Evolution of Intelligent Quality Management Process Based on Using Performance Quality Indicators

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Abstract: Today inadequate use of knowledge, experiences and human creativities is caused to a know-do gap in quality and performance management. In this sense enterprises are not able to sustain long-term organizational advantages, continuously improve the quality of performance and fulfill customer satisfaction. What can be done with Knowledge Management (KM) to overcome this challenge? KM is integrating various components on the organizational framework to empower an enterprise to develop customer-oriented approaches and to convert knowledge into added values and profits in long-term. In addition; this, in connection with innovations and culture-oriented approaches, results in enhancement of product lifecycle. In this paper, based on former efforts [An09a, An09b], a renewed process model for this integration approach is introduced entitled as Intelligent Quality Management Process (IQMP). IQMP utilizes performance quality indicators to evaluate the success of knowledge intensive business process. These indicators are defined either based on Key-Performance-Indicators (KPIs), Quality Indicators (QIs) or by adopting of experts/technical staff's objectives which is carried out within structured surveys or observations inside an enterprise. This paper addresses the concept and theoretical background of IQMP as the work-in-progress, and presents the first level results realized by implementation of a prototype of Management Cockpit.

1 Introduction

Transformation of a Quality Management (QM) society into knowledge and learned based society requires cross-functional and innovative approaches. One of the most famous philosophies and long-term corporate strategies of QM is Total Quality Management (TQM) in that the main objective is to enhance product, company and process quality [Pf02]. TQM is based on the three principles of customer, people and process orientation [Pf02]. The fundamental aim of TQM and related activities is to ensure continuous improvement of the performance of the enterprise [Pf02]. Although the three pillars of TQM are obviously indispensably vital, it still requires more resources to understand how information, knowledge or creative contents potentially

influence on effective management of customer, people and performance, and provide ways through efficient problem solving and process improvement. In this context Knowledge Management (KM) has a significant function to "turn information into actionable knowledge, foster innovation, enable learning from mistakes and best practices, and promote effective knowledge sharing" [Ep06]. Maier defines KM as "the management function responsible for the regular selection, implementation and evaluation of goal-oriented knowledge strategies that aim at improving an organization in order to improve organizational performance" [Ma07]. Obviously knowledge is valuable and worthwhile. Knowledge enables humans to make decisions, take action and solve problems, and therefore to implement strategies and achieve objectives [Pf02].Knowledge has now become the most important source for competitive advantages [Ra01]. Companies are therefore increasingly being transformed into intelligent enterprises and e-business, in which knowledge is being produced, absorbed and adequately commercialized [Ra01]. Thus enterprises which process more knowledge qualitatively than their competitors are capable to develop customer-oriented approaches to convert knowledge into added values and profits [Ra01].

1.1 Similarities and Differences

Besides, KM and QM (TQM) have some similarities considered in both concepts e.g. people-orientation, result-orientation, customer satisfaction, et al. [Ep06, EL10]. Also there are differences e.g. KM is more based on innovation and IT-based solutions [Wi06, Ma07] whereas TQM is more based on leadership and continuous improvement [Ra01, Pf02]. Therefore integration of KM into QM needs proper understanding and recognition of QM (TQM) deficiencies. For example, continuous improvement is not reached and maintained without sufficient and adequate knowledge [Pf02]. But an important issue is how to enable a system or enterprise with adequate knowledge? Also continuous improvement of the performance within the enterprise and increase customer satisfaction are reinforced by concentrating on utilizing KM and related aspects such as learning, transferring, exchanging and sharing of the skills, experiences, best practices and lessons learned. In QM the main objects are resources (e.g. personal equipments), processes and product services, whereas in KM the main objects are implicit and explicit knowledge (know-how, know-what, know-why, know-who) in all forms [Ep06]. Articulating knowledge (tacit knowledge) is often difficult, since it depends on the individuals. Therefore KM "must connect knowledge workers, elicit their knowledge, map their skills, and use their experiences" [Ep06]. The main tools and methods to fulfil effective KM is to use knowledge maps, expert directories, groupware systems, document management systems, enterprise content management systems, knowledge discovery and retrieval software, intelligent search engines, collaborative systems and web 2.0 tools like blogs, chat systems, forums and wikis.

There are different accounts according to integration of these two fields. On the one hand, the study published by Bullinger, Wörner and Prieto [Bu97] among 311 German companies in 1997 about the significance of KM and their expectations of it, confirmed the integration of two management skills in one unit towards improving product quality, increasing innovation capability and enhancing customer relations[Bu97,Pf02]. In

addition the revised version of European Foundation of Quality Management (EFQM) Excellence Model released in 2009 increases the significance of process-oriented QM approaches by activities of "innovations", "learning" and "creativity" [Ef09]. The revised version applies the term "creativity" to the whole EFQM Excellence Model [Ef09]. This, in turn, in conjunction with innovations and learning should result in an improvement cycle during application of the model and its implementation in the company [Pf02, Ef09]. On the other hand, some scientists believe while "these two fields share many common goals, such as the documentation of procedural knowledge and the continuous improvement through systematic learning, exchange between the two disciplines seems to be neither frequent nor intensive, nor particularly fruitful" [Li99, Ep06]. These accounts on integration of these two fields are mainly discussed earlier in [An09a, An09b].

Moreover, there are some questions and critiques concerning KM e.g. complexity, novelty, and distinctly differences from older theories and concepts such as organizational learning and organizational change [Ma07]. In this context, Maier warns against an implementation of KM systems without considering the human and organizational side, and believes that "a careful coordination with a corresponding strategy, an organizational design and people-oriented measures is required in order to provide a systematic and potentially successful intervention into an organization's way of handling knowledge" [Ma07]. On this point, Pfeifer also points out that apparently quality managers and knowledge managers pursue the same objectives and they are even runners in adjacent lanes, which overlap in places [Pf02]. Also the observations on the subject of KM have shown; it would be fatal to rely just on IT, if full use is to be made of the knowledge available in the enterprise [Pf02].

Based on the previous efforts [An09a, An09b] some of the important aspects for integration of KM into QM have been revealed and explained. Specifically the basic idea of the Intelligent Quality Management Process (IQMP) is introduced in [An09a]. The IQMP is a closed-loop process consists of phases and feedback [An09a]. The proposed IQMP in [An09a] encompasses lacks to be associated and implemented as a powerful model. Also it is not able to utilize KM techniques effectively, because the support scenario is just only based on providing a decision-making platform to continuously improve the outcome of the IQMP. Nevertheless KM potentials are rather wider to be restricted just in decision-making. The efforts towards enhancing, elaborating and developing the IQMP are led to some modifications. The modifications are dedicated to acquire objective feedback from the knowledge intensive business process, and to reduce the gaps, particularly know-do gap, between related theoretical aspects of continuous improvement and practical issues by means of KM. The following sections clarify the renewal of IQMP more in detail. In this context, the renewed-IQMP includes a basic trait as iteration, whereas a distinctive trait using KM-Unit for feedback analysis and continuous improvement. The iteratively repetition of the phases primarily provides potentials of continuous improvement. However this is not sufficient, because the lack of feedback or feedback analysis can be led to keep or push forward the errors and faults. Also this can be ultimately resulted in halting or stopping the overall process. Therefore employing closed-loop-feedback or feedback-control-loop (controller) avoids main problems of the open-loop such as instability. Control engineering model can be

transferred to QM and accordingly there are different applications of quality control loops explained in various literatures [Pf02]. Particularly, the application of QM methods is effective only when these techniques are integral parts of quality control loops [Pf02]. Due to the principal and extreme purpose of IQMP to transfer and integrate KM into QM, it is distinguishing from approaches of applying quality control loop or transferring control engineering models to QM. However the logic of control theory and engineering is a dependable and reliable basis carried out within IQMP.

2 Intelligent Quality Management Process

2.1 What is IQMP

IQMP is an iterative and closed-loop quality management process consisting of knowledge intensive activities for continuously improvement and enhancement of performance of an undertaken business process within an enterprise. These activities are classified in two categories as pre-KM activities within or between enterprises (e.g. scoping, acquiring "know-how" and assessment) and post-KM activities (e.g. objective feedback analysis and reasoning). Basically, proper completion of these activities is a key factor to ensure successfully fulfilling of target-performance quality of the business process. Thereby IQMP reinforces the continuous improvement of the business process by using and processing objective feedback to either improve on or standardize utilizing of "know-how"/"know-what", and , in addition, to urge reason from current status of the business process, failures, and customer feedback (see Figure 1). Therefore the trait to supply the process with handling and managing knowledge is caused to be intelligent. The pre-KM activities of IQMP and feedback sources are shown in Figure 1.

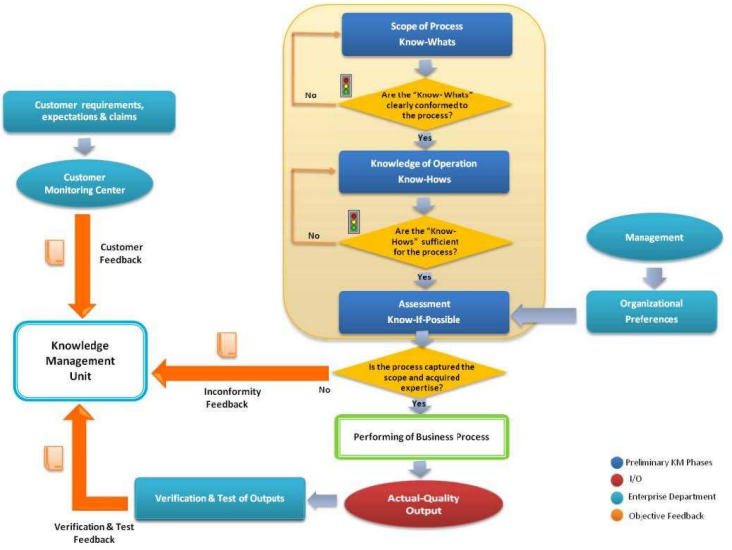

Figure 1: Pre-KM activities and feedback sources of IQMP

Furthermore, IQMP consists of three kinds of pre-KM activities which are supporting the business process to be effectively handled and conducted, and consequently to be improved and levelled up per iteration. The activities are defined and described in the following as:

1. **Scoping:** to know and understand the operation or application area covered by the existing or planned business process and to formulate related goals (know-what).
   In case that acquired "know-what" is conformed to the business process's target the next activity will be turn on, else the scoping repeats to completely fulfil required know-what.

2. **Knowledge of operation:** to acquire the expertise to accomplish the existing or planned business process (know-how).
   At this point, sufficiency of acquired "know-how" is examined. In case of insufficiency of "know-how" in accordance with formulated goals and scopes, this phase is repeated.

3. **Assessment:** to prove whether the business process is assessed and analyzed in conformity to the criteria and preferences provided by the management team, based on the organizational policy and strategy of the enterprise. It is assumed that the criteria and preferences include and comprise organizational related issues. Therefore this phase proves and verifies whether there is an inconformity among the defined and acquired requirements and organizational preferences (know-if possible).

Accomplishment of three pre-KM activities is a proof that basic knowledge requirements for starting the business process are acquired and completely analyzed with reference to organizational preferences. Thus the business process can be started, unless the inconformity feedback is reported to the KM-Unit i.e. a report presenting a failure to establish knowledge requirements of the business process. Furthermore, the pre-KM activity workers are classified as internal (e.g. technical/organizational staff, domain experts) and external (e.g. consultants, third parties, customers) business process contributors within or between enterprises. Pre-KM activities should be done structurally by implementing guidelines and using KM systems like document management or groupware systems. The result could be seen as developing of wiki for documenting acquired or extracted knowledge.

2.2 KM-Unit

As stated in section 1, the KM-Unit accomplishes and completes continuous improvement within IQMP. Because enterprise-wide continuous improvement is a never ending task, it requires a consistent and reliable solutions and advices. Thus KM-Unit exerts objective feedback acquired from three sources (see Figure 1 & 2) as:

4. **Inconformity feedback:** to report the failure for initialization of the business process due to inconformity between the defined requirements in the pre-KM activities and organizational preferences.

5. **Verification and Test feedback:** to prove and verify the correctness of the business process' outcomes, and to evaluate and determine the truth. This process is normally performed by quality control/assurance department of the enterprise, and the result is reported as kind of objective feedback. The verification and test is applied on "actual-quality-output" (see Figure 1) i.e. an existing and current output in certain degree of quality resulted from the business process, and is planned to be upgraded per iteration to approach "desired-quality-output".

6. **Customer feedback:** is gathered and analyzed by customer monitoring center of the enterprise, and collected data and information are transmitted as kind of objective feedback to the KM-Unit for further analysis.

In addition these three types of objective feedback are stored in the "Improvement Database" (see Figure 2). In IQMP the term "Improvement Database" only refers to the storage for warehousing and managing objective feedback using existing systems e.g. Enterprise Content Management System. The importance of concentrating on objective feedback, on the one hand is highly related to the value of enterprise-intellectual capital and creative contents, and on the other hand the direct or indirect potentials of quality improvement based on explicit or tacit knowledge [Fa09].

KM-Unit is not only responsible to monitor and evaluate current performance of the pre-KM activities within the business process, but also is aimed at providing adequate response to upgrade them. Therefore it consists of two steps as "Evaluation" and "Response" (see Figure 2). The evaluation step is firstly to monitor objective feedback based on criteria and indicators, and secondly to establish matrices for presenting the current status of each pre-KM activities and the business process' phases.

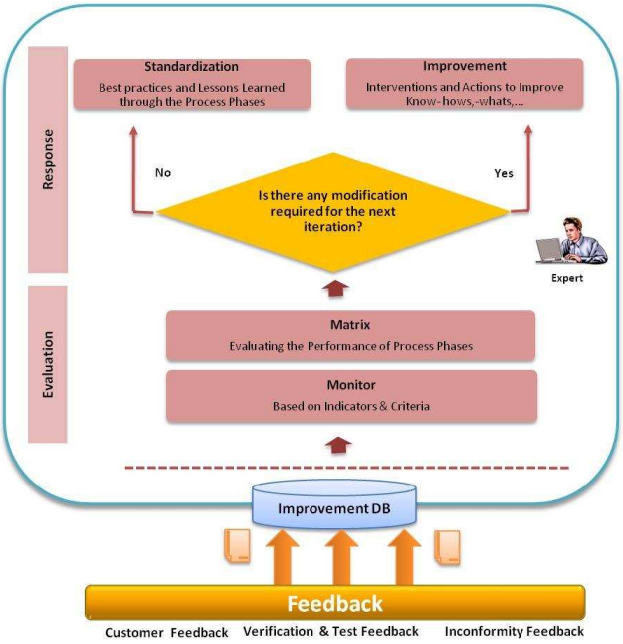

Figure 2: KM-Unit consists of "Evaluation" and "Response" steps

The indicators which are used in the evaluation step are categorized in three groups as:

- **Key Performance Indicators (KPIs)** e.g. Mean-Time-To-Repair (MTTR), Mean-Time-Between-Failure (MTBF).
- **Quality Indicators (QIs)** e.g. the quality indicator is calculated using the following formula [Pf02]:

$$QI_s = \left[1 - \frac{\sum_{i=1}^{3}(F_i \times f_i)}{Max(f_i) \times \sum N_{tot}}\right] \quad [1]$$

where "Q_{Is}" refers to the quality indicator for each segment of the business process e.g. quality department could use quality indicator Q_{Is} to describe the quality of shipment (QI_1), and supplier audits (Q_{I2}) [Pf02]. Regarding QI1, "F_i" stands for the number of parts with critical, minor or major faults (i=1, 2, 3),"f_i" represents the weighting factor for the fault categories e.g. f_1 (critical faults), f_2 (major faults) and f_3 (minor faults) where $f_1 > f_2 > f_3$, and "N_{tot}" symbolizes the total lot size [Pf02]. The formula for the purpose of overall evaluation of the business process is as follows:

$$QI_{tot} = \left[\frac{\sum_{s=1}^{n}(W_i \times QI_s)}{\sum W_i}\right] \quad [2]$$

where "QI_{tot}" refers to the total quality indicator of the business process based on different segments (s=1,…,n), and "Wi" stands for the weighting factor of the various

quality indicators corresponding to their significance for the customer [Pf02]. The values of quality indicators are between 0 (the worst level of quality) and 1(the best level of quality) [Pf02]. Therefore both quality indicators (Q_{Is}) and total quality indicator (QI_{tot}) range from 0 to 1as [Pf02]: $0 \leq Q_{Is} \leq 1$ and $0 \leq QI_{tot} \leq 1$.

- **Knowledge-Based Indicators** acquired by adopting of domain experts/ technical stuffs objectives (experiences/implicit knowledge) which is carried out either by structured surveys or observations.

Since the work is in progress, the principal assumption is that all three groups of indicators are seen as attributes to the utility or surplus of knowledge resources or contributors within or between enterprises. On the one hand the main focus is to find out direct/indirect connection and association between knowledge and the indicators. For example MTTR and MTBF as attributes of "Availability" could be rooted in availability of experienced manpower or domain experts, and QItot of an enterprise could be corrected by multiplying correction factor, based on availability, deliverability and inter- or intra-communication within or between knowledge contributors such as knowledge-holders,-buyers, and -sellers. On the other hand the main effort is to create or define new kind of indicators, based on direct association with knowledge.
In addition the evaluation step deals mostly with two distinctive types of feedback, first inconformity feedback resulted from pre-KM activities of IQMP (measuring the success of pre-KM activities), and second verification and test feedback resulted from the business process (measuring the success of the business process). Therefore indicators are adapted to these two major areas, and because customer feedback is interconnected with and affected by both major areas, the evaluation could provide an adequate response to improve customer satisfaction level. In the evaluation step based on defining of appropriate indicators, the matrix is created to present the results. In general by defining "n" phases and "m" indicators the m-by-n matrix is created (Qm×n). As depicted in Figure 3, the given matrix is filled by four types of color as Green, Yellow, Red and White for Good, Fair, Critical and Neutral conditions.

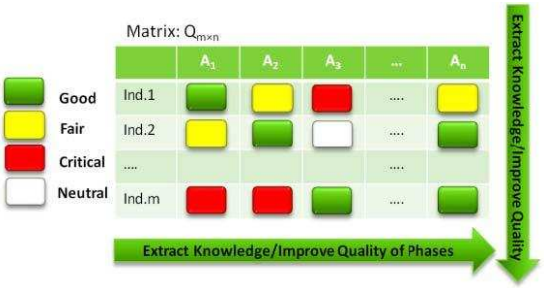

Figure 3: Creation of Qm×n Matrix

These colors are defined based on quantitative or qualitative intervals e.g. as quality indicators (QIs) ranges between 0 (the worst quality level) and 1 (the best quality level), the colors could be addressed in this interval as: Red ($0 \leq QIs \leq 0.30$), Yellow ($0.30 < QIs \leq 0.60$), and Green ($0.60 < QIs \leq 1$). Also White (Neutral condition) points out that an indicator either has no connection to the target phase or it could not be used to indicate it

anymore. By filling up such matrix, knowledge is extracted either regarding the evaluation of performance of each phase “Aj” (j=1, 2, 3, … , n) in accordance with various indicators (see each column), or about performance of distinctive phases in accordance with an indicator (see each row) “Ind.k” (k=1, 2, 3, … ,m). Figure 4 exemplifies the creation of a matrix for a sample production company.

Figure 4: Matrix for a sample production company

Executing the evaluation step provides an adequate basis to properly measure the success of either pre-KM activities (e.g. scoping), or the pertained phases of the business process. Thereby, in the response step, the quality/performance management expert (domain expert) is able to conclude that each phase of IQMP or sub-phases required improvement according to “know-how”/“know-what” , and also to make reasoning about origins of failures (know-why), based on his/her expertise and available guidelines. For instance, by defining an indicator as “How many fault conditions are recognized per iteration?” the related data is gathered continuously within each iteration. The accumulation of data (information) acquired based on this indicator is led to have overall evaluation of the process e.g. 60% fault conditions shows that there are approximately 6 faults per 10 iterations. Therefore the solutions and scenario of the phases should be modified to decrease this percentage, based on enlarging knowledge use within or between departments of an enterprise. On the one hand the repetition of gathering and evaluating of objective feedback addresses the gravity centre of problems (bottleneck) i.e. distinguished as the main sources of problem (e.g. the analyses could be led to modifying the scope of the process due to identifying high intensity of faults causing from this phase). On the other hand by repetition of various iterations, the expert becomes able to decide whether there is a kind of lessons learned inside IQMP phases (pre-KM or the business process phases), and accordingly standardize it as a kind of best practice.

In order to facilitate the evaluation and response steps, to increase the ability to identify positive and negative trends, and make decision, a Management Cockpit is being used. The prototype of such Management Cockpit has been developed in the Institute of Knowledge Based Systems and Knowledge Management (KBS&KM) since 2010. This prototype is particularly evolved based on KPIs, and currently is planned to be expanded by using QIs and defining Knowledge Based-Indicators. The screenshots of different instants of the prototype for a testing project is represented in Figure 5.

Figure 5: Management Cockpit -Screenshots of different instants for a testing project

Finally the KM-Unit provides the "improved-quality-input" which proceeds to the start of the next iteration of IQMP, and includes modified solutions "know-how-what" for each of pre-KM activities. Thereby the entire analysis leads to modify the goals and scenarios of each phase. Figure 6 reveals the full-scheme of IQMP.

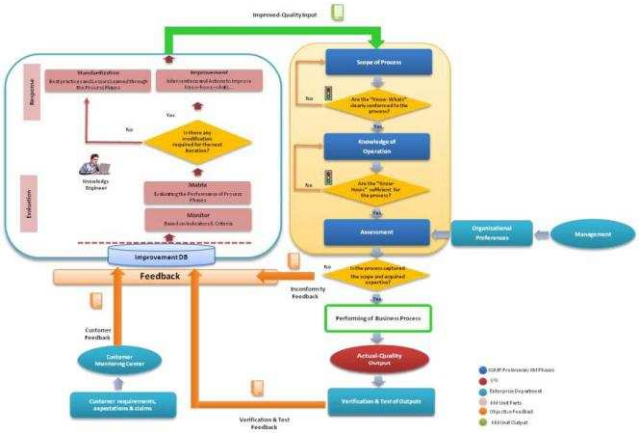

Figure 6: Full-Scheme of IQMP

3 Conclusion and Outlook

Long-term competitiveness of the enterprise is not only achieved by conducting and managing of quality of products, organizations and processes, but managing and handling of knowledge also promotes its continuous improvement of the performance, and empowers its long-term corporative strategies. KM sustains customer satisfaction by indicating customer-requirement and providing durable solutions. Besides, the integration approach needs to be realized in the kind of model. In respect of the previous efforts, in this paper, the renewed model of IQMP is presented. The IQMP is specifically focused on applying KM-Unit in order to utilize acquired objective feedback either from the business process or customers, and thus to continuously improve and level up the performance of the business process within the enterprise. To fully accomplish the aims

of IQMP defining precise indicators as KPIs, QIs or KB-Indicators is required. This enables KM-Unit to distinguish potentials of improvement for identifying and selecting lessons learned and standardizing best practices found through IQMP activities, and for efficiently modifying "know-how-what" and costumer-oriented strategies. In order to realize the evaluation and response steps, based on the IQMP concept, a prototype of Management Cockpit is introduced which is currently under development in KBS & KM.

Also the future work will be focused on benchmarking of this approach and evaluating its performance in comparison with existing QM models supported by KM, and realizing the development potentials of IQMP in both theoretical and practical aspects particularly for expanding the Management Cockpit. In addition proper guidelines for applying pre- and post-KM activities within enterprises should be created especially based on recognition of knowledge resources and contributors. As far as within each integration approach many influential factors should be considered, the parallel work on improving the capability, developing and sustaining the long-term and durable benefits of IQMP is considered and pursued.

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