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A Maturity Model for Quality Improvement in Knowledge Management

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Abstract

Due to the growing importance of knowledge management (KM) for business success, it is increasingly employed to enable organisations to achieve sustainable competitive advantages. However, no approach has been developed yet which allows organisations to determine their current state of KM on a process level and to derive the necessary steps for further development. To fill this gap, a new model called Knowledge Process Quality Model (KPQM) is proposed. This model is based on the ideas of quality management and process engineering. It helps organisations to assess and improve their KM structures to control knowledge processes. Thereby it also supports systematic knowledge management learning.

Keywords

Continuous Quality Improvement, Knowledge Process, Knowledge Management Maturity, Knowledge Management System

INTRODUCTION

In the current volatile economic environment, Knowledge Management (KM) is becoming more important for achieving sustainable business success. Especially knowledge-intensive companies (e.g. financial services, chemical industry, consultancies) have started KM initiatives to be able to meet the challenges of the dynamic markets. However the question arises, whether these initiatives are successful and whether the right initiatives were chosen at all. To answer this question, both researchers and practitioners have developed different approaches to measure the impact and success of KM. Viewed from the perspective of quality management, the limitations of these approaches require the development of a new concept to assess and enhance KM on a process level.

In order to close that gap we propose a new model which is driven mainly by the ideas of quality management in software engineering: the Knowledge Process Quality Model (KPQM). The underlying idea of that model is that knowledge processes can be improved by enhancing the corresponding management structures. Designed as a maturity framework, KPQM allows the identification of different stages of maturity and the implementation of a continuous quality improvement process. Therefore it supports the systematic and successful implementation of KM by allowing managers to analyse the current status of KM practices and to determine necessary activities and their priorities.

This paper is structured as follows: first, existing models to determine and improve the quality of KM are analysed. Based on this analysis, the structure and elements of KPQM are presented. This is followed by a description of how to use the model for continuous improvements. Additionally, the application of the model is illustrated by an example from software development. Finally, potential issues for future research are outlined.

QUALITY OF KNOWLEDGE MANAGEMENT

Up to now, no commonly agreed definition of KM exists. Several authors define the task of KM as the management of “processes by which knowledge is created and applied” (Quintas *et al.*, 1997). Other authors emphasise the importance of the creation and maintenance of an organisational knowledge base (e.g., Maier and Lehner, 2000). Based on this process-oriented view, the following definition of KM will be used:

- Managing knowledge processes to support business processes. This includes the management of activities such as using or distributing knowledge.
- Managing knowledge processes to support the organisational knowledge base (organisational memory), e.g., the management of storing new knowledge, or evaluating existing knowledge.

Most authors agree that KM is a comprehensive management concept that has been influenced by several disciplines. KM has to consider organisational, human (i.e. psychological and sociological) and technological aspects in order to deliver a thorough and successful business support (Quintas *et al*., 1997). Unfortunately, many practitioners tend to concentrate on isolated aspects that are mostly either human- or technology-centred and therefore miss the opportunities of an integrated KM approach.

In this paper, the term Knowledge Management System (KMS) does not only refer to technological systems (software and/ or hardware), but comprises all system elements: organisation (including processes), people and technology.

In order to assess and improve KMS numerous approaches have been developed. As a basis for this research, existing approaches were analysed and grouped by using four attributes: level, object, precision, and scale of analysis. “Level of analysis” describes the organisational level for which the analysis is designed. The “object of analysis” explicates the entity that is to be analysed. “Precision of analysis” examines the question, what kinds of indicators are used, whereas “scale of analysis” investigates how many indicators are analysed and how they are ordered. Since not all models can be described thoroughly in this paper, only selected aspects are presented to describe the different types of models. Table 1 summarises the main characteristics of selected examples.

Example	Model	Level of Analysis	Object of Analysis	Precision of Analysis	Scale of Analysis	Characteristics	Limitation
Strassmann (1998)	Knowledge capital	Unit level	KM results	Quantitative measurement	Single indicator	Market-based indicator to support the value determination of companies	Does not allow detailed evaluations of KM
Sveiby (1997)	Intangible Assets Monitor	Unit level	KM structures	Quantitative measurement	Various indicators	Systematic framework for designing measurement systems for intangible assets	Unit-based view makes it difficult to transfer results directly to business processes
Hiebeler (1996)	Organisational KM Model (KMAT)	Unit level	KM structures	Qualitative measurement	Percentage rating (importance and performance)	Benchmarking against results in other organisations	Strategic model which makes it difficult to derive operative actions
Langen (2000)	KM Maturity Model (KMMM)	Unit level	KM structures	Qualitative measurement (quantitative within model)	Five stages	Systematic development of KM structures	Not based directly on processes like CMM
Swaak *et al*. (2000)	KM Evaluation (KnowME)	Unit and individual level	KM structures and results	Qualitative and quantitative measurement	Various indicators	Identifies management and employee view on KM	Does not assess KM structures in concrete business processes

Example	Model	Level of Analysis	Object of Analysis	Precision of Analysis	Scale of Analysis	Characteristics	Limitation
de Gooijer (2000)	KM Behaviour framework	Individual level (combined with unit level)	KM behaviour	Qualitative measurement	Seven stages	Identifies concerns about adopting KM (combined with scorecard-approach)	Does not assess KM structures in concrete business processes
Housel *et al.* (2001)	Knowledge value-added	Process level	KM results	Quantitative measurement	Single indicator	Basis for assessing projected benefits of IT investments from KM perspective	Requires several assumptions to calculate value which may not be valid in every case
Roy *et al.* (2000)	KM Performance Measurement Framework	Process level	KM results	Quantitative measurement	Various indicators	Systematic approach to develop process-based indicators	No measurement of necessary KM structures
Bohn (1994)	Stages of knowledge	Process level	Technological process knowledge	Qualitative measurement	Eight stages	Active steering of learning processes in production	Limited possibility to transfer model on other types of knowledge
Moore (1999)	Knowledge Work Measurement	Process level (software projects)	Knowledge work influence factors	Quantitative measurement	Various indicators	Determines the impacts and interrelationships of influence factors	Operative limitations, since numerous different metrics are necessary

Table 1: Characteristics of existing approaches for measuring KM

Level of analysis

On a *unit level* in the sense of an organisational unit, assessments are performed for whole companies or business units. This delivers a broad overview of the current state of KM, but makes it difficult to derive concrete activities for single business processes. Examples range from the calculation of the knowledge capital of a company (Strassmann, 1998) over benchmarking models (Hiebeler, 1996) to more detailed maturity models (Langen, 2000).

On the other hand, *individual level* approaches concentrate on the attitude of employees towards KM and on their resistance to necessary changes (de Gooijer, 2000). Again, it can sometimes be difficult to determine the right activities which are suitable to add value directly in business processes.

Process-based models have the potential to combine both views. Since processes can be examined on different levels of aggregation, high level and detailed analyses are possible. Process models also allow one to directly assess the impact of KM activities on business processes. A framework to derive corresponding indicators has been developed by Roy *et al.* (2000).

Object of analysis

Most approaches assess either *KM structures* (enablers) or *KM results* (e.g., Sveiby, 1997; Housel *et al.*, 2001). Other models, such as KnowME (Swaak *et al.*, 2000) that is built upon the ideas of EFQM (1999), consider both enablers and results. An interesting approach was chosen by de Gooijer (2000), who proposes to analyse *KM behaviour* that can also be viewed as a result from existing KM structures.

Different approaches were developed by Bohn (1994) and Moore (1999). Bohn (1994) measures *process knowledge*, restricting his analysis to technological knowledge while Moore (1999) takes a special view on KM by analysing *knowledge work* and its influencing factors in software projects.

Precision of analysis

Indicators can generally be distinguished between *quantitative* and *qualitative*. Some models combine both types of indicators, thereby balancing the respective advantages and disadvantages (Swaak *et al*.). The KMMM (Langen, 2000) is based on qualitative analysis, but includes quantitative factors within the model: on the "managed" stage the systematic use of KM measures is required. In this model, the use of quantitative indicators is therefore a sign of KM maturity.

Scale of analysis

Many models provide a framework to systematically derive *multiple performance measures* for KM (e.g., Sveiby, 1997). Some models use only *one indicator* to assess KM for a whole organisation (Strassmann, 1998) or single processes (Housel *et al*., 2001).

Maturity models are based on a defined *range of stages* that serve to measure the maturity or capability of the object of analysis. In contrast to other indicator approaches they allow one to describe explicit development steps and adequate measures for improvement.

Requirements for a new approach

Many KM ideas like system approaches or continuous learning are also fundamental ideas of Quality Management (QM). Adopting the established QM concepts for the relatively new theory of KM could therefore give valuable insights for further developments. From a QM perspective, an ideal model for evaluating KM should contain the following elements (Wilson and Asay, 1999):

- Focus on processes.
- Employee involvement.
- Continuous learning and improvement.
- Measurement and standardisation.

The number of KM approaches which take account of quality management (QM) concepts (e.g., Langen, 2000; Swaak, 2000), demonstrate the influence of QM on KM. However, Table 1 shows that none of the existing approaches meets the requirements listed above. A new model should therefore be a process-based model which takes account of employee concerns towards KM and includes the idea of maturity for measurement, standardisation and continuous improvement.

During the research for a new model the authors took up the ideas from Langen (2000) and Moore (1999) and analysed existing QM models in software management. Since software can be viewed as a knowledge medium (Armour, 2000), it seems to be a valid assumption that models from software management can be adopted for KM.

Langen (2000) uses the concept of maturity from the Capability Maturity Model (CMM) (Paulk *et al*., 1993). The CMM that is based on the generic Quality Management Maturity Grid (Crosby, 1979) is used to evaluate the maturity of a software producing organisation. It can be used to assess the management of processes in software development on five maturity stages. These stages define requirements on the process structures, ranging from initial to optimising. Later supplements to the CMM take account of special human resource and KM issues, e.g. the People CMM (Curtis *et al*., 1995) for human resource management, or additional key process areas for KM (Baskerville and Pries-Heje, 1999).

Although based on processes, CMM only allows the evaluation of whole organisations, because each process is assigned to one maturity stage and not assessed independently from the other processes. This criticism of CMM led to the foundation of the SPICE project (Software Process Improvement and Capability dEtermination) that afterwards was the basis for the development of ISO/ IEC 15504. The SPICE model has been designed to evaluate individual process structures instead of whole companies (El Emam *et al*., 1998). Special process attributes are used to evaluate management practices on the basis of six maturity stages ranging from incomplete to optimising. Therefore, the quality of process structures is defined by a set of attributes – a view which conforms to the concept of quality by Smith (1993). Recently, the SPICE concepts have been adopted for CMM to create the continuous representation of the new model CMM Integration (CMMI Product Team, 2002).

The comparison with the requirements stated above shows that the process-based SPICE methodology seems to be an adequate basis for the development of a new KM assessment model. However, it is, similar to CMM, necessary to take into account the special characteristics of knowledge processes and KMS.

THE KNOWLEDGE PROCESS QUALITY MODEL (KPQM)

Based on these ideas, the authors developed a maturity model that allows both assessing KM on a process level and outlining the path for further improvements. Its structure is built upon the following elements:

- Maturity stage dimension.
- Knowledge activity dimension.
- Management area dimension.
- Assessment structure.

Maturity stage dimension

SPICE is based on the six maturity stages 0 – incomplete, 1 – performed, 2 – managed, 3 – established, 4 – predictable and 5 – optimising. For KM, several adjustments to this stage structure are necessary to take account of KM characteristics:

- In software development, distinct work products can be defined to evaluate whether a process is performed completely or not (step from stage 0 to stage 1). In the context of knowledge processes this requires that special knowledge outputs can be defined and identified. The example of Bohn (1994) shows that measuring knowledge involves a high degree of complexity. Mostly the question rather is, whether a knowledge process delivers the desired output, not whether an output exists at all. For this reason, no stage 0 is used in KPQM. Instead, stage 1 (CMM term: initial, chaotic process) describes the primary state of KM.
- de Gooijer (2000) and Bohn (1994) emphasise the importance of awareness as a first step towards maturity. For KM it is a major prerequisite to create structures that make sure that the conscious handling of knowledge is embedded in daily work. Therefore, KPQM stage 2 is called “aware” instead of “managed”.
- While stage 3 and stage 5 were directly adopted from SPICE, the new CMMI term “quantitatively managed” was selected for stage 4. The authors believe that this term expresses the requirements of stage 4 better than the SPICE term “predictable”.

Maturity stage	Description
1 – Initial	The quality of knowledge processes is not planned and changes randomly. This state can be best described as one of chaotic processes.
2 – Aware	Awareness for knowledge processes has been gained. First structures are implemented to ensure a higher process quality.
3 – Established	This stage focuses on the systematic structure and definition of knowledge processes. Processes are tailored to react to special requirements.
4 – Quantitatively Managed	To enhance the systematic process management, measures of performance are used to plan and track processes.
5 – Optimising	The focus of this stage lies on establishing structures for continuous improvement and self-optimisation.

Table 2: Maturity stages of KPQM

Table 2 shows the resulting five maturity stages and their definitions.

Knowledge activity dimension

SPICE is designed to assess the maturity of management structures in software development. Since KPQM should support the assessment of generic knowledge process structures, it is necessary to define what these knowledge processes are and how they differ from business processes.

Generally, processes are a set of activities in a defined order. Knowledge processes can correspondingly be defined as a set of knowledge activities (KA). KAs represent those parts of business activities (BA) in which the handling of knowledge is of particular importance. Figure 1 shows that, depending on the knowledge focus, knowledge processes run in parallel with business processes or cross them (Karagiannis and Telesko, 2000). Following Sveiby (1997:30), “focal knowledge is the knowledge about the object or phenomenon that is in focus”.

Processes in software development can be grouped by using a theoretical framework like the software development lifecycle in order to simplify assessments. Figure 1 demonstrates that the development of such is problematic, since the knowledge focus and the business processes involved can vary considerably. Nonetheless, the idea of the software development lifecycle can be transferred to the knowledge lifecycle from creation to deletion. Thus, the different types of activities to handle knowledge are used as the basis for evaluation.

‘Which kinds of KAs can a knowledge process consist of?’ is a question, that been addressed by several authors (e.g., Nissen *et al*., 2000; Shin *et al*., 2001). From these works a set of KA types was extracted which allows the representation of all kinds of activity instances: identifying existing knowledge, generating new knowledge, using knowledge, storing knowledge, distributing knowledge and evaluating (eventually deleting) knowledge.

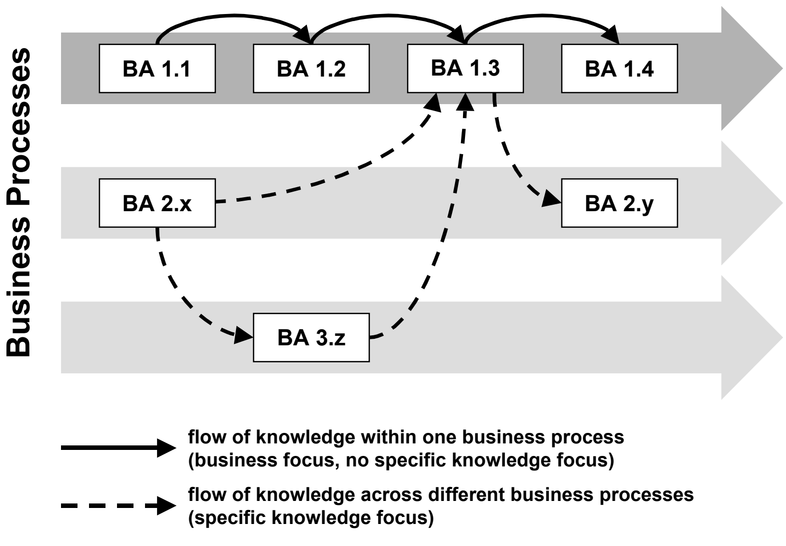

Figure 1: Business processes vs. knowledge processes

The different processes and activities demonstrated in Figure 1 hint at a potential conflict: knowledge processes may cross different business processes and therefore also different responsibilities. Therefore, a clear division of responsibility and an adequate model for management roles is necessary. In this paper, distinction will be made between one role responsible for a knowledge process called “process owner” and other roles responsible for the respective business process, simply called “managers”.

Activity type	Description
Identify	Comprises activities which aim at finding and procuring knowledge.
Generate	Activities for the development of new knowledge, e.g., R & D activities or external training.
Use	Activity type to describe the application of existing knowledge within the business process.

Activity type	Description
Store	Transforming existing knowledge into an explicit structure that can be re-used.
Distribute	Activities for transferring knowledge to other people, e.g., presentations, internal training.
Evaluate	Comprises activities for the evaluation of knowledge, e.g., regarding timeliness or relevance. Also includes devaluating or deleting existing knowledge.

Table 3: Knowledge activity types

Management area dimension

SPICE uses the maturity and the process dimension. For KM, an additional dimension, *management area*, serves to take account of the KMS elements organisation, people, and technology.

Within *organisation*, structures concerning process definition, responsibility (process owner) and staffing (process resources) are assessed. This area comprises important aspects of process organisation as already described in SPICE.

As de Gooijer (2000) pointed out, individual change management must be considered for implementing and improving KM. The management area called *people* therefore takes account of the incentive structures for employees and managers, who might be reluctant to adopt KM methods and tools.

The third management area, *technology*, is used to describe the information and communication technologies that are necessary to support KM methods.

Assessment structure

In SPICE, the unit for process ratings is a process instance that describes a singular instantiation of a uniquely identifiable process. Each instance is assessed by means of nine process attributes (PA).

In KPQM, the rating unit is the instance of a knowledge activity. For each stage from “aware” to “optimising”, five PAs were identified, by analysing the illustrated QM and KM models. In order to be compatible with the SPICE assessment structure, the management areas grouped these PAs. Therefore, the “attribute dimension” which consists of maturity stages and management areas can be used for every KA (reduction to a two-dimensional model). For a first overview, it is also possible to evaluate a knowledge process as a whole without differentiating between KAs. Table 4 shows the PA target values of the attribute dimension.

Maturity stage	Organisation	People	Technology
1 – Initial	none	none	none
2 – Aware	*PA 2.1*: The process is planned and documented. *PA 2.2*: A process owner and basic skill structures exists.	*PA 2.3*: Structures to gain individual employee awareness for KM methods exist. *PA 2.4*: Structures to gain individual manager awareness for KM methods exist.	*PA 2.5*: Partial technological support for KM methods exists.
3 – Established	*PA 3.1*: A standard process is established. *PA 3.2*: Skill knowledge is structured and people are staffed accordingly.	*PA 3.3*: An incentive system to use KM methods within the process exists. *PA 3.4*: An incentive system for managers to promote KM within the process exists.	*PA 3.5*: Systematic technological process support exists.
4 – Quantitatively Managed	*PA 4.1*: The process is managed on a quantitative basis. *PA 4.2*: Staffing decisions are managed on a quantitative basis.	*PA 4.3*: The incentive system for employees is managed on a quantitative basis. *PA 4.4*: The incentive system for managers is managed on a quantitative basis.	*PA 4.5*: The impact of technological support is evaluated quantitatively.
5 – Optimising	*PA 5.1*: Structures to improve the process on an ongoing basis exist.	*PA 5.3*: Existing structures promote continuous improvements in knowledge handling.	*PA 5.5*: Technologies for process support are optimised on a regular

Maturity stage	Organisation	People	Technology
	PA 5.2: Structures to improve staffing on an ongoing basis exist.	*PA 5.4*: Structures ensure continuous involvement of managers in KM.	basis, pilot projects are performed.

Table 4: KPQM process attributes

In order to determine the maturity stage for each activity or process, indicators to identify the existence of KM structures are necessary. Each PA is defined by general and activity-specific management practices. Table 5 shows an example for PA 3.2 (excepts).

Process attribute 3.2	***Process resource attribute*** **The extent to which staffing decisions are based on structured skill knowledge and the execution of the process uses skilled human resources.**
Activity-independent general practices	• Describe relevant knowledge structures (e.g. using ontologies or knowledge maps) • Define human resource skills • Communicate required process skills
Activity-specific practices: generate knowledge	• Provide adequately skilled human resources • Establish interdisciplinary teams to enhance creativity • Examine possibilities to acquire necessary skills (e.g. recruiting)

Table 5: Description of PA 3.2 “Process resource” (excerpt)

Additionally, management practices are further described by corresponding characteristics (qualitative indicators) and quantitative indicators in order to simplify the measurements of results.

In accordance with SPICE, process attributes are applied by using a four step rating scale: not achieved, partially achieved, largely achieved and fully achieved. To attain a particular maturity stage, the attributes of that stage have to be fully or largely achieved and all lower stage attributes are required to be fully achieved. Thereby the model allows some volatility in the ratings of the PAs.

Single maturity ratings may be aggregated. In SPICE, this is done by representing the distribution of all respective maturity stage ratings (El Emam *et al.*, 1998). For simplification, it can be defined that the least mature activity instance determines the overall maturity stage, since the management structure is not able to ensure a constant maturity stage. By applying this strict rule, a single maturity stage for a knowledge process or a set of KAs can be obtained, although considerable information on the stage distribution is lost.

USING KPQM

Given the complexity and variety of knowledge processes, it does not seem to be realistic to demand that all existing KM activities in an organisation be assessed. The improvement of knowledge processes is not an end in itself, but serves to improve business processes and to add value. Therefore, the approach of Roy *et al.* (2000) was adopted which starts with the identification of knowledge bottlenecks in business processes and ends with the measurement of business process results (Figure 2).

Measuring KPQM results also serves to validate whether the application of the model is suitable or not. Since KPQM is designed for process improvements, the results should also be measured on a process base. On a high organisational unit level (e.g., Strassmann, 1998), outcomes are influenced by too many external factors.The effects of applying KPQM can be evaluated with regard to the knowledge process or the business process. In the *knowledge process*, changes of the quantitative indicators for management practices will reveal positive or negative effects. However, these indicators cannot directly represent the effects in business processes. Therefore, suitable measures for the *business process* should be derived by applying the framework of Roy *et al.* (2000). For future research, it is an interesting question, how the process-based measure knowledge value-added (Housel *et al.*, 2001) can be used to validate KPQM.

To demonstrate the basic process of applying KPQM, the following simplified example from software engineering will be used. Figure 3 shows a part of the software development process (business process) of a software organisation, where recent analyses of customer satisfaction pointed to a problem in the business activity “Install software”. Although a minor issue at first glance, these problems regularly caused delays in the development process with high visibility for the customers. It was decided to approach the problems from a KM perspective using KPQM. First, knowledge activities with the knowledge focus on software installation were identified and modelled. To support the task of identifying the relevant activities, the knowledge activity dimension was used.

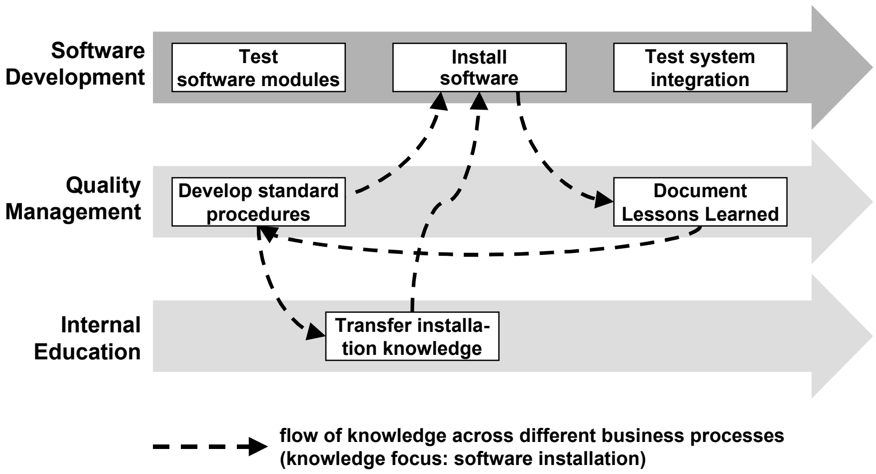

Figure 2: Generic process for using KPQM (cf. Roy et al., 2000)

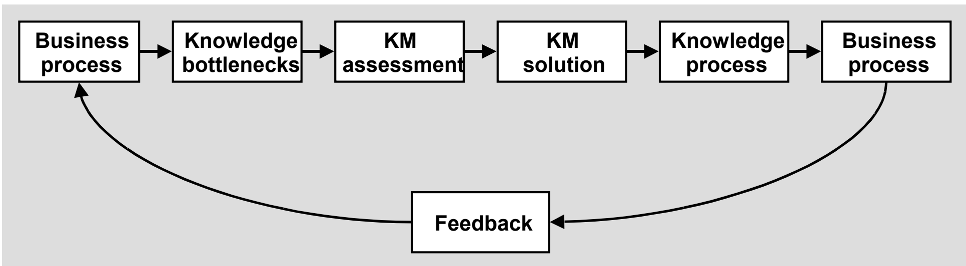

Figure 3: Knowledge process for software installation (simplified example)

Afterwards, the activity structures were evaluated using the PAs and the corresponding qualitative indicators. This delivered the following results: “Develop standard procedures” (generate): stage 2, “Install software” (use): stage 3, “Document Lessons Learned” (store): stage 1, “Transfer installation knowledge” (distribute): stage 1. The results show that KM structures exist to establish guidelines for software installation. The problem is the internal knowledge transfer concerning storing or distributing experiences. This first analysis allows the identification and prioritisation of the next steps. At first, stage 2 should be the stage of all activities. By skipping maturity stages, e.g. by solely enhancing the more mature activities, no significant improvements can be expected.

Up to now, no results could be measured. It is planned to use the indicators “duration to install software” and “customer satisfaction” to validate the KPQM results and the impacts of knowledge process changes on the focal business process.

CONCLUSIONS AND FUTURE RESEARCH

In this paper a new model was presented that has the potential to help companies to assess their knowledge management structures and to find ways for future improvements. Its process base allows organisations to enhance knowledge processes with direct results on business processes. Therefore, the model provides the basis for systematic KM learning and for building adequate KMS.

However, KPQM has a number of limitations. Like any process-based model, it does not prescribe the level of aggregation that is appropriate for process analysis. Either a too broad or a too narrow view may reduce possible insights and improvements. Furthermore, it does not recommend a distinct KM strategy (Hansen *et al*., 1999). Nonetheless, it is flexible enough to be applied within any level of aggregation, as well as for personalisation and codification strategies.

The improvement of knowledge processes implies a number of questions for future research. First of all, further tests are necessary to evaluate the model in practice. This also includes the analysis of suitable measures for validation.

Additionally, a modelling language to graphically represent knowledge processes is necessary to enable organisations to analyse and document knowledge processes systematically. For this purpose, the development of a formal representation using XML nets, a new form of higher Petri nets, is planned. This could allow modelling knowledge activities as well as the relevant knowledge objects and changes within these objects (Lenz and Oberweis, 2001). Additionally, modelling with Petri nets offers several possibilities for further use, e.g., simulations or workflow support (Desel and Erwin, 2000).

To progress on these issues, a research project at Goethe-University Frankfurt, Germany, is currently being carried out in co-operation with business partners.

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