Experience Management: Lessons Learned from Knowledge Engineering[1]

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Es ist not, dass wir all lernen
und das getreulich unseren Nochkummen
mitteilen. - Albrecht Dürer, 1528

Abstract: *Experiential knowledge has been recognized as a critical success factor since the beginning of Knowledge Management, but practical work in the KM-field has shown that dealing with experiential knowledge is still not easy. Since the 80^{ies} Knowledge Engineering has been faced with the same kind of challange and can contribute by teaching us some important lessons, that we propose should be used as a foundation or kernel in conceiving Experience Management solutions and systems. Among these lessons, the fundamental one is, that in order to improve experience sharing we first should understand experiential knowledge in a way that promotes the appreciation of human factors. This can be reached by understanding the following five aspects of experiential knowledge from a constructivist point of view: the Function, the Mechanism, the 2 States, the Organisation and the Handling of Experiential Knowledge. Based on the proposed understanding, five consequences are deduced that we suggest should serve as leading principles for conceiving and using Experience Management solutions and systems.*

1 Introduction

Within the discipline of Knowledge Management the role of experiential knowledge has been fundamental since its beginning (around 1990) when one main question was how the sharing of experience (lessons learned, best practices, project databases, faq, etc.) could help organisations in "knowing what they know" and by that contributing to a more efficient an effective use of the available knowledge assets.

Where have we arrived today? As illustrated by a recent opinion poll through the RWTH Aachen [Pf01], implementing knowledge management encounters frequently problems, practical solution approaches and methods are missing and - we would add from our point of view - the theory lacks in transparency and consistency across the huge number of contributions. As a simple but indicative example of this theoretical insufficiency consider that the english term "tacit" (knowledge) is translated by 99% of german authors with the german word *"implizit"*, although nowhere in the english literature the correspondent english word "implicit" is ever used in place of "tacit".

This situation indicates that Knowledge Management has reached *a turning point* where we need to understand the deeper reasons for its failures (causes of defects and obstacles) and radically change the main direction of development. **Experience Management** (EM) - that we understand as that branch of Knowledge Managament which is focused on the task of organising (managing) the handling (processes) of *experiential* knowledge - could become a major contribution to meeting the challenge of this turning point, if it will be able to take seriously some important lessons that can be learnt from Knowledge Engineering.

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2 Message

Which are then these deeper reasons which cause Knowledge Management projects to fail? Conventional defect analysis tends to explain defects by other defects and this prevented us until now to see those deeper reasons. Knowledge Engineering instead - by teaching us three fundamental lessons - can help in performing the deeper defects analysis required for answering the above question. The *first* lesson is, that experiential knowledge should be regarded as a key success factor of business critical processes. The *second* lesson suggests, that the major cause of failure in dealing with experiential knowledge at a meta level (knowledge processes) lies in an inadequate and poor appreciation (estimation) of the relevant human factors involved (see Fig. 1). Finally the *third* lesson claims that what prevents the human factors from beeing adequately appreciated is the established understanding of knowledge as "mapping".

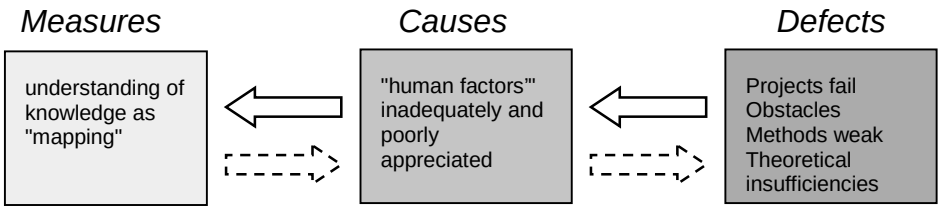

Fig. 1: Defects analysis for Knowledge Management

Accordingly, our message in this paper is that in Experience Management we must substitute our established understanding of knowledge with one which promotes the appreciation of the relevant human factors. After explaining the mentioned three lessons (part 3 and 4) we will develop an understanding of knowledge which is more suitable in the needed sense (part 5) and finally derive from it a set of guiding principles (part 6) which should control the conception and the use of Experience Management solutions and systems.

3 Importance of Experiential Knowledge

Knowledge Engineering was developed originally (first-generation) over a period of about 20 years (between 1964 and 1983) from an insight that Edward Feigenbaum and David Lenat summarized later [FL91] as the so called "Knowledge Principle" which states that *"A system exhibits intelligent understanding and action at a high level of competence primarily because of the knowledge that it can bring to bear: the concepts, facts, representations, methods, models, metaphors and heuristics about its domain of endeavor"*. Feigenbaum and Lenat want to point out that in the absence of knowledge, all you have left in a program is search and reasoning, and that is not enough. The same happens with theoretical and experiential knowledge: in the absence of experience all you have left is theory, and that is not enough.

3.1 Experiential and theoretical knowledge

We distinguish here two subclasses of knowledge - empirical (experiential, practical) and theoretical - in a similar way in which Aristoteles distinguishes "productive" and "observing" knowledge[4]. *Experiential knowledge* is knowledge of what to do in a lot of particular cases (know how) and knowledge of the specific reasons for doing that (know why)[5]. These cases are directly related to productive acts, to acts of interaction with the world. The raw material of empirical knowledge are sensations. *Theoretical knowledge* is knowledge of a lot of general principles and general causes. Both empirical and theoretical knowledge are collected into a system of connected and compared operands: experience and science (theory). In order to become elements of one of these two systems, the operands must in both cases be consistent, coherent and validated.

[4] Aristoteles (Metaphysics, Book A, [981a,b]) uses the words ποιητικη (productive) and θεωρητικη (observational, speculative)

[5] Aristoteles (Metaphysics, Book A, [981a,b]) distinguishes here εμπειρια and τεχνη.

From the development of commercial knowledge-based systems we learnt that it is mainly *experiential knowledge* - not theory - which should be regarded as a key success factor to the automation of knowledge processing in business critical tasks. And this is not trivial! In fact, experience is not receiving in the academic and business world the attention it deserves. Otherwise we would have since long a well established discipline of experience management in the academic domain and its systematic use in enterprises.

3.2 Experiential knowledge in the light of Cybernetics

Fortunately the Knowledge Engineering background puts us in a better position for understanding the increasing importance of organizing experiential knowledge (at a meta level) and enabling its systematic handling by computer technology to support any kind of business critical processes, not only those where knowledge can be automated through Artificial Intelligence technologies.
Why is experiential knowledge becoming increasingly important? We see the following causal chain: by defining the trends, clients force enterprises to make their organization more and more client-oriented. In the same time the steady acceleration of change and increase of quality standards forces the enterprises to react more and more quickly (shorter time to market, just in time delivery, etc.) with better and better quality. In this situation experiantial knowledge plays more and more the role of a critical success factor because technical and organisational means are not able to cope in short terms with the new time and quality challenges. As Ross Ashby pointed out [RA56], variety can never increase in a machine and usually decreases (Section 7/25).
The human being on the contrary has the ability to flexibly adapt to new situations by rapidly increasing the variety of his or her handling options synchronously with the increase of complexity in the environment, and by doing this, further develops his or her experiential knowledge (know-how and know-why). In the light of Ross Ashby's *law of requisite variety* [RA56] the advantage of the human being is the tight relation between the control of variety (by experience, communication and learning) and its application in the control of disturbances that come with a new situation.

4 Defects from Understanding Knowledge as "Mapping"

Knowledge Engineering is a highly demanding activity in which the handling of knowledge consists of two coupled main steps: a) Developing a conceptual model of expertise and b) Mapping this model into a formalized model that can be run on a computer. As a result of these two steps the expertise (how to process knowledge-intensive tasks) can be metaphorically regarded as "transferred" from an expert to a knowledge-based computer system. The knowledge-based system uses knowledge not simply to process data or information like conventional applications: it uses knowledge to automatically process knowledge. In this sense we speak of knowledge automation [Be00].

4.1 Obstacles in knowledge automation

After an initial great wave of enthousiasm about the potential of knowledge automation in every area of business (1980-1987), a lot of problems with knowledge acquisition, explanation, maintainability, reusability and with the management of knowledge automation projects led to the identification of a set of major obstacles (1988-1993), for instance:

- Trying to make explicit the expertise by extracting it from the domain experts (knowledge acquisition as mining) did not work [DKS93].
- Alternative approaches to the same task of making expertise explicit (knowledge acquisition as modeling) did not reach the strength needed by commercial applications: the ideas remained too weak and the tools did not become powerful enough [Fe93]. Knowledge acquisition was and is still today the bottleneck of knowledge engineering.
- The role and contribution of domain experts in a project was and still is not appreciated enough.
- The task of building the model of expertise was and still is too much focused on computer specialists and suggestions to revise the distinction of roles between domain experts and computer specialists has been formulated only very recently [Sc00, BF01].
- The evolutionary, prototyping approach to system development supported by academic research was and still is only weakly accepted and used in practice [BF01].

By putting together all these experiences and by analysing them from the perspective of our own practice we come to the conclusion that one principal common source of these obstacles was and still is an *inadequate and poor appreciation (estimation) of the relevant human factors* involved in knowledge engineering.
And because knowledge engineering is basically a way of dealing with experiential knowledge at a meta level exactly like knowledge (or experience) management [Li01], we suggest that also the defects of knowledge management may have the same common cause like the obstacles to knowledge engineering.

4.2 Inadequate appreciation of human factors

The crucial question at this point is what in the daily practice of Knowledge Engineering prevents human factors from beeing adequately appreciated? Our hypothesis - confirmed by some successful realizations of knowledge automation systems - is that it is our established understanding of knowledge as "mapping" which determines the measures and actions leading to the mentioned inadequate and poor appreciation (estimation) of the relevant human factors involved in knowledge engineering (see Fig. 1). Let us have a look at some cases which seem to confirm this hypothesis.

- *Knowledge engineering paradox:* Waterman reports [Wa86], that the more competent domain experts become, the less able they are to describe the knowledge they use to solve problems. This is a paradox only if knowledge is considered as a map of reality. An alternative view has been proposed by Maturana (autopoietic model of cognition), who remarks that even scientists explain their doing in a way which does not match what they do in science. The reason is - as Maturana suggests - that they are not aware of their ways of knowing [Ma88, Ma98]. It is hence a question of awareness (a human factor), not a paradox.

- *Bottleneck and weakness of methods in knowledge modelling:* We have already mentioned the difficulties in building knowledge-based systems. In the beginning of the 90^{ies} a methodology called KADS [SWB93] was developed for overcoming these difficulties on the basis of an understanding of knowledge as "construction" instead of "mapping". Unfortunately KADS has not been widely used in commercial projects. One important reason could be that its underlying new approach to knowledge was and still is mostly tacit - a more or less hidden premise [Sc00] - and this makes that KADS cannot be understood well enough for commercial use.

- *Unsurmontable difficulties in cognitive robotics:* in the area of Humanoid Robots enormous finance means are being invested world-wide, but the developers are confronted with difficulties which appear insuperable because they are inherent to their underlying views of cognition. After AI research had recognized that the world models of robots "*cannot be fully pre-specified but need to be acquired*" [Ve98], the researchers began with the search for methods that allow a robot to acquire by interactions their own world model. But here we hit on a "*fundamental problem that we all know but have pushed to the back of our consciousness and out of our active research agenda*" - as Rodney Brooks recently wrote [Br01]. This problem lies in the domain of visual object recognition. Brooks writes: "*None of our robots can reliably differentiate a cell phone, a stack of business cards or a wallet*". He is convinced, that "*without this capability, our robots cannot have any reasonable understanding of the world for carrying out complex tasks*". Another fundamental problem is illustrated by Cog from MIT: it has no long-term memory. Consequently it has not idea of what it did two days or even two minutes earlier.

- *Defects in Software Engineering:* the constantly increasing need for modelling knowledge-intensive tasks (for instance the assessment of tax returns) causes in software engineering 3 main knowledge-related gaps: a) a gap between user and developer (understanding knowledge needs), b) a gap between developer and system (implementing knowledge specifications) as well as c) a gap between system and user (knowledge is processed in a different way than expected). From our experience with the modelling of knowledge-intensive tasks we have learnt that difficulties in this area have their roots mainly in the inadequate, implicit and *unaware* understanding of knowledge which underlies our conventional approach to modelling [Be95].

5 A More Appropriate Understanding of Knowledge

Given the previous defect analysis our next step will be to substitute the established understanding of knowledge as "mapping" with a new one which promotes the appreciation of the relevant human factors involved in Experience Management. This more appropriate understanding of knowledge can be found by questioning some fundamental aspects of knowledge: the function, the mechanism, the two states, the organisation and the handling of knowledge.

5.1 Function of knowledge

Analogously to other instruments (e.g., a screwdriver) also knowledge has not value in itself but only on account of its function. A screwdriver is worthless if one wishes to clean teeth - and also with the hardest toothbrush no screws can be turned. Now the crucial question is: In what consists the function of knowledge? A school of knowledge research initiated by the Swiss psychologist Jean Piaget in the 30^{ies} in Geneva, the so-called "Constructivism", has suggested that [Gl95]:

- the function of knowledge is the adaptation of the knowing organism
- the core-mechanism of this adaptation *cannot* be the "mapping" of reality; it is a mechanism of self-determined "construction" of a *viable* experience (consistent, coherent, valid). Therefore the name Constructivism.

The construction of viable experiences is determined by the factors with which the human knower steers and controls his or her adaptation, i.e. by intentions, interests, wishes, hopes, expectations, etc. These *human factors* are highly individual and make that the knowledge (logic) of every single person is also highly individual.
Adaptation creates the individual worlds in which every single person lives. This can lead on the one hand to solitude but it can also on the other hand be the basis of a constant enrichment: if 2 persons adapt themselves to the environment in a different way, their conclusions will be necessarily different. Employees and entrepreneurs should be glad of this variety, because complex problems always require the evaluation - and often also the integration - of several solutions in order to be solved optimally.

5.2 Mechanism of knowledge

The word "construction" is generally used in connection with industrial and civil engineering. What is to be understood, however, under "construction" in connection with knowledge? The meaning is very similar. The brain "constructs" its knowledge in the sense that it can know only what it has done (i.e. planned, built and tested).
The first who formulated this in such a way was the Italian philosopher Giambattista Vico about 1710 [Gl95]. Today Prof. Walter J. Freeman - neurophysiologist in Berkeley - writes in his newest book [Fr00]*: "All that brains can know has been synthesized within themselves, in the form of hypotheses about the world and the outcome of their own tests of the hypotheses... ".* Freeman has proven with his experiments on rabbits that the patterns of perception are not imposed to the organism from outside.
In the same way as a Smart, a Swatch or simply a corkscrew are not "maps" of reality but useful constructions, one must also consider as useful constructions the knowledge-objects that he or she "constructs" in his or her head. As a first example of a useful construction we would like to suggest a small experiment: If we draw in the air with the forefinger a circle of approx. 30 cm of diameter, how do we operate in order to perceive the circle? What do we map if there is nothing at all to be mapped?
As a second example let us take something from daily life (what we daily do is namely what concerns all of us), for instance two common daily words, "look" and "see". These are two very interesting words. Because they designate two coupled experiences which take place one after another and are dependent of each other. They are useful to recall us the fundamental insight that

what we see depends on *how* we look!

The same happens with 2 other words, namely "listen" and "hear": how I listen determines what I hear. Language hence embodies in such words-pairs already since thousands of years Vico's insight that everything we know (the *what*) is determined by what we do (the *how*, our way of knowing) and not by what is given (the indefinite something). In 5 words: the how determines the what.

Besides the already mentioned G. Vico, J. Piaget, H. Maturana and W.J. Freeman also I. Kant, E. von Glasersfeld, P. Watzlawick, Heinz von Förster, E. de Bono and V. Birkenbihl have given important contributions to the development of constructivism.

5.3 Two states of knowledge

If we understand the activity of the brain as construction instead of mapping, then we can also better understand one of the principal reasons why the subject of Knowledge Management is so controverse, contradictory and hard to communicate. One main reason lies in the circumstance that knowledge - at an individual level - can be distinguished in two states, tacit knowledge and explicit knowledge. Why is it so important to understand this distinction thoroughly? The principal reason is that each individual in daily work (and life) constantly performs transformation processes from tacit to explicit knowledge (map, represent) and vice versa (interpret, make sense).
Tacit knowledge, the "treasure in our heads", is that part of individual knowledge which exists only in the heads of the employees, hence is not yet explicitly formulated and therefore also not yet accessible to others. Tacit knowledge consists mainly of experiential knowledge, is genereted as a result of construction and *not* of mapping processes, adapts itself dynamically to all situations, belongs to his or her constructor and goes with him or her every evening home. Like in an iceberg, where the quantity of visible mass is much less than the unvisible part under the surface, so also the explicit part of knowledge is relativly small compared with the tacit part which includes thumb rules (heuristics), experiences, skills, talents, known cases (stories), analogies, views, values.

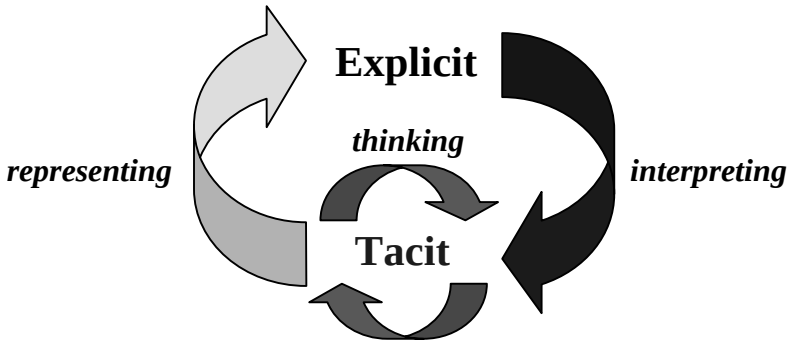

Fig. 2 Individual transformations between tacit and explicit knowledge

In any individual explicit knowledge is generated by embodying the living, dynamic tacit knowledge in material carriers (artifacts). Such artifacts are for instance manuals, laws, reports (documents of any kind, incl. diagrams and drawings), procedures, organizational methods and structures, equipments. Explicit knowledge is so to speak "frozen" tacit knowledge, its shadow, and we could well call the transformation from the tacit to the explicit state either "mapping" or "representing" or "embodying".
Viceversa tacit knowledge is generated in any individual either from available tacit knowledge ("thinking") or from explicit knowledge by producing mental constructs coupled[6] with given artifacts: this activity could be called "interpreting" but *by no means* "mapping" *nor* "representing"! These transformations at the individual level are at work also when individuals of a team (or of larger organisational units) interact: consequently a collective transformational model like that proposed by Nonaka and Takeuchi [NT95] should be grounded on such an individual transformational model.

[6] In this coupling the influence of the artifacts (or more generally of matter and energy) on the mental constructs should be regarded as a set of constraints not as cause of conformation and reference: the mental construct generated is merely *constrained by* and cannot be *referred to* nor *conform to* the material something because *we have no way of making reference to something independent from us*. [Ma88, Gl95, Ma98].

5.4 Organization of knowledge

The practical knowledge of an employee stands often only at his or her disposal although many other would like to access it. In millions of years Nature has developed a solution for this problem and we can find it in our head, as "hardware" as well as as "software".
The German philosopher Immanuel Kant described already 220 years ago in his main work [Ka81] knowledge as a "*whole of compared and connected mental constructs*" i.e. as a system of constructs and their connections, as a network. The world-famous creativity researcher Edward de Bono has contributed a lot to explain pragmatically the dynamism of this network. He surprises everyone with the assertion [Bo90]: "*In practical life most mental effort is done in the domain of perception*" hence not - as generally maintained - in the domain of logic, of subsequent elaboration.
The idea of networking as a basic principle of the organization of knowledge is being supported also by Vera Birkenbihl - the famous management-trainer and bestselling author. She has formulated this idea even explicitly in a model where she emphasizes as follows the outstanding importance of networking: *"... Everything what you have ever learned is a thread in a gigantic knowledge-net*" she writes [Bi00]. Indeed, without networking of new experiences with the existing ones we could not even understand the sense of a simple situation - as for example in traffic the changes of a traffic light color from green to red.
Finally also the structure of the human brain - with more than 10 billion nerve cells (10^{10}) and more than 10 thousands million connections (10^{13} or 10^3 to 10^4 per neuron) suggests the idea that networking should be fundamental also as an organizational principle for making knowledge available, accessible and used.

5.5 Handling of knowledge

The name "Knowledge Management" misleads persons external to the discipline to think, knowledge itself is meant to be the straight object of management measures. This is also the view of Prof. F. Malik (Univ. of St. Gallen) wo then of course concludes that knowledge "cannot be managed".
This view is from our perspective very problematical. In fact, not the knowledge itself, but the *handling of* knowledge should be and has been regarded as the object of management tasks and measures. Consequently an obvious, simple solution of the problem consists in understanding the overall task of knowledge management as *organizing the handling of* knowledge (i.e. organizing knowledge processes).
But which forms can the handling of knowledge assume in a firm, in a department, in a team or even in a single individual? This question is very important in order to perform problem analysis - finding out how the enterprise is handling knowledge - and solution synthesis - designing how the enterprise should handle knowledge - in a systematic way. Approx. 5 years ago the "Geneva Knowledge Group" around Prof. Gilbert Probst, in co-operation with managers of the most different branches has first of all identified practical knowledge problems, then collected the found problem settings into groups and finally associated these groups into larger problem categories. As a result they defined six activities as core processes of Knowledge Management [PRR97]. In our research at FHBB we have integrated this process model into a roadmap model that we developed specifically for enabling systematic thinking and planning in knowledge management projects [Be01].

6 Leading principles of "Constructive Experience Management "

Finally we would like to derive from our previous line of thought five leading principles of a "Constructive Experience Management" which show how the enterprise should be considered from a knowledge perspective and how experience management solutions and systems should be conceived and implemented in order to achieve a better use of practical, experiential knowledge.

1. *Understand experiential knowledge more appropriately.* We recommend as first that experiential, practical knowledge should be understood more appropriately: a) as a *construction* of tacit knowledge from tacit or explicit knowledge, not as an image or mapping of reality; b) as a networked organization of experiences to a whole; c) as a resource which should not be organized directly but only indirectly through the organization of knowledge processes.

2. *Inner bond between knowledge and its human source.* We recommend as the most important consequence of the described new understanding of knowledge to carefully consider that an inalienable inner bond subsists between a human being and his or her knowledge, exactly like between the citizen and his or her freedom -

as J. J. Rousseau proposed in his main political work [Ro62]. As a consequence knowledge must always be approached together with the employee with whom it is connected. Many studies and opinion polls have stressed again and again that the employee should be considered as a primary success factor of KM initiatives. Now, with the understanding of knowledge shown here, we can also explain why this is so. And this explanation is necessary, because it is only on the basis of this understanding that the inner bond between individual and his or her knowledge can be seriously regarded as an essential constraint for EM solutions and systems.

3. *Socio-economic balance*. We conclude from the inner bond between an individual and his or her knowledge that a very close connection exists in Knowledge Management between intrinsic economic constraints and human-social requirements. In organizing and applying knowledge management systems the constraints of economy and business should not be emphasized one-sidedly, because otherwise one will hardly be able on a medium- or long-term to avoid that the introduced system either is not used, or fails or even worst becomes a means of "human exploitation" hidden under the garnments of the new economy. We have experienced such tendencies several times in projects where excessive economic thinking (fixation on shareholder value) caused great damage to the project work and results. In leading Knowledge Management approaches we miss a clear statement about the socio-economic balance. As a consequence an essential foundation is missing when solutions are conceived and implemented and the KM measures contribute to separate more and more the human user from his or her knowledge.

4. *"New pact" between firm and employee.* In our opinion, in order to avoid or reduce the above mentioned separation, a suggestion by Prof. Giorgio de Michelis (Lab. of Cooperation Technology, University of Milan) should be considered as trend-setting. In it de Michelis recommends to firms to negotiate with their employees a new pact - one could say a "knowledge contract". Such a pact can be summarized in the sentence: "You let your individual knowledge flow, we appreciate, promote, protect it and let the company's knowledge flow ".

5. *Networking and cooperation*. Last but not least "Constructive Experience Management" recommends that knowledge processes should be organized (designed, led and used) in such a way that a steady networking between the two states of the knowledge (tacit and explicit) is made possible and that a continuous cooperation is promoted and maintained between individual knowledge workers.

These 5 leading principles describe an ideal situation, but are nevertheless meant for practical use, like a lighthouse, i.e. as fundamental points of reference for guiding the conception, implementation and application of Experience Management solutions and systems which allow firms to make a better usage of their experiential knowledge assets.

7 Conclusion

A knowledge process is something fundamentally different from any other business process. The reason is, that a task or process can easily be separated from its formal owner (executing and responsible person) but knowledge - as our paper suggests - cannot and should not! One main consequence is, that the organisation of knowledge processes requires *a quantum leap*, a true paradigm shift that distinguishes it from conventional organizational development measures for business processes. This is the starting point from which Experience Management should begin its undertaking.

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