case study organisation supports the decision-making and problem-solving processes; Section 5 presents the conclusions and implications of the research; and Section 6 discusses the limitations of the work done, and also highlights possibilities for future work.

Theory Development

Knowledge creation, and its integration, can be viewed as collective processes of constructing, articulating and redefining shared beliefs and mental models through social interaction that help manage complex tasks and activities during collaboration, (Grant 1996, Huang 2000, and Chang et al 2012). However, Huang et al (2001) argue that current conceptualisation of how knowledge is integrated and made available within the context of coordinating specialised expertise and tasks remains limited. It is therefore important to explore the dynamics of knowledge integration while performing collaborative activities such as decision-making and problem-solving which further generate ideas through collective input.

The ability to create, store, integrate, disseminate, and utilise knowledge and expertise has become a primary way to compete (Hayashi, 2004). Amassing and synthesising specialised knowledge from multiple sources is an integral factor during decision-making and problem-solving processes. The importation of new knowledge coupled with the recombination of existing knowledge provides information and knowledge that can be leveraged to improve decision-making and problem-solving, and lower performance risk. Decision-making is often compromised when team members fall victim to the fallacy where benefits are overestimated and costs are underestimated. Knowledge provides tacit insights and judgment, and forms the basis for better decision making. Moreover, the knowledge integration process involves social interactions among individuals using internal communication channels for knowledge transfer to arrive at a common perspective for problem-solving. Collaborative linkages are the primary means of transferring specialised knowledge (Tasi, 2001), which facilitates knowledge reuse, and the recombination of existing knowledge is an important antecedent of uncertainty resolution and innovation (Marjchrzak, Cooper, & Neece, 2004; Terwiesch & Loch, 1999).

Newell et al (2004) state that objective measures and collaboration strongly influence the creation of common knowledge. Measures provide tangible benefits to be gained by creating common knowledge and people working together need to be able to identify the value gained by creating common knowledge, and therefore learn and contribute to the effort. Also, collaborative activities form ties and are important for knowledge integration and researchers have long recognised the need for people to collaborate in order to sustain innovation (Davenport 1993 and Van De Van 1986). Dougherty and Hardy (1996) confirm that collaborative structures of cross-functional teams, and the collaborative processes of decision-making and problem-solving, are important for sustained innovation.

An effective collaborative mechanism for achieving knowledge integration is to facilitate the flow of knowledge and make it available to coordinate the planning of interdependent work process strategies (Styhre 2003). Prior research indicates knowledge integration can be achieved when people are involved early in the work process (Boynton, Zmud, & Jacobs, 1994). Mutual consideration of work process strengths and weaknesses allows individuals to identify requirements and capabilities for targeted work processes, predict what resources are needed to fulfil the requirements, and determine how best to deploy resources to optimise performance and minimise delays (Mitchell & Zmud, 1999). The act of coordination is a knowledge integration process that facilitates a common understanding of task objectives and the means to reach those objectives, (Reich & Benbasat, 1996).

Tasks that require knowledge integration are communal, and the flow of knowledge between individuals is essential to facilitate collaborative activities and foster complex knowledge transfer. The transfer process

can slow down where the complexity of knowledge is determined by the degree to which it is tacit, and whether an individual is dependent on another for the transfer and acquisition of knowledge, (Mckenzie & van Winkelen, 2004). Effective knowledge flows provide integrated, task relevant knowledge support from appropriate competence areas to balance multiple perspectives and stakeholder interests. Thus available knowledge and consequent collaboration help create a sense-making community who understand the interactions and synergy of workflows through a multi-perspective view of diverse knowledge competence areas.

Further, effective knowledge flows are critical for interaction and sustaining knowledge integration. Briggs, Vreede and Nunamaker (2003) report on the value of facilitating interaction and accomplishing organisational tasks, and how in the case of inter-organisational collaboration, knowledge flows support significantly complex tasks when goals are to be accomplished by teams whose members do not share culture, communication and coordination processes. Gladstein (1984), Hackman (1987), and McGrath (1984) argue that performance is a result of the interactions and dynamics among team members, and Argote and Ingram (2000) state that the utilisation of knowledge embedded within a team's interactions and tasks is the key to achieving better performance. Several researchers have investigated the importance of team work as members with diverse skills, knowledge, experiences, and expertise are required to work together to resolve the issues or problems encountered during project execution. However, a focus on how knowledge flows and supports collaboration and knowledge integration appears to be limited.

Knowledge flows influence the efficiency and scope of knowledge integration which Grant (1996) identified as critical for organisational competitiveness. Effective knowledge flows facilitate the generation of common knowledge and its seamless coordination between team members. The flow of knowledge within an organisation helps attain a level of integration efficiency relative to the scope of integration required, and facilitates the ability to continuously innovate and maintain competitive advantage. Knowledge flows enable the diverse pool of team members to access, share and discuss knowledge uniquely distinct to each member, thus creating knowledge not possessed before which is vital for creativity, innovation, and developing solutions. Knowledge integration is realised by synthesising different perspectives and expertise during decision-making and problem-solving processes, and enables different views to be incorporated. Team members bring different sets of assumptions about optimal ways to proceed, prioritising different values and perspectives, which are integrated in the problem-solving process to develop required solutions. With problem-solving being central to their work, team members recognise that failure is an opportunity for understanding and learning to avoid mistakes, and it is therefore imperative to make an effort to support collective problem-solving and reflection.

Distinct expertise needs to be shared between diverse team members with a sufficient level of congruence to enable individuals to understand each other and work together towards their common goals from different perspectives (Xue et al 2011). Combining previously unconnected aspects or recombining previously associated aspects creates common knowledge (Leonard-Barton, 1992), as team members realise that tasks are better achieved through dynamic interaction and feedback. In this way teams are likely to create new and common knowledge and engage in effective sharing and integration of knowledge to achieve their predefined goals. To study how this dynamic knowledge is created, integrated and shared while performing collaborative tasks, the research focused on identifying how knowledge flows during the decision-making and problem-solving processes.

Case Study

An extended case study was conducted at a large software service organisation to examine how knowledge flow supports knowledge creation and integration and collaboration within the developmental processes. Exceptional access negotiated for this research provided an opportunity to study and analyse the well established and highly mature work methods practised in the organisation. The research propositions required the study, analysis and identification of the flow of knowledge between the functional areas of the development effort. The data was collected over a period of twenty-six months, through interviews, questionnaire and observation which were conducted in parallel to enable researchers to confirm key phrases, events, instances and insights and provide a degree of clarification, redundancy and triangulation.

Observation

The researchers observed the specific project management, knowledge and software process areas within the organisation, and the functioning of teams in their collaborative work environment. The observations were carried out by ensuring that each field visit was for a minimum of three weeks. This was done to ensure that after the initial observation session, individual team members were familiar and comfortable with the researchers being present during such meetings and sessions. Team members were made aware of the research being conducted, and this benefited the researchers by enabling them to conduct interactive group discussions, and also obtain confirmation and feedback about the observations at the end of each session. The interactive group discussions played a part in strengthening the value and perceived importance of the trends that were observed and enabled early clarification of issues. The researchers observed various meetings including weekly reviews, design, project start-up, closure, and conference calls with on-site developers and clients, in addition to software development activities and daily team interactions. Weekly review meetings lasted on average between an hour and a half to about two hours, while project start-up, closure and design meetings were considerably longer. Most design meetings lasted a minimum of a half day (four hours), with some meetings lasting for three-quarters of a day or even a complete day (eight hours). Certain design meetings required to be resumed the next working day. Focused project start up meetings that involved initial stakeholders would typically last for half a day, while the same was the case for project closure meetings.

The researchers were able to observe software processes and the functioning of project teams within their work environment. The researchers were present within the coded access areas of the team's workplace for a half day session at each instance, and were able to observe, examine and make notes of team interaction, and work methods and practices. The researchers were also invited to observe senior management interactions for extended sessions, for example 8am to 2pm, and make notes of work routines and problem solving methods. In total, the researchers observed 97 meetings, which were of 11 different types, yielding 340 hours of observation.

Interviews

Thirty-eight open-ended interviews were conducted with individuals within the organisation and included an Executive Vice President, the second most senior executive within the organisation, a Vice President, Consultants, Researchers, Project Managers, Project Leads, and members of the Software Engineering Process Group (SEPG). The depth in organisational hierarchy represented in the cross-section of individuals interviewed helped ensure that the interview data collected did not have an over-reliance on either easily accessible or elite respondents, as suggested by Miles and Huberman (1994). A total of 62 interviews were conducted involving 38 individuals with varying levels of seniority and experience lasting a total of 100 hours.

Questionnaires

A detailed survey questionnaire was administered primarily to obtain responses from a wider cross section of respondents within the distributed organisation. The researchers were able to get views and opinions of on-site team members, that is, those team members who were based on the client's site and were currently not available for interviews at the organisation's premises. The questionnaire provided access to employees working on the projects being examined and analysed and who were not available for a face-to-face interview. A total of 24 questionnaires were sent out of which 20 individuals responded; that is a response rate of 83 per cent. The researchers were subsequently able to communicate with the respondents via email to seek clarifications and further discuss relevant issues related to the research, thus extending the questionnaire instrument into a more dynamic information gathering tool from remote subjects.

The interview and survey questions were developed to determine and gain a clear understanding of the: organisation's knowledge strategy

- primary vision for the knowledge strategy
- issues and barriers faced while implementing the strategy
- flow of knowledge within the processes and functional areas of the organisation
- requirements to facilitate a smooth flow of knowledge

- modes and channels of communication and coordination within the organisation
- mode of facilitation of tacit knowledge within the organisation
- roles and responsibilities
- impact of use of KM tools and assets on work practices, project management processes and software development processes, and methods to measure the same if any exist
- organisation's knowledge strategy review process and ability to learn continuously, identify patterns, and formalise routines
- development of the organisation's knowledge culture
- influence of KM infrastructure and processes on organisational maturity
- role of KM infrastructure and processes on decision-making within the organisation and impact on problem-solving
- important and integral areas of decision-making
- decision-making tools, inputs and resources
- role of knowledge flows on quality and testing and
- use of knowledge and experience in subsequent projects, especially in the decision-making process

The collected data provided a rich empirical basis to analyse the flow of knowledge and its dynamic creation and integration during decision-making and problem-solving during project implementation within a software organisation. The large volume of data was examined, reviewed and checked to ensure accuracy. Data reduction and display techniques were applied in systematic ways as suggested by Miles and Huberman (1994) to categorise the data in groups based on their attributes that adhered to the theoretical propositions and orientation of the research. The groups and attributes were placed in multiple columns and rows matrix to enable analysis and identify similarities, interactions and relationships, and form impressions. An iterative process of ongoing analysis based on reformulation of ideas and emerging insights provided the basis for reliability in the qualitative approach suggested by Yin (2003).

Findings

The case study provided evidence of the flow of knowledge during collaborative tasks in software development. The researchers established the mechanisms of feedback and interaction that facilitate the flow of knowledge by identifying the activities, tasks, and actors involved in the development processes. The effects of interaction and feedback, and the tacit and explicit dimensions of knowledge flows, were determined by analysing the knowledge input, executed tasks, and outcomes, of collaborative activities. The collective team performance, output, and experience was further analysed to identify the specific knowledge created and integrated during the development process and applied for decision-making and problem-solving.

The researchers analysed how knowledge was dynamically created and made available to team members within the functional areas of the development effort. The interactions between the knowledge flows and functional areas were identified and depicted the overall complexity of the development effort. The case study analysis is presented below, and the flow of knowledge between the functional areas is discussed and presented to model the relationships as dynamic systems of nodes and arrows. Nodes represent the functional areas, while arrows represent the relationships between these functional areas.

The case study analysis confirms the existing knowledge of team members is applied, and further knowledge created during problem-solving and engagement in development activities within the technical area. This process of knowledge creation and integration, creates process and product specific knowledge, and also enhances the individual and collective team experience. Thus the output flow from the technical area is the

creation of new product knowledge and an enhancement of individual and team experience. A diagrammatic representation of this relationship is provided below in Figure 1.

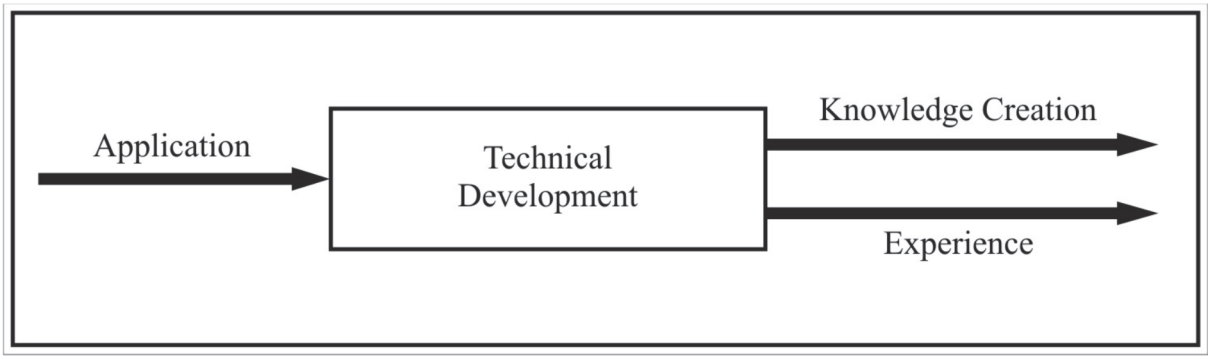

Fig. 1. *Inflow and Outflows for Technical Area*

The analysis further confirmed the product specific knowledge flows to the quality area where it is applied to identify mismatches and detect defects in the product. New learning emerges in this area when errors are corrected, and knowledge is also created while analysing the defects to ensure that the product conforms to the required specifications. The new knowledge created further integrates with the existing knowledge when updating checklists and performing causal analysis. Thus the quality area benefits from the product specific knowledge created in the technical area and provides further learning and reflection, (Dyba 2003). These flows are presented below in Figure 2.

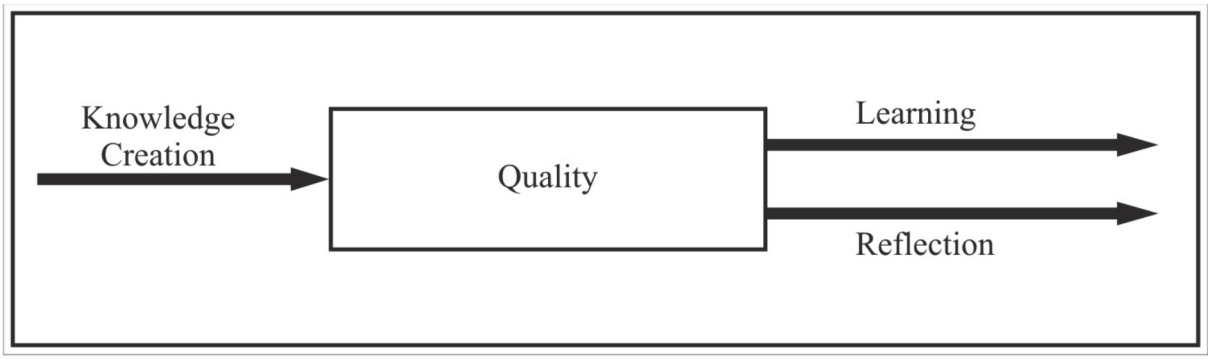

Fig. 2. *Inflow and Outflows for Quality Area*

Analysis of the data establishes that the functional area where project management tasks are performed benefits from enhanced experience gained in the technical area, and from the further reflection provided by the quality area. The project management area integrates such experience and reflection by updating project management templates and modules to ensure more effective planning, control and monitoring of projects. Integrating experience and reflection creates further dynamic knowledge, which the project management area is able to transfer to the decision-making area. Figure 3 presents these relationships, highlighting the project management area's focus on the transfer of knowledge.

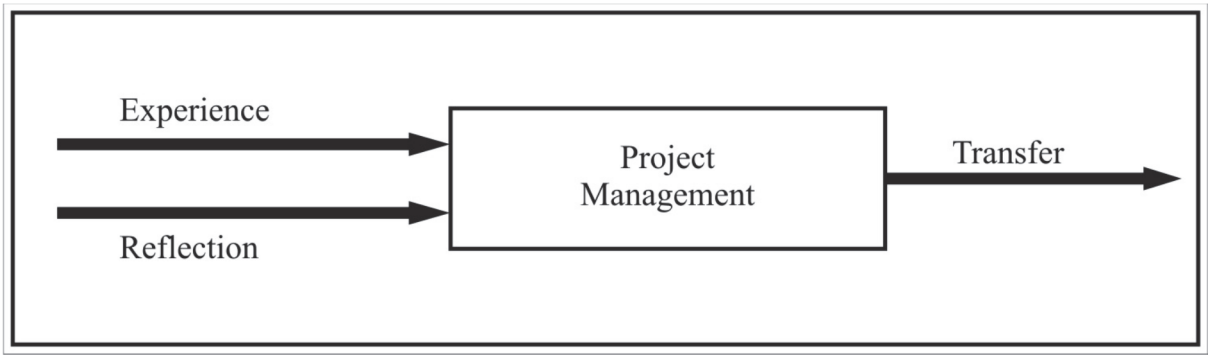

Fig. 3. *Inflows and Outflow for Project Management Area*

The functional area for decision making benefits from product specific learning from the quality area and the dynamic knowledge from the project management area. This enables more effective decision making that is applied within the technical area for current and subsequent projects. The literature confirms that knowledge is applied for effective decision making while making sense of uncertain and unstructured situations, (Simon 1977, Nutt 1989, Gruenfeld et al 1996, Politis 2003). The decision-making area is concerned with the application of decisions, and this is represented in Figure 4.

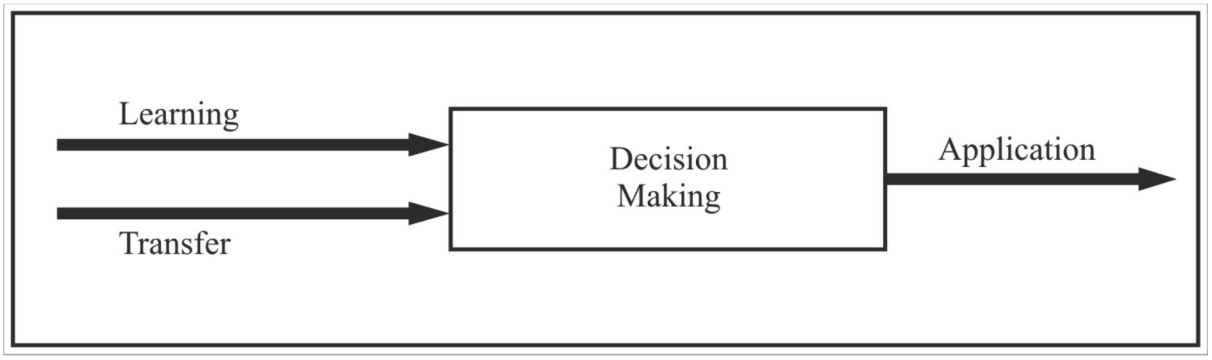

Fig. 4. *Inflows and Outflow for Decision-Making Area*

The above discussion analyses the flow of knowledge within the functional areas of the development process. The flow is iterative, and the continuous inflows and outflows of knowledge from the individual areas confirm the non-linear relationships and interactions between them. The relationships present in the form of closed and continuous loops of knowledge flows, and depict the interactions and feedback of the development process as established by Abdel-Hamid and Madnick (1991). The loops ensure that new knowledge integrates with existing knowledge in a dynamic manner, and allow experience gained while executing collaborative tasks to be effectively transferred and applied in the decision-making process. The continuous view provided by the feedback loops is modelled to represent the dynamic flow of tacit and explicit knowledge within the functional areas of the development effort and is termed the Knowledge-Dynamic Feedback Model (K-DFM).

The K-DFM presents the flow of knowledge between an organisation's functional areas of project management, technical development, quality assurance, and decision-making. The model balances the interactions and interdependencies between the different functional areas and provides a complete picture of how the problem-solving requirements of an organisation are addressed. The K-DFM addresses the knowledge needs of organisations and provides the framework that ensures both tacit and explicit knowledge are made available to the right person at the right time and place. In other words, the model depicts how knowledge is made available throughout the development processes of the organisation, and is not located in a single place. The K-DFM is presented in Figure 5.

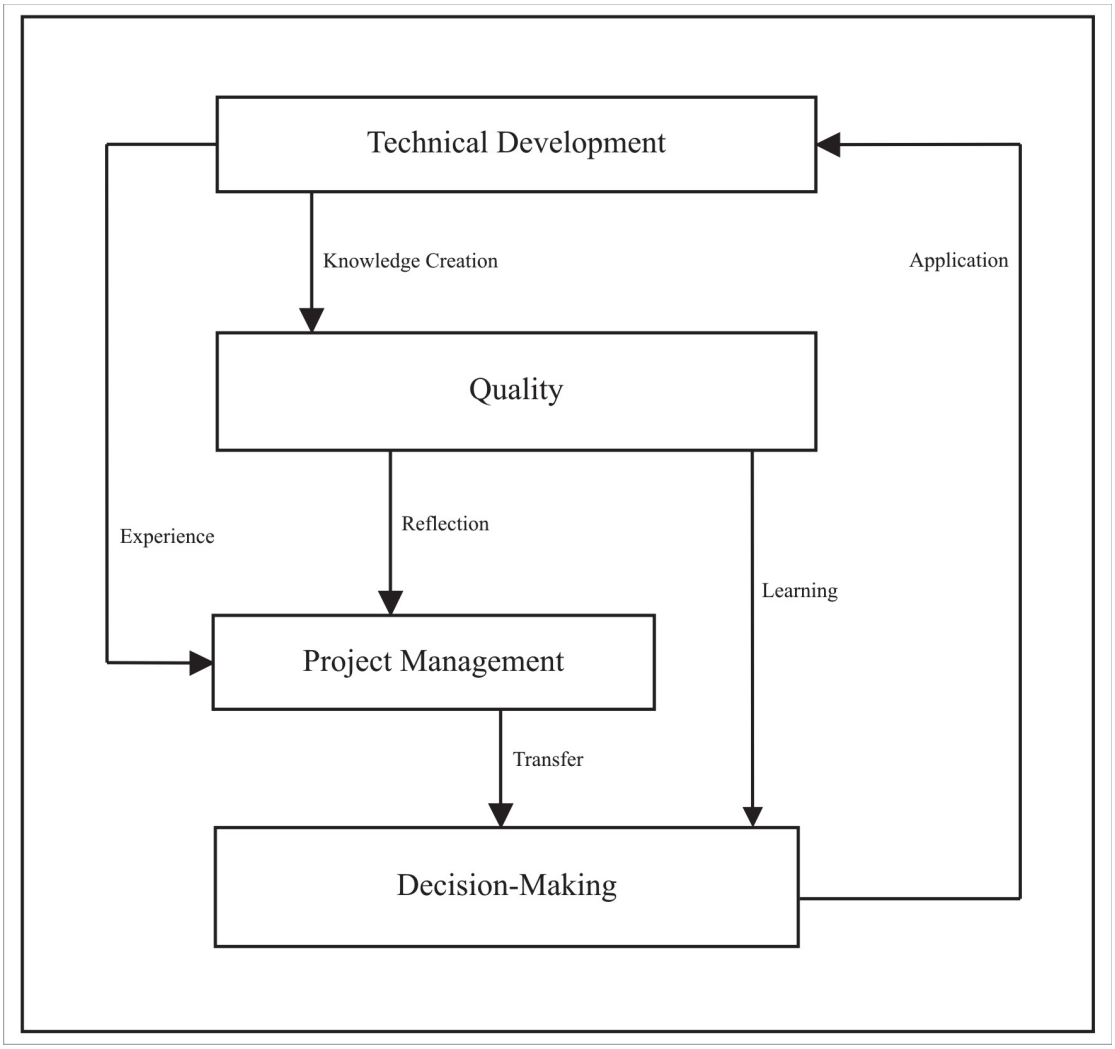

Fig. 5. Knowledge-Dynamic Feedback Model (K-DFM)

Assessing the K-DFM

Rubenstein-Montano et al (2000) recommend that a knowledge management framework should:

- be both prescriptive and descriptive, that is a combination of the two approaches
- be consistent with systems thinking
- link knowledge management to organisational goals and strategies
- be planned before the knowledge management activities take place
- acknowledge the organisational culture, and the knowledge management practices must be compatible with the culture
- direct knowledge management through learning and feedback loops

The K-DFM is a dynamic model that presents the flow of knowledge between the functional areas of project management, decision-making, technical development, and quality, through feedback loops. The model is descriptive in its depiction of the flow of knowledge between the four functional areas. However, rather than being prescriptive, the model highlights the flow of knowledge. The model uses a systems approach and depicts the relationships and interactions of project management, software development and knowledge management. In doing so, the K-DFM highlights the fact that consideration must be given to non-technical aspects of the software development effort. The function of the decision-making area is to integrate

different perspectives and considerations, and make sense of the knowledge that is created and emerges from the functional areas and flows through the feedback loops, thereby making the K-DFM consistent with systems thinking.

By presenting the flow of knowledge through the feedback loops, the K-DFM provides the organisation with the ability to provide knowledge management support to its software development and project management processes. The K-DFM provides the infrastructure that facilitates the flow of knowledge and hence supports knowledge sharing activities. Thus the model provides the framework that links knowledge management to a software project organisation's goal and strategy of continuously improving its processes in order to make them more efficient, effective and productive.

As mentioned, the K-DFM gives consideration to the non-technical aspects of the software development effort. The model acknowledges the important role of organisational culture in the effectiveness of the knowledge management initiative of a software project organisation. An organisation's culture is central to encourage interaction between individuals which is important to facilitate knowledge flow, and also provides individuals the ability to self-organise their own knowledge to facilitate knowledge sharing and therefore problem solving, O'Dell and Grayson (1998). The K-DFM provides the framework to facilitate such knowledge sharing with all functional areas, a further enables knowledge and new learning to flow through the feedback loops. Therefore, assessing against Rubenstein-Montano et al's (2000) criteria for knowledge management frameworks, the K-DFM:

- is a dynamic model
- is consistent with systems thinking
- links knowledge management to a software project organisation's goal and strategy of continuous process improvement
- provides knowledge management support to project management and software development processes
- acknowledges organisational culture and provides the framework to facilitate interaction and knowledge sharing
- enables the flow of knowledge and learning through feedback loops

Thus the K-DFM appears to match and satisfy Rubenstein-Montano et al's (2000) criteria for knowledge management frameworks. Table 1 presents how the K-DFM satisfies the knowledge management framework criteria.

Table 1 Assessing K-DFM against Knowledge Management Framework Criteria

No	Knowledge Management Framework Criteria	K-DFM Characteristics and Features
1	Combination of prescriptive and descriptive approaches	The model is dynamic, facilitative and descriptive
2	Consistent with systems thinking	Uses a systems thinking approach
3	Link knowledge management to organisational goals and strategies	Links knowledge management to a software project organisation's goal of continuously improving it processes
4	Be planned before the knowledge management activities take place	Provides knowledge management support to project management and software development processes
5	Acknowledge the organisational culture, and the knowledge management practices must be compatible with the culture	Considers non-technical aspects of software development; knowledge activities within and between the functional areas rely upon the organisation's culture
6	Direct knowledge management through learning and feedback loops	Enables the flow of knowledge through feedback loops

Conclusions and Implications

The paper presents a long-term perspective for effective decision-making and problem-solving in organisations operating in environments of rapid and unprecedented change. The paper establishes that knowledge flows between functional areas can support tasks and activities of the development effort. The K-DFM presents a framework that emphasises dynamic knowledge support, especially tacit knowledge support in the form of human judgement, insight, intuition, and experience, for decision making in the non-structured situations identified by Simon (1977). The feedback loops presented in the model support collaboration, and integration of knowledge to create new common knowledge which is further applied for improved decision-making and problem-solving. The paper confirms the processual nature of knowledge as argued by Styhre (2003), which exists throughout an organisation and is not located at one single time or space.

The processual nature of knowledge and its flow has implications for a large part of management literature that focuses on how to make knowledge more manageable. Managing knowledge provides a connotation of control and ownership where the first step is to establish its ownership. However, it is difficult to assign ownership, and store and retrieve something that is abstract and elusive in nature. Knowledge is considered tacit by nature, that is, implied and understood implicitly in the situation, without being definable and visible. Capturing tacit knowledge is viewed as a challenge by organisations that need to spread knowledge for better decision-making and greater innovation. This research presents an approach where the flow of knowledge supports collaborative tasks and activities in areas where the knowledge is required and applied within a context. The approach considers knowledge as something that is made resourceful by being competently mobilised and utilised, and consequently new knowledge is created by improving the ability to facilitate, mobilise and utilise existing knowledge.

For organisations this paper's findings have implications regarding their ability to manage context, provide feedback and facilitate interaction, and therefore build upon their existing knowledge resources to improve problem-solving. The research provides organisations with a perspective that would help them achieve excellence not only through integrating various considerations for effective decision-making, but also through knowledge creation, sharing and learning. The K-DFM's focus on supporting the flow of knowledge, learning, experience and reflection within the functional areas provides organisations with the benefits of continuous process improvements and competitive advantage. Thus the research presents an approach to ensure that the right knowledge is available to the right person at the right time during the

decision-making process. This provides a starting point in the quest to address the requirements of effective problem-solving.

Limitations and Future Work

The research has some limitations and several possibilities for future work emerge from the results of the current study. The case study is located within a single organisation. The study did not attempt to isolate specific conditions that may tend to moderate the findings within a specific organisation. A focused study within several organisations, combined with an objective evaluation of the flow of knowledge and capability support within the various knowledge management initiatives, would provide useful follow-up research. Also, the model presented in this research has been proposed and validated for collaborative tasks and activities associated with software development projects. Interesting research possibilities exist to extend and test the model within other developmental domains and industrial sectors. Therefore further studies need to be conducted to look at organisations in other areas and domains to determine if the same practices apply.

There was no attempt to categorise the findings based on the size of the organisation. Opportunities for similar research appear to exist in this area, to determine if the research factors differ based on organisation size or structure. While this study was focused on the flow of knowledge within collaborative activities, there is evidence in the literature that effective knowledge management strategies may tend to enhance the flow of knowledge. Therefore, a longer-term study examining changes in the flow of knowledge before and after performing collaborative activities would yield useful and interesting results.

Finally, further work is required to develop measures to determine the flow of knowledge while performing the above mentioned collaborative activities. Such research will help determine, establish and confirm the benefit and impact knowledge flows have on work practices and resources of an organisation. Assuming that such access can be negotiated, this will enable researchers to build on the findings of the extended longitudinal work offered through this research.

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