December 2004

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Abstract

A number of process improvement failures have been attributed to unjustified commercial strategies, inadequate process orientation, or just based on deficient application (technological or otherwise), but it appears that many repeatedly overlook the organisational elements, attributes and behaviours of the sociocultural systems that can form the foundation of success. This research effort seeks to provide further understanding, by illustrating some parallels through which Software Process Improvement (SPI), Organisational Learning and Knowledge Management (KM) strategies might be seen as a multilateral approach to understanding and improving organisational capability.

Keywords

Knowledge Management, Software Process Improvement, Organisational Learning

INTRODUCTION

Over the last 10-15 years many software development organisations have initiated new approaches and practises in seeking to develop "performance improvement" strategies. They often look to a range of theoretical frameworks and technological models in an attempt to improve their own characteristic situation. Many of the organisations that have selected one of the myriad of options available have failed to realise expected benefits from their chosen initiatives, for a range of multifaceted and often complex reasons. Improvement success stories provide testimony of the progress, enrichment and maturing of the organisation but the many organisations that fall shy of expectations (or fail completely) are not always as keen to provide a candid account of their endeavours. Whilst this may safeguard against market perceptions in not wanting to disclose financial losses incurred etc, many just don't know what went wrong. These organisations gradually become members of the disenfranchised that will prevent further failure (and genuine success) by total avoidance of these "business improvement" concepts.

Those software development organisations undertaking software process improvement (SPI) programs typically utilise normative models to assess current software practices and offer guidance on how to implement improvement practices and activities. Pursuing process improvement outcomes/benefits through the adoption of formal software improvement models and standards (SPICE-ISO 15504, CMM, CMMI, ISO/IEC-12207, ISO-90003:2004 etc.) or more generic business process improvement strategies (BPR etc.), has seen a number of success stories but numerous failures and many achieving very low success rates (Goldensen and Herbsleb, 1995; Mathiassen et al, 2001; Wilson et al, 2000). Some even regress while the improvement and implementation practices are being institutionalised into the organisation. Typically, SPI programs fail because of three major causes: the lack of software management skills where often the emphasis is on skill development in technology rather than process, the late impact of the improvement program on projects both for daily practices and for performance, and significantly, lack of management commitment and understanding (Debou & Kuntzmann-Combelles, 2000). Moreover, a number of authors suggest that these can be further decomposed into other contributing aspects of "critical success factors and critical barriers to success (Niazi et al, 2003), including an organisation's readiness to undertake such programs. As Wilson et al (2001) suggest, "How do companies evaluate and validate the necessary organisational requirements for the establishment of successful SPI programs?"

A number of these failures may have been attributed to unjustified commercial strategies, inadequate process orientation, or just based on deficient application (technological or otherwise), but it appears that many repeatedly overlook the organisational elements, attributes and behaviours of the sociocultural systems that can form the foundation of success. This research effort seeks to provide further understanding, by illustrating some parallels through which Software Process Improvement

(SPI), Organisational Learning and Knowledge Management (KM) strategies might be seen as a multilateral approach to improving organisational capability.

SPI can be seen as a strategy for learning and knowledge management

There is good reason for the analogy and linking of software process improvement (SPI) and knowledge management (KM) in the software business. Process improvement practices which include process assessment of capability (and of current organisational knowledge specific to the process tasks/activities), benchmarking, best practice transfer, and even employee development point to the realisation of the importance of organisational knowledge and management of those "recognised intangible assets" in general. The creation of organisational knowledge, or intellectual capital, is needed to meet product or customer needs, and is driven through the relationship of human capital (employee knowledge and skills), structural capital (organisational capability to respond to market demands) and customer capital (Kakabadse et al, 2001). This mandates that making knowledge explicit and managing it like a precious resource; for example, each experience realised or improvement achieved must be transferred as fast and efficiently as possible to other projects/personnel. The relevance of having an integrated view on a process-orientation and knowledge management strategy is underlined by strong dependencies between the two approaches on the operational level. The identification of knowledge intensive software processes is strongly related to selection of promising candidates for process oriented knowledge management initiatives. Knowledge is created within the operative business processes and can be shared with other business processes (Maier and Remus, 2002). A performance capability driven focus would suggest that the goals that drive SPI or KM have to be aligned with the business goals of the organisation to ensure maximal contribution of knowledge to the company's organisational context.

Software process improvement strategies can support the flow of knowledge between business processes and possibly between business units as well as supporting the creation and collection of knowledge that can be characterised by the type of knowledge activities or processes it (primarily) focuses on. "*It can be argued that knowledge management is core to software process improvement models, for example, these models advocate that information about processes be defined, standardised, and used by the entire organisation*" (Meehan & Richardson, 2002). Bomarius et al, (1998) suggest that continuous improvement (within any business domain of non- trivial complexity) requires continuous learning on the organizational level and that individual learning, while still an essential requirement, would be far too slow if it were the only means of learning and dissemination of knowledge. Nonaka (1994) postulates that the fundamental basis for the theory of organisational knowledge creation should be focused on the active, subjective nature of knowledge (represented by such terms as "belief and commitment") that are "deeply rooted in the value systems of individuals". This "situated knowledge" is embedded in and carried through multiple entities of the organisation including flows and systems, actions and events, objects and artifacts, organization culture (history and identity, routines, policies, values, norms, etc.), as well as individual employees (Ciborra et al, 1996).

The basic components of a well managed knowledge/learning environment therefore, consist of expressed organisational knowledge (and knowledge structures), the knowledge processes by which they come about and through the people that are implicated. The organisational learning process, ie knowledge acquisition, dissemination, interpretation etc, suggests that there is a modification of behaviour as a consequence of this learning process, and it is this level of learning, that is critical to the achievement of software process improvement. The important distinction that leads to questioning what type of learning is apparent - is whether the organisation is prepared to modify its underlying assumptions and strategies, and consequently modify its own learning system, which conditions the prevailing patterns of organisational inquiry (Argyris and Schon, 1978). This level of learning can vary in depth and extent, and is dependent on the changes to the underlying norms, routines, practices, knowledge base etc. of the organisation (see figure 1).
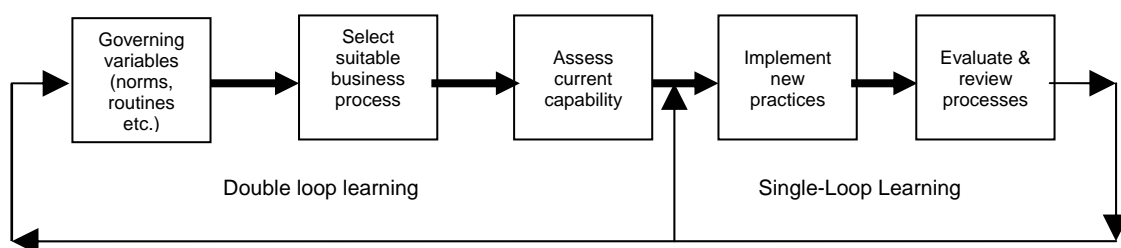
Figure 1. Software Process Improvement with single and double loop organisational learning infrastructure (Argyris and Schon, 1978)

Argyris and Schon maintain that there are three modes of learning: single loop, double loop, and deutero learning. Single loop learning occurs when errors are detected and corrected and the firm carries on with its present policies and goals. Double loop learning occurs when in the detection and correction of errors, the existing norms, procedures, policies or objectives of the organisation are modified. Deutero learning occurs when an organisation "learns how to learn", that is: "*When an organisation engages in Deutero learning its members learn about previous contexts for learning. They reflect on and inquire into previous episodes of organisational learning, or failure to learn. They discover what they did that facilitated or inhibited learning, they invent new strategies for learning, they produce these strategies, and they evaluate and generalise what they have produced*" (Argyris and Schon, 1978). It is this type of learning that is of most interest to the successful adoption of SPI practices and knowledge creation. The organisation must "reflect on and inquire into previous episodes of success, or failure to learn" and transfer that into new episodes of learning. Fundamental to this assertion is that an organisations' knowledge and learning environments can be made explicit and managed explicitly.

In the development of new software or in an improvement program (i.e. performed as a distinct project of its own merit), new methods, techniques, or procedures may be explored, but it is critical that organisations not only change their daily work practices but make modifications to the organisations underlying competencies, knowledge base or routines. Where explicit knowledge is treated as knowledge that can 'provide evidence' or be formalised, tacit knowledge is deeply embedded personal beliefs, attitudes, values and experiences that give knowledge its meaning. As such it is at best difficult and at worst impossible to articulate as it is highly situated in the context and to abstract it from its context of application is to lose much if it's intrinsic meaning and value, as Markus et al, (2002) suggest, knowledge intensive processes have challenging information requirements. This reference to "emergent knowledge processes", offers a precise view of software development practices and the characteristics these processes often exhibit in combination: deliberations with no best structure or sequence; highly unpredictable potential users and work contexts; and information requirements that include general, specific, and tacit knowledge distributed across experts and non-experts. Fundamentally, the organisation provides a context for individuals to create knowledge through social interaction, both formally and informally. Informal communities of social interaction can provide a forum for nurturing the emergent property of knowledge, for example, intra-organisational communications between software developers and the IT support group in defining solutions to customer/client problems. Alternatively, the prescribed documentation and specifications communicated between project members or interest groups constructs new emergent knowledge and understanding.

As mentioned previously, many process improvement attempts that have been unsuccessful have concluded that a concentration on technology rather than process often with poor management support and commitment inhibited the actual transitioning of the SPI program into the organisation. As such, m many organisations have repeatedly overlooked the organisational elements, attributes and behaviours (the formative context) of the sociocultural systems that may possibly form the foundation of success.

The formative context and SPI

The formative knowledge creating context represented (figure 2.) refers to the pre-existing arrangements, cognitive frames, and imageries that actors bring and routinely act in a situation of action, and comprises the interpretive schemes and organisational routines that influence the problem solving in the organisation (Ciborra et al, 1996). The framework helps establish an understanding of the sources of situated knowledge creation and accumulation processes (through the flows and systems, objects and artefacts, and actions and events) of the organisation, and determines where that knowledge resides after use (organisational memory) and the formative context that develops. The "interpretive schemes" refers to the individual's own interpretation, perception, experience, history, and cultural background in the context of the software development environment in which the learning takes place

The ability of an organisation to learn and adapt to its environment, as well as its capacity to grow simultaneously, will often depend on the formative context and associated cultural forces that undermine its capacity to learn (Murray and Chapman, 2003). Dube' and Robey (1999) describe three cultural perspectives that are valuable to appreciate that may reside within this sociocultural system: an "*integration*" perspective, that views culture as a set of values and assumptions that are shared by all

members of an organisation and united by cultural themes (i.e. unified in work, valuing innovation and rewarding hard work etc); the "*differentiation*" perspective, that is sceptical of the organisation-wide consensus (assumptions, practices and interpretations may be inconsistent and consensus exists primarily within sub-cultural boundaries); and the final perspective, of "*fragmentation*" that seeks to escape simplicity, order and predictability imposed by the first two perspectives and considers ambiguity, complexity, multiplicity and flux to be the essence of organisational culture. These three cultural perspectives (i.e. may/may not exist in the organisation) will therefore offer multiple interpretations and challenges to the researcher, but present significant opportunity to understand the organisational situation i.e. software development environment in an organisational context. The requirements of SPI adaptation may therefore be accommodated by changes in the socio-structural system (those interworkings of formal structures, policies, strategies and management processes) that may or could not be translated into the cultural system, thus bringing these systems into a state of dissonance or dissynchonisation (Allaire and Firsirotu, 1984).

The framework used to examine the progress of a [software] process improvement program within the organisation (in terms of its contribution to organisational learning and knowledge management), included the performance of software process assessments, the use of focused project group and individual interviews, observation of developers and other organisational members at work, and examination of documentation within the organisation. By inquiring into the actions and behaviours of individuals and project teams, based on a description of daily practices and routines, process assessments and participant observation, the framework was used to help consider where knowledge is situated in the organisation by exploring their "learning loops" i.e. find the strengths and weaknesses in the actual learning processes. Learning loops are how people at work engage in knowledge acquisition, dissemination and interpretation based on individual and collective actions and reflections (Ciborra et al, 1996). Nonaka (1994) describes this as a spiral of knowledge conversion that has "socialisation, externalisation, combination and internalisation" modes that are enacted by the organisation through its individuals. Examination of these "learning loops or modes of knowledge creation" using process assessment (and improvement) practices can be used to identify key processes of knowledge production and accumulation in the organisation. Although it is to be remembered that there is an effective "duality of learning" that exists with knowledge management practices facilitating continuous and ongoing routines of learning and unlearning within those specific business processes.
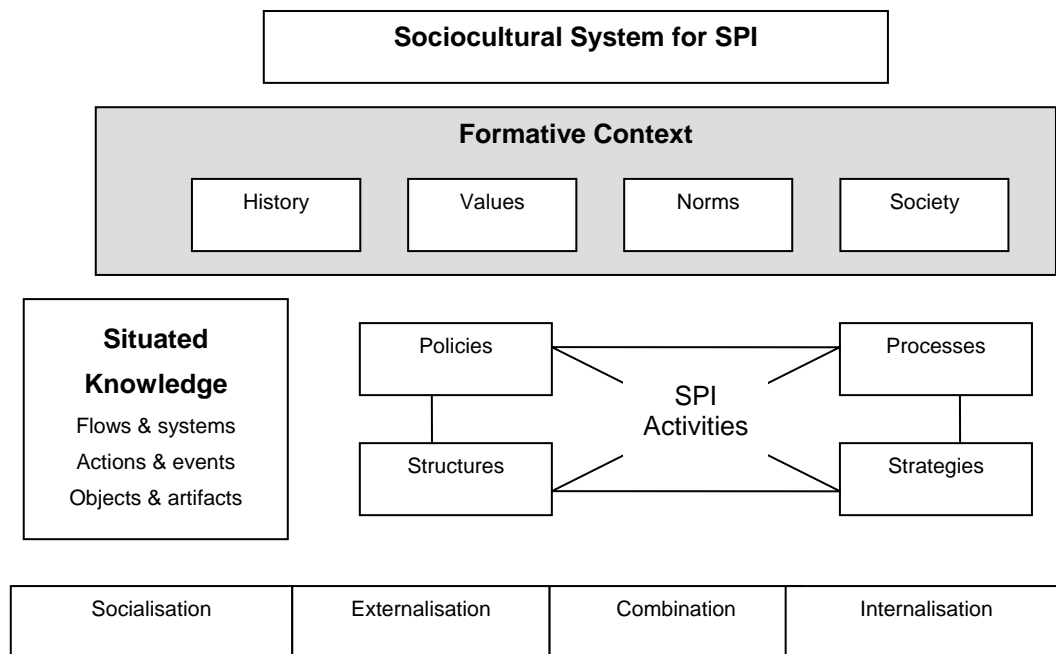

Figure 1. The formative knowledge creating context

In many cases an SPI approach is related to incremental and cumulative improvements that contribute to the organisation's ability to produce and deliver quality software (within time and budget constraints etc.). Considered improvements would not just become part of the task but would become part of an appropriate organisational learning and knowledge management infrastructure to support the changes

at an organisational level. This is an interactive social process that takes place between individuals, groups and organisational units (Kautz and Thaysen, 2001). Sharing knowledge between actors is considered to be a socialisation process and provides contextual basis for the dissemination of "right information to the right decision maker at the right time". Thus Nonaka's (1995) "spiral of knowledge creation" sees the four processes – socialisation, externalisation, combination and internalisation" as part of the knowledge infrastructure. Knowledge transfer with an individual or group of individuals shares the knowledge or "know-how", thus establishing the right conditions for new knowledge to be created and consequently, the development of personal learning (Kakabadse et al, 2001; Nonaka and Takeuchi, 1995). For SPI, this becomes an important and integral component of situated learning (Lave and Wenger, 1991). Lave and Wenger suggest that learning occurs in the function of the activity, context or culture in which it occurs. It is situated through the social interaction within a "community of practice", which embodies the behaviours and beliefs of the learners.

The challenge that software organisations face
Huber (1991) and Nonaka (1994) define knowledge as "a justified belief that increases an entity's capacity for effective action". Kakabadse et al (2001) suggest there are various conceptualisations of knowledge, and thus, confusion as to what constitutes knowledge management; and that there is often no coherent framework for implementing the management of knowledge in the organisation. In order to effectively manage knowledge one has to understand the meaning and significance of knowledge, understand one's own ability and limitations of knowledge and its potential meaning for organisational endeavours. The difficulty most organisations face is that abstractly, the concept of knowledge may be viewed from several perspectives (1) a state of mind, (2) an object, (3) a process, (4) a condition of having access to information, and/or (5) a capability (Spielger, 2000). These different views of knowledge lead to different perceptions of knowledge management and consequently different interpretations of how to create, manage and store knowledge in the organisation. If knowledge is a process, then the implied knowledge management focus is on knowledge flow and the processes of creation, sharing, and distribution of knowledge. Continuous organisational improvement suggests a knowledge management perspective centred on building core competencies, as a "knowledge" capability, and possibly accumulating intellectual capital. The major implication of these various conceptions of knowledge is that each perspective suggests a different strategy for managing the knowledge and a different perspective of the role of systems in support of knowledge management.

Kakabadse et al, (2001) suggest that knowledge management needs to embrace people, process, technology and culture. However, knowledge management encompasses broader issues, and in particular, creation of processes and behaviours that allow people to transform information into the organisation and create and share knowledge. Korac-Kakabadse and Kouzmin, (1999) refer to these as vertical and horizontal knowledge transfers which are seen as long, expensive and difficult processes that require technological, physical and intellectual infrastructures. Agarwal *et al.* (1997), contend that the inability of organisations to cope with uncertainties can often be attributed to a non-existent but essential social and organisational infrastructure for individual and collective learning. The success and continuous improvement of organisations will be seen as dependant on their ability to see things in new ways, gain new understandings, and produce new patterns of behaviour, on a continuing basis and in a way that engages the organisation as a whole. But such new ideas will not by themselves create a new learning organisation. Without accompanying changes in the way work is performed, only the potential for improvement exists.

Continuous improvement not only requires a commitment to learning on the part of the organisation, but an explicit strategy of managing and sharing of the knowledge. While reengineering implies one-shot radical change in organisational processes to achieve maximum increases in efficiency, knowledge management implies continuous and ongoing renewal of organisational schemas to anticipate the future opportunities and threats. Knowledge management can then be seen as a framework within which software organisations can view all its processes as knowledge processes. In this view, all business processes involve creation, dissemination, renewal, and application of knowledge toward organisational sustenance and survival. Knowledge management through process improvement facilitates continuous and ongoing processes of learning and unlearning. This can be knowledge processes supporting the collection, processing and storing of information as an outcome of conventional business processes. The achievement of such objectives not only relies on aspects of communication and technology, but the organisation's knowledge infrastructure. This infrastructure becomes part of a formative context of the organisation that influences the 'learning' process, and in doing so, is also structured by its result (Orlikowski, 1992, Giddens, 1976).

Organisational knowledge may be specific information embedded in software development routines and processes which enable progress through the development lifecycle. It could also be knowledge captured by the organisations documentation systems, training processes, product releases, software support rules and customer culture. That is to say - knowledge that is created within the operative business processes may be shared with other business processes; on the other hand knowledge also plays a crucial role when an organisation decides to implement the concept of process improvement. Nonaka (1994) describes this spiral of knowledge conversion as "socialisation, externalisation, combination and internalisation" that is enacted by the organisation through its individuals. All of these modes interact in a dynamic and continuous entanglement to drive the knowledge creation process. By concentrating on the concept of organisational knowledge creation, it is possible to develop a perspective that goes beyond the straightforward notions of "organisational learning". If we also recognise that knowledge is recursive and reflexive in nature, i.e. a process that generates new data and information, as well as new knowledge, then the formative context of the organisation influences the management of knowledge, and in doing so, is also structured by its result. Often this can be initiated or established through change as a result of establishing software process improvement programs or introducing knowledge management practices (or technologies). This "structuration process" changes the formative context through interaction of software developers, managers, customers etc. and influences the structural features of the organisation which is a key factor for successful continuous process improvement. The development and distribution of process knowledge in improvement or change processes contributes to the adaptation of an organisation to environmental change.

The dissonance or dissynchronisation referred to previously is a consequence of the adaptation of new or dissimilar SPI practices, often leads to significant changes in the sociostructural system (formal policies, goals, strategies and management practices etc) of the organisation. For example, new training and education practices for members is often required, structural change to the power and control mechanisms of the Process Engineering group or the Quality Assurance group is deemed necessary, and finally, management are encouraged to take a different view of the SPI strategy, in regards its motives and outcomes etc. This all becomes part of a new learning and knowledge infrastructure.
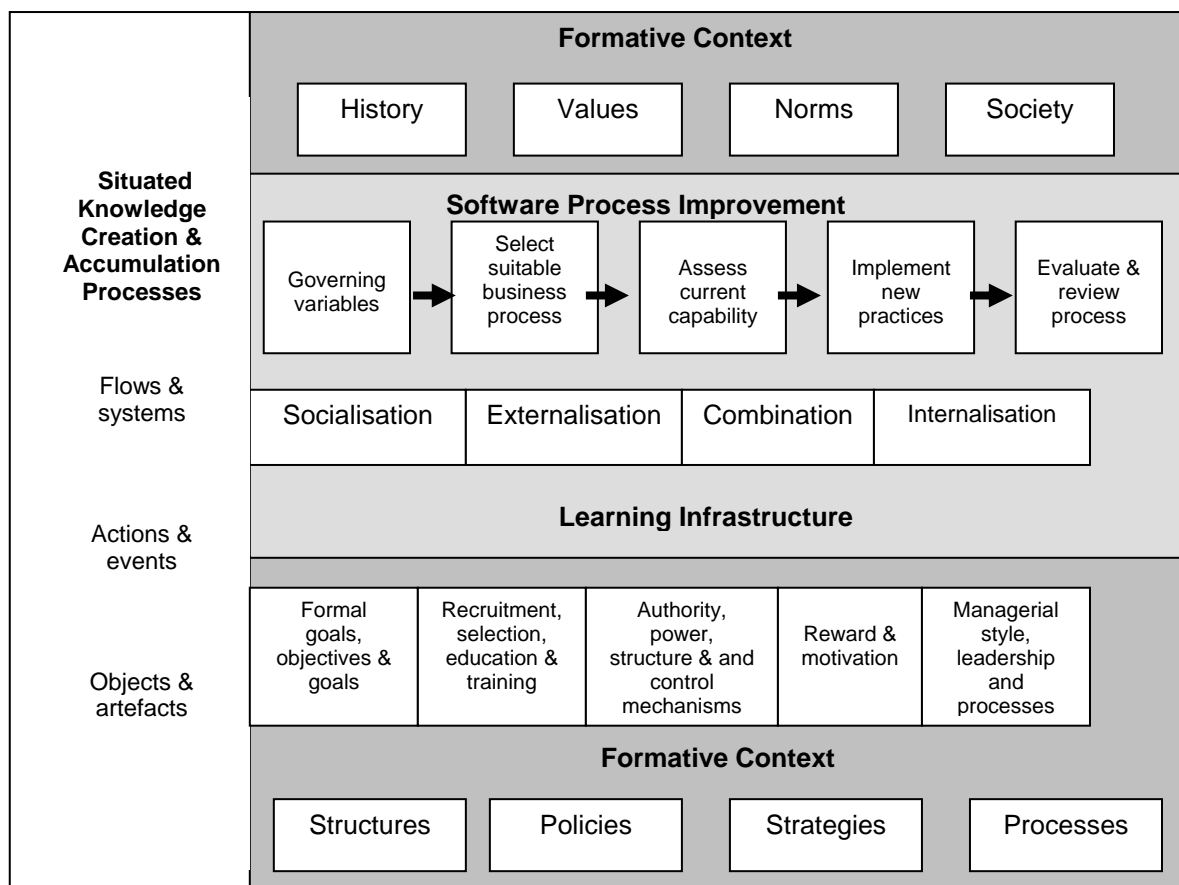

Figure 3. Organisational Knowledge Infrastructure for SPI (Adapted from Organisational Learning Evaluation Cycle- Gasston and Halloran, 2000)

CONCLUSION

This fundamental rethinking doesn't appear in the form of top-down reshuffling of organisational processes, people and structures. It is ingrained in the day-to-day operations of the business at the operational level and driven by the people who interact within the "formative context" of the organisation. However, as previously mentioned, knowledge management encompasses broader and more intricate issues, and in particular, creation of processes and behaviours that allow people to transform information into the organisation and create and share knowledge should be leveraged. Organisations must be aware that individual members will acquire, disseminate and interpret information from various sources of situated knowledge within the organisation and as a result lead to behavioural change and performance improvement. But it is important therefore that organisations identify these potential sources, so as to obtain optimal benefits from software process assessment and improvement programs through knowledge management. Starting with a single business process may have some advantages concerning the acceptance of the knowledge management activities to other business processes; however, preliminary findings showed that significant improvements of the handling of knowledge in one business process became important success factors for the implementation of organisational knowledge management benefits. Identified knowledge processes could provide support for the flow of knowledge between business processes and business units as well as the (business process independent) creation and collection of knowledge. In order to effectively manage "process" knowledge, one has to understand the meaning and significance of the process oriented knowledge, understand one's own ability and limitations of identifying and using that knowledge and its potential meaning for broader organisational endeavours.

In order to effectively assess an organisation's capability to continuously improve its processes, human actors engage in an active process of sense making to continuously assess the effectiveness of those 'best practices.' In this view, 'best practices' are not implemented without active inquiry by the human actors. More importantly, they should have the capability of judging if the organization's 'best practices' are aligned with the dynamics of the business environment. Such knowledge workers are the critical elements of the "*double loop*" learning and unlearning cycle that should be designed within the organisational business processes. The software developers would also need to have an overall understanding of the business of their organisation and how their work contexts fit within it. Such understanding is necessary for their active involvement in the organizational unlearning and relearning processes. Only if they understand the implications of changes in their work contexts for the business enterprise, they can be instrumental in synchronising the organizational 'best practices' with the external reality of the business environment. Given the need for autonomy in learning and decision making, such knowledge workers would also need to be comfortable with self-control and self-learning. In other words, they would need to act in an intrapreneurial mode that involves a higher degree of responsibility and authority *as well as* capability and intelligence for handling both.

Further, if the software process improvement/knowledge management activities can be made explicit, they may help improve software process maturity in the organisation (Meehan and Richardson, 2002). Data gathered during the assessment process may be analysed in terms of identifying process strengths and weaknesses and identifying opportunities for improvement based on stated business objectives. The results of the assessments conducted during this period can be compared to identify the extent to which recommendations for improvement had or had not been adopted over the agreed period of time. Further examination of the results of the process assessments can be conducted to identify the mode of learning and exploring whether learning within the organisation is moving through behavioural change and consequent performance improvement.

This last step in the model examines movement through organisational learning phases in order to explore whether continuous learning is in fact taking place; that is, a restructuring of the formative context of the organisation, and hence, the situated knowledge. That is, whether changes to processes had in fact occurred and secondly, whether those changes had been embedded into the organisation's infrastructure and formative context through behavioural change. The aim is to "observe the knowledge attributes and knowledge dependant processes" under review and identify where knowledge is now located within the organisation.

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