Knowledge Process Modeling in SME and Cost-Efficient Software Support: Theoretical Framework and Empirical Studies

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ABSTRACT

Current research in knowledge management is concentrated on concepts for large companies. In this article the focus lies on the modeling of knowledge processes for small and medium-sized enterprises (SME). In the first part of this paper an empirical study conducted at the Department of Information Systems (University of Innsbruck) illustrates the key knowledge processes (knowledge identification, knowledge acquisition, knowledge arranging and knowledge transfer) for SME. The result of this survey is a knowledge process model which links efficient methods of the knowledge management to SME. Furthermore, this paper reports the findings of the empirical study designed to allocate cost-efficient software products to each of the four knowledge processes in SME. This paper analyzes knowledge processes and gives a framework of methods and cost-efficient software tools.

1. INTRODUCTION

Business process modeling [Hammer & Champy, 1993] has become a major research field in the information systems discipline in the last ten years. Davenport sees the term business process as "a structured, measured set of activities designed to produce a specified output from a particular customer or market" [Davenport, 1995]. However, in recent years, not only business process management, but also knowledge management is developing into a new research field [Probst et al., 2005; Rao, 2004]. The linkage of these two research fields is called knowledge process modeling. For Richter-von Hagen et al. "a process is knowledge intensive if its value can only be created through the fulfilment of the knowledge requirements of the process participants" [Richter-von Hagen, 2005, p. 358]. Gronau describes the following facts of knowledge intensive processes: diversity of sources and media, variance and dynamic development of the process organization, a plenty of process participants with different expertises, use of creativity, high level of innovation and influence on the area of the decision [Gronau, 2004, p. 410]. Edwards and Kidd [Edwards & Kidd, 2003, p. 124] named the following five characteristics to enforce the argument that knowledge management and business process management should be integrated:

- Knowledge management is important for business if the initiative implied an advantage for the customers. The idea to implement the customer's requests – may be internal or external – is the base for including the customer [Fink et al., 2006].
- Knowledge doesn't follow the business borders. Business processes also model activities by global trading companies and build the base for modeling knowledge intensive processes.
- Knowledge management can only be efficient if it follows a structured model. Business processes are modeled by structured actions and they are necessary to deduce knowledge intensive processes.
- The success of knowledge management depends on the measurement of knowledge. There exists a similarity to the measurement of business processes. The measurement of the knowledge potential provides a central position and biases the success [Fink, 2004].
- Knowledge management is affected by a holistic approach. Every part of the business process modeling is important for success but every aspect should be considered.

In addition, knowledge management and business process modeling initially focused on large companies. The knowledge economy has to shift from the view of large companies to small and medium-sized enterprises (SME) because of their importance for the industrial economics. A definition of SME will be given in the next chapter. The driving reason behind today's shift from large companies to SME is that all businesses are depending on methods and tools of knowledge management in order to gain competitive advantages and deal with the knowledge potential of their employees [Fink, 2004]. In western industrial economies SME have a share on the market of more than 95% and supply more than 60% of the employees [Statistical Yearbook Austria, 2005]. Therefore, in this paper the focus lies on the impact of knowledge process modeling for SME to help them getting a framework to be more innovative [Donnellan, 2006]. In Chapter Two the theoretical framework for the identification of knowledge processes in SME will be discussed. Chapter Three covers the use of cost-efficient software products for the implementation of knowledge processes in SME. Chapter Four gives an outlook of future research by the determination of innovation underlying knowledge processes.

2. THEORETICAL FRAMEWORK

This chapter introduces the framework for the definition of knowledge processes in SME and the realization of these processes through the use of cost-efficient software products – in this case the main focus lies on the investment costs.

2.1 Definition of SME

In the literature of business management there is a variety of about 200 different definitions of SME. A cause therefore can be the huge amount of possibilities of operationalization of the term SME. For this study it was not necessary to define SME qualitatively. So a quantitative definition was chosen by the use of the definition of the European Union which was established in the year 2005 [European Commission, 2006].

SME are quantitatively determined by three factors: (1) the number of employees, (2) the total assets and (3) the annual turnover. SME can be divided into three more detailed categories: (1) *middle enterprises* (less than 250 employees AND less than 50 Mio. EURO annual turnover OR less than 43 Mio. EURO total assets), (2) *small enterprises* (less than 50 employees AND less than 10 Mio. EURO annual turnover OR less than 10 Mio. EURO total assets) and (3) *tiny enterprises* (less than 10 employees AND less than 2 Mio. EURO annual turnover OR less than 2 Mio. EURO total assets).

This research focuses on SME which have less than 250 employees and less than 50 Mio. EURO annual turnover or less than 43 Mio. EURO total assets. The next sub-chapter will show the development of the knowledge processes for SME.

Figure 1. Theoretical concept of knowledge processes for SME [Fink et al., 2006]

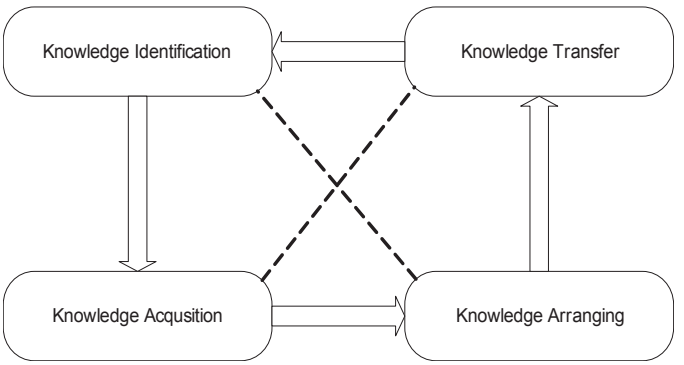


Table 1. Research sample for knowledge processes in SME

Knowledge Identification	
Balanced Scorecard	Tobin`s q
Market - Asses Value - Method	Knowledge Balance
Skandia Navigator	
Knowledge Acquisition	
Brainstorming	"Synektik"
Mind Mapping	System Simulation
eMail System	Scenario Technique
Business Game	Knowledge Network
Search Engine	
Knowledge Arranging	
Document Management System	Conceptualization
Checklist	Mind Mapping
Content Management	Neural Network
Database	Project Review
Experts System	
Knowledge Transfer	
Knowledge Maps	Lessons Learned
Questionnaire	eMail System
Best Practice	Microarticle
Chatroom	Story Telling
Communities of Practice	Handbook
Groupware	FAQs
Checklist	

2.2 Knowledge Processes in SME

To make knowledge usable for all stakeholders of an organization a knowledge base must be implemented. This base covers all the knowledge which an organization needs to operate and solve problems: It should include individual but also collective parts of knowledge like abilities, skills, norms, routines experiences and myth. The theoretical approach of Probst, Raub, Romhardt [Probst et al., 2005] is the basic framework for the identification of knowledge processes in SME for this paper. [Probst et al., 2005] defined eight "building blocks of Knowledge Management" which are: (1) identification of knowledge, (2) acquisition of knowledge, (3) development of knowledge, (4) sharing of knowledge, (5) use of knowledge, (6) conservation of knowledge, (7) evaluation of knowledge and (8) aims of knowledge.

In the first step the authors conducted a study with the objective to find the key knowledge processes – based on the framework of [Probst et al., 2005] – for SME. The detailed research design is described in [Fink & Ploder, 2006]. In short, 20 expert interviews were conducted by the Department of Information Systems at the University of Innsbruck in summer 2005 [Fink & Ploder, 2006]. Ten experts from science and ten experts from practice were asked about the most important knowledge processes in SME. The result of the interviews was a knowledge process model for SME. Figure 1 illustrates the four key knowledge processes: (1) Knowledge Identification, (2) Knowledge Acquisition, (3) Knowledge Arranging and (4) Knowledge Transfer.

2.3 Quality Model (ISO/IEC 9126) for the Evaluation of Software Products

This knowledge process model for SME was the first step in the research work and the general research framework. The second step was to find out which process can be supported by which knowledge method. After a literature analysis [Coakes & Clarke, 2006] the following methods were identified to support the four processes [Fink et al., 2006].

In a third step, the objective was to match a cost-efficient software product to each knowledge method which are usable in practice. In the research design the focus lies on Freeware and Shareware software products in order to fulfil the presetting of cost-efficient software support. The research method was an online research with the result of a list of evaluated cost-efficient software products. The evaluation of each software product was conducted by applying the ISO/IEC 9126 norm. The Quality Model of the norm (ISO/IEC 9126-1) is divided into two parts which are important for the evaluation of the software products to support knowledge methods:

- the internal and the external quality of the software as well as
- the quality for use.

The ISO norm lists five characteristics to evaluate software products: (1) functionality, (2) reliability, (3) usability, (4) efficiency and (5) assign ability. For each characteristic a different number of items were assessed by a likert scale from -2 up to +2. The process how the authors did the assessment is shown in the appendix. The data sample of the quality model was more than 200 different software products. A key research finding was that some of the software products can not be used in practice because their quality was not sufficient. Finally there were 45 software products which are efficient for use in SME.

The following research question can be formulated: Which of the methods are efficient for use in SME and which software products will be implemented by SME? Therefore the authors formulated two key hypotheses:

Hypothesis 1: Knowledge Management Processes can be realized in SME with more than a 30% support of office similar software.

Hypothesis 2: More than 50% of the SME which can image to invest into Knowledge Management in the next year will invest more than 3.000 EURO per year.

2.4 Data Collection Procedure

The survey 2006 was developed and executed by the Department of Information Systems at the University of Innsbruck and is an update and extension of the empirical study conducted in 2004/2005 [Fink & Ploder, 2005a; Fink & Ploder, 2005b]. The objective of the empirical study was to find out which cost-efficient software products can support the efficient methods of the four knowledge processes (see chapter 2.1). For this approach the authors differ between two categories of software. At the one hand side there are the standard software products which are already in use in SME (for example: MS Office, Internet Explorer, Operating System and so on.) and at the other hand side there are software products like Shareware, Freeware and Open Source products characterized by the issue of cost-efficient software installation in SME. This described issue is the key objective of the empirical study. The research method for this study was the online question technique. The questionnaire was built with HTML, PHP and based on a MySQL database.

The data sample of 537 SME was average allocated over the regional federal states of Austria, Switzerland and Liechtenstein to get a representative result for

Table 2. Ranking of cost-efficient software products

	absolute adequate +2	adequate +1	less adequate -1	not qde-quate -2	no answer	Ranking	Supporting cost-efficient software products	ISO Ranking	Ranking Survey
Knowledge Identification									
Knowledge Balance	25	98	36	10	51	92	no cost-efficient software product		
Balanced Scorecard	17	107	38	7	51	89	no cost-efficient software product		
Skandia Navigator	17	102	42	10	49	74	no cost-efficient software product		
Market - Asses Value - Method	11	76	61	21	51	-5	no cost-efficient software product		
Tobin`s q	16	63	58	26	57	-15	no cost-efficient software product		
Knowledge Acquisition									
Search Engine	100	76	22	11	11	232	Google Desktop Search; MSN Toolbar; Yahoo Dektop Suche	not possible	25; 12; 10
Brainstorming	83	96	15	11	15	225	Brainstorming Toolbox; Concept X7	6;17	44; 88
Knowledge Network	77	87	20	9	27	203	no cost-efficient software product		
Mind Mapping	66	102	23	8	21	195	Free Mind; Think Graph, Tee Tree Office	16; 12; 8	69; 53; 28
eMail System	72	71	45	18	14	134	Pegasus Mail; Thunderbird Mail; Amicron Mailoffice 2.0	21; 21; 12	63; 165; 26
Scenario Technique	39	107	39	10	25	126	no cost-efficient software product		
System Simulation	32	106	52	10	20	98	no cost-efficient software product		
Business Game	40	92	51	15	22	91	Gamma	15	75
Synektik	12	63	56	24	65	-17	no cost-efficient software product		
Knowledge Arranging									
Database	100	79	19	9	13	242	MySQL; MSDE		86; 44
Mind Mapping	68	103	25	7	17	200	Free Mind; Think Graph, Tee Tree Office	16; 12; 8	69; 53; 28
Document Management System	74	94	23	12	17	195	Office Manager; UDEX dotNETContact; QVTutto	15; 15; 14	74; 35; 22
Checklist	60	95	29	11	25	164	CUEcards 2000	8	128
Content Management	44	99	29	16	36	126	CONTEX; ContentKit; VIO MATRIX	16; 13; 13	0; 47; 13
Project Review	56	85	39	18	22	122	no cost-efficient software product		
Experts System	30	94	46	17	32	74	KnowIT; KnowME	10; 7	38; 52
Conceptualization	25	79	47	21	48	40	no cost-efficient software product		
Neural Network	20	63	55	29	53	-10	no cost-efficient software product		
Knowledge Transfer									
eMail System	81	76	33	10	20	185	Pegasus Mail; Thunderbird Mail; Amicron Mailoffice 2.0	16; 12; 8	63; 165; 26
Handbook FAQs	60	97	36	11	16	159	no cost-efficient software product		
Communities of Practice	53	100	32	11	24	152	no cost-efficient software product		
Groupware	47	98	37	8	30	139	eGRoupware1.2; AlphaAgent 1.6.0; Tiki CMS - Groupware	15; 14; 16	40; 26; 24
Questionnaire	43	99	33	21	24	110	Easy Survey	10	61
Best Practice	49	84	42	16	29	108	no cost-efficient software product		
Checklist	38	99	44	14	25	103	CUEcards 2000	8	128
Lessons Learned	40	93	48	11	28	103	no cost-efficient software product		
Knowledge Maps	32	101	45	19	23	82	InfoRapid KnowledgeMap	13	69
Story Telling	26	80	58	16	40	42	no cost-efficient software product		
Chatroom	40	69	62	29	20	29	Skype; MSN, ICQ	not possible	71; 33; 25
Microarticle	20	73	61	25	41	2	no cost-efficient software product		

the whole sector and were opted stochastically. The population for the survey can be described as all SME in the three countries and got a number of about 540.000 SME. The online questionnaire was carried out in summer 2006 after a successful pre-test with 20 respondents. The online questionnaire was partitioned into three parts:

- Generally questions referring to the IT support and application of knowledge management within the enterprise itself.
- Rating relevance of the methods concerning the four knowledge processes for SME and get an idea of the favor supporting software tool.
- Information about future capital investment plans referring to knowledge management.

The return quote of the survey was about 40 percent. This means that 220 SME filled out the questionnaire. The failure rate was calculated as 6.63%. So all statements out of the survey are correct at a percentage of 93.61%. In the following chapter the research findings of the methods and the supporting software tools are presented and discussed.

3. RESULTS

The distribution of industries can be described as follows. The bigger part of the SME was from industrial SME with 30% and from Consulting and Information Technology with 22%. The bargaining SME got a level of 13% and the Handcraft 19%. The rest of 16% were divided to Banks and Affirmations 9%, Transport 2% and Tourism 5%. Fifty-seven percent of the SME already use knowledge management and 85% of the SME use a connected infrastructure. A web space is (hosted intern or extern) available in 78% which is necessary to deal with software products which need such an infrastructure.

3.1 Mapping of Cost-Efficient Software Products with Knowledge Processes

Table 2 gives an overview of all methods supporting the four knowledge processes for SME and the corresponding cost-efficient software products. Table 2 lists the absolute number of each method in the likert scale. The ranking of each method is the calculated value based on the likert scale. The "ISO Ranking" illustrates the assessment of the software based on the quality model (chapter 2.3). The absolute frequency of naming of the software through the respondents can be seen in the last column.

As the highly ranked method for the first process of the *identification of knowledge* the Knowledge Balance (92) was named. 56% of SME think that this is the best method to identify knowledge. Further methods are the Balanced Scorecard (89) and the Skandia Navigator (74). The methods Market-Asses Value-Method (-5) and Tobin`s q (-15) were rated by less than 30% of good use in SME.

Brainstorming (225) and Knowledge Network (203) are popular methods of the *acquisition of knowledge*. Also the Mind Mapping (195), eMail System (134), Scenario Technique (126) and System Simulation (98) are proper methods for this knowledge process. Business Games (91) are also a possibility. The method of "Synektik" was rated very bad because of the complexity of this method. The absolute star for acquisition of knowledge was the Search Engine (232) with a percentage of over 70% for efficient use in SME. In the case of the Search Engine the Google Desktop Search Engine was the prior selection of the software. eMail-Systems can be supported by the software Thunderbird1.5 which was chosen by 60% of the respondents. For Brainstorming a good tool will be Concept X7, for Mind Mapping the tools Free Mind (42%) and Think Graph (41%) were well rated. Gamma is software to support a Business Game and this product is well rated by 64%.

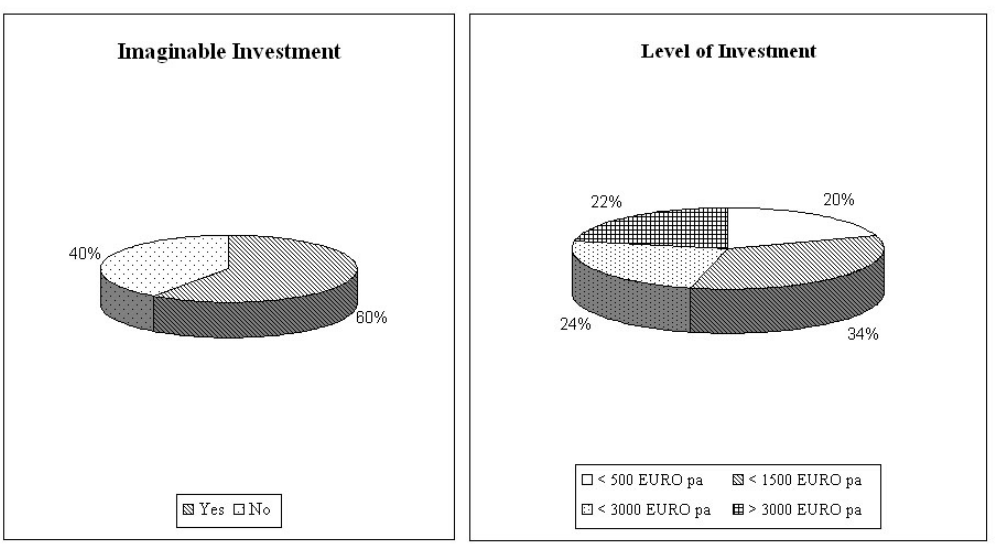
To realize the *arranging of knowledge* databases (242) are a proper method. 80% of the SME think that they will arrange their knowledge by databases. Mind Mapping (200), Document Management System (195) and Checklists (164) are further efficient methods. Content Management Systems (126), Project Review (122), Expert Systems (74) and Conceptualization (40) are methods which can be chosen but are not the favorite choice. Neural Network (-10) is no adequate method for arranging knowledge in SME. There were a lot of different software products to support the arranging of knowledge. These software products and the ratings of them are shown in table 2. MySQL is the favorite database software followed by the MSDE from Microsoft. Document management can be done by the Office Manager, the UDEX dotNETContact or the QVTutto. There are also software tools for the other methods which are described in table 2.

As it is illustrated in table 2 the methods eMail-System (185), Handbook FAQs (159), Communities of Practice (152), Groupware (139), Questionnaire (110) and Best Practice (108) are the favorites of the *transfer of knowledge*. It has to be pointed out that the methods Micro Article (2) and Chatroom (29) are rated not as well by the survey. The software products for the methods of the transfer of knowledge are InfoRapid supporting Knowledge Maps, EasySurvey supporting Questionnaire, Skype and MSN supporting Chatroom, eGRoupware1.2 and AlphaAgent1.6.0 supporting Groupware, CUCards 2000 supporting Checklists and Pegasus Mail, Thunderbird1.5 and Amicron Mailoffice 2.0 for the support of eMail-Systems.

3.2 Investment Allocation

75% of the respondents assumed that they are still using knowledge management in their SME. As it is shown in figure 2 the attendance to invest into knowledge

Figure 2. Investment allocation



management in the next year exists for 60% - 40% can not image to invest into knowledge management in the next year. 20% of SME which can fancy an investment in the next year want to spend less than 500 EURO, 58 % will spend between 500 and 3.000 EURO and only 22% will invest more than 3.000 EURO. The last question in the online questionnaire was about the knowing of the methods by the respondents. 49% of the respondents did not know one ore more methods which was not a problem for the survey because at every method it was possible to get a description of the method.

3.3 Hypotheses Test

The two hypotheses explained in Chapter One should be tested by the survey. For testing these hypotheses the authors choose a chi-square test at a level of confidence of 95%. The hypotheses are:

- *Hypothesis 1:* Knowledge Management Processes can be realized in SME with more than a 30% support of office similar software.
- *Hypothesis 2*: More than 50% of the SME which can image to invest into Knowledge Management in the next year will invest more than 3.000 EURO per year.

If the calculated chi-square score for the hypothesis is less then the score of a comparison table than there is a significant relationship between the two factors.

For the first hypothesis the calculated chi-square score was 2.58 and this is less than 9.49^{463} from the comparison table. In the next step the content must be valuated. 21.82% of the SME which use knowledge management already think that only less than 30% of the methods can be supported by Office products. So the hypothesis can be verified.

The second hypothesis was rated with a chi-square score of 3.89 and this is less than the score of the comparison table with 7.81^{466}. Because of the fact that only 18.11% of the SME which can image to invest into knowledge management will invest more than 3.000 EURO this hypothesis is incorrect.

4. CONCLUSION AND OUTLOOK

Knowledge process management is a research field that has attracted academic and practitioner's attention. The paper shows up a framework to implement knowledge management cost-efficient in SME and not only in large companies which can invest a large amount of money. The four important knowledge management processes in SME can also be supported by a large number of efficient methods which are supported by cost-efficient software products.

One future problem for the implementation of different software products could be the interfaces of the different applications. With Service Oriented Architecture (SOA) it would be possible to solve the problem of interoperability and the problem of security [Kang et al., 2006]. Future research will deal with SOA and should also consider Open Source Software (OSS).

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APPENDIX

Assessment of the Software by ISO/IEC 9126 (example):

Functionality	ISO Ranking	Reliability	ISO Ranking	Usability	ISO Ranking	Efficiency	ISO Ranking
Accuracy	2	Maturity	2	Comprehensibility	1	Time Responsebility	1
Adequacy	2	Fault Tolerance	1	Lernability and Usability	2	Ressource Responsibility	1
Interoperability	1						
Subtotal	5		3		3		2

Assignability	ISO Ranking
Installation	1
Conformance	1
Compatibility	2
Subtotal	4

Summation	17

Process:	Knolwedge Acquisition
Method:	Brainstorming
Software:	Concept X7

Costs:	€ 149
Disk Space:	74,7 MB
Licence:	Licence for one PC/User
Annotation	supporting tablett computers, great functional range, also usable for other methods