Computer-Supported Knowledge Management in SME

- A Combined Qualitative Analysis -

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URI: http://hdl.handle.net/10125/41717
ISBN: 978-0-9981331-0-2

Abstract

Knowledge management (KM) and Knowledge Management Systems (KMS) are not new. With the rise of the Internet, distributed and increasingly social technology, the management principles as well as the tools supporting KM also start to address small and medium-sized enterprises (SME). Todays SMEs are increasingly required to manage knowledge assets in order to sustain their position on the competitive forefront in agile markets. This paper investigates the current state of the art on computer-based KMS (or KM tools as we call them) and commercial KM tools in order to harmonize the picture, derive a joint feature and application system scope and finally inspire future design-oriented research by unveiling gaps. It shows that recent SME-related KM tools do not address KM in a holistic managerial way, fail to link operative data sources such as ERP and CRM, lack effective reward and enabling processes to more quickly establish a knowledge sharing culture amongst SME employees. The main objective of the paper is to inform future design-oriented research.

1. Introduction

Benjamin Franklin was presumably among the first thinkers on the planet to publicly claim that „an investment in knowledge, always pays the best interest“. However, knowledge and especially the management of knowledge did not happen to be a primary research focus for scientists all over the world during this period of time. This situation changed in the beginning of 1990ies when Nonaka, in an article for the Harvard Business Review journal, coined the term, „the knowledge creating company" and Senge developed its concept of the „learning organization“ [29]. In their seminal work Nonanka and Takeuchi classified knowledge as being explicitly stored in documents, models, concepts as well as tacitly captured in the brain of the workforce [25].

Since the early 1990ies, a growing body of research investigated the role of knowledge in enterprises. However, the role of knowledge, knowledge management and the information systems that support the underlying activities in small and medium-sized enterprises (SME) have only recently gathered attention. Even if researchers as well as practitioners almost equivocally agree that knowledge has a crucial and even gaining influence on the success and performance of SMEs, it appears to be largely dependent on the individual context factors how and to which extent knowledge management and elements thereof are being understood and used in SMEs today. This seems to be partly due to special and size-dependent organizational characteristics of SME such as priority, time and budget, management commitment and lack of confidence / trust [5; 19] but also due to missing or incomplete tool support addressing these special characteristics [7]. For that purpose, it appears to be an important research objective to investigate the state of the art on SME-related knowledge, knowledge management and supportive information systems in order to derive a first prototypical architecture of a knowledge management system that covers the special needs of SMEs and allows them to manage knowledge in a holistic way.

2. Research Scope and method

This research is being conducted as part of a larger and longitudinal research project funded by the German ministry of research and education. The final research goal of the overall project is to develop a first prototype implementation of an open source based knowledge management system (KMS), which is specifically tailored to the needs and requirements of small and medium-sized enterprises. In order to support the prototype development during later steps of the overall research project, the primary focus of this paper is to conduct a first analysis of existing commercial knowledge management (KM) tools and conduct a joint requirements and gap analysis. For that purpose, a qualitative research focus is adopted. Scholarly contributions on KM and KMS with focus on small and medium-sized companies are relatively scarce. Hence, we follow a two-part approach. First, we analyze the current scholarly state of the art with regard to actually applied KM tools for SMEs and derive a set of features. Second, we scan the market of commercial KM tools and classify their features. By combining these two inputs, we derive a comprehensive set of already addressed as well as only sparsely supported requirements that will support future design oriented research and our overall research objective, hence. In order to better focus our research as well as improve the readability of this paper, we start out by defining relevant terms. After analyzing scholarly research as well as commercial offerings, we will compare and discuss our findings and specifically

the relation between scientific and commercial advances on KM tooling. Finally we put our findings into context, draw conclusions from these findings and provide a brief outlook on future research.

3. An introduction to relevant terms

Related literature unveils that a clarification of the terms knowledge, knowledge management and knowledge management systems is required in order to better structure existing research on this subject matter. Knowledge management made its way into research during the early 1990ies, when it became obvious that the formal structure of organizations was not enough to explain either success or failure of a firm. In other words, the success of a company is not only caused in applied formal hierarchies and formal business processes, but also resides in the talent and experience a company leverages. Organizational theory has been addressing this effect long before computer scientists or, more generally spoken, engineers did [11]. They experienced the increasing demand and ability of ordinary employees to actively design their work environments. McGregor coined the term empowerment to enable them to take own decisions [21]. What became known as contemporary organizational theory therefore merely focuses on the cognitive capabilities of humans [11]. The cognitive capability of humans basically differentiates this species from others because it enables them to take conscious decisions by combining hard and soft facts and learned and trained cause-consequence chains constrained by the special context to which the decision applies and / or in which it is being taken. The hard and soft facts that are used as inputs to decision making as well as the learned and trained procedures can be understood as knowledge.

Information and knowledge are often synonymously used. However, most scientists do agree that information is the formal representation of knowledge, which is also known as explicit knowledge [30]. Tacit knowledge, however, only resides in the human brain and may not be expressible at all. Due to the increasing importance of knowledge and the widespread application of information systems the terms knowledge management and knowledge management system became more and more explicitly used. Knowledge management can be understood as "activities that are carried out to enable knowledge creation and process innovation" [8]. A more recent definition of knowledge management is given by Maier et al. as follows: "Knowledge management is defined as the management function responsible for regular (1) selection, implementation and evaluation of knowledge strategies (2) that aim at creating an environment to support knowledge work (3) internal and external to the organization (4) in order to improve organizational performance." The authors further assert that "[…] implementing knowledge strategies comprises (5) person- or organization-, product- or process-oriented instruments (6) suitable to improve the organization-wide level of competencies and ability to learn." Finally, KMS can be understood as "information systems that are developed to boost the effectiveness of the organization's knowledge management" [1] and as the practice of using previous knowledge to make decisions that affect current and future organizational effectiveness [18]. The latter is interesting insofar as KMS not necessarily have to be understood as computer-implemented, but could also be purely procedural and paper / pencil based. For this research we require a KMS to be at least partly computer-implemented, however. In order to avoid misunderstandings amongst readers we use the term KM tool for that purpose.

Finally there are different definitions on small and medium-sized enterprises (SME) or small and medium-sized businesses (SMB) (as they are sometimes entitled in the USA). For the purpose of our work we rely on the definition of the European Commission which reads as follows: an SME is an enterprise, which has a maximum of 249 employees, as well as up to 50 Mio. € annual turnover or up to 43 Mio. € balance sheet total [32]. The limits may change over time or with regard to the concrete research scope. For instance in Germany an SME according to the definition of the "Institut für Mittelstandsforschung" (IfM) may also have up to 500 employees [34] whilst in a report of the New Zealand Ministry of Economic Development an SME only has up to 19 employees [23]. It is important to mention, that regardless of the applied definition, SME / SMB are usually constraint by a lack of human resources, money and expertise as well as characterized by their need to react flexible on changing market conditions by enabling relatively simple business processes [3].

4. Scholarly research on KM tools

Cerchione et al. conducted a review of extant literature on knowledge management in SMEs [6]. Even though the body of literature focusing on KMS in SMEs is

scarce, 29 research articles could be identified. The articles were then sub-categorized into those that mostly focused on methodological aspects of KM (18 articles) and those that deal with tools. The latter sub-category contains only 11 articles. We focus on these 11 since they are related to the tooling scope of our paper. Grace for instance presented a tool selection and implementation framework as a result of three case observations on Wiki system adoption [16]. The author found out that a driving force behind the use of Wikis is their relative ease of use. Razmerita and Kirchner claim that Wikis are often rolled-out bottom up by younger employees for their personal knowledge management at first [27]. Grace found Wikis to be very useful as central information repositories and in order to release organizational reliance on E-mail [16]. Various authors ascertain that adopting an appropriate organizational culture is prerequisite to harness any

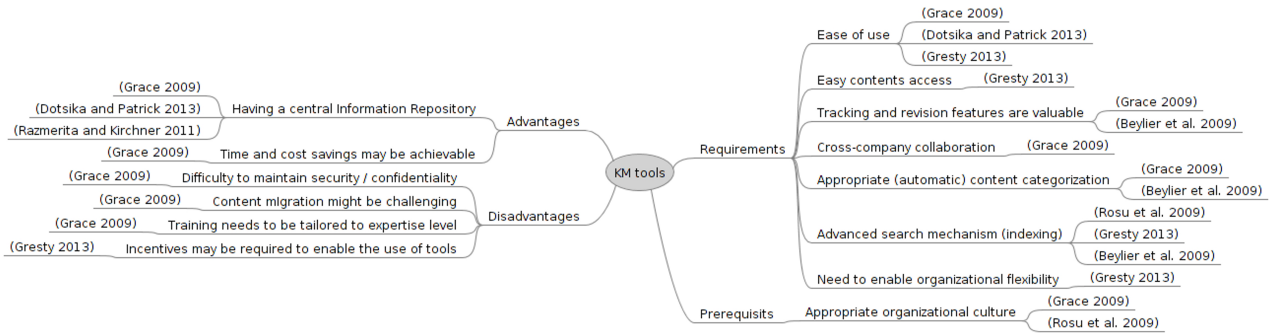

Figure 1: KM tool scope

KM tool [2; 16; 17; 27]. According to Beylier et al. establishing a knowledge sharing culture requires simple tools to codify and personalize knowledge as well as means to identify expertise during project execution [2]. Beylier et al. as well as Grace outline building trust as a prerequisite for an organizational knowledge sharing culture [2; 16]. The authors claim that Wiki or social software systems in general support to build a knowledge sharing culture as they flatten organizational hierarchy and encourage employees to share rather than retain knowledge. This according to Boyd is "supporting the desire of individuals to affiliate, their desire to be pulled into groups to achieve their personal goals" [4]. Zhou et al. conduct an AHP analysis on a KM tool feature matrix [36]. However, the authors fail to explain the construction process of their feature matrix, the source of the features and the evaluation process undertaken. The results of their work, for instance, that self-learning capabilities and general user concerns are amongst the most important features, remain questionable therefore. Rosu et al. suggest a wider range of KM tools and entitle them knowledge base applications (KBA) [28]. The authors claim the integration of existing corporate information sources such as document management systems (DMS), enterprise resource planning systems (ERP) or customer relationship management (CRM) tools to be very important. Their understanding of KBA also contains scenario analysis tools, knowledge innovation applications and external performance monitoring applications. Unfortunately the authors did not explain their research methodology precisely, either. In that regard, an evaluation of the system architecture they developed is missing and remains to be conducted. Beylier et al. develop a tool to support the problem solving process in an engineering company by keeping track of related support data and contextually linking it to the process of problem solving engineering activities [2]. The tool enforces internal exchange of support data, collaborative improvement as well as enrichment of this data and its exposure to external collaborators. The authors emphasize the importance of good filtering and searching possibilities (i.e. contextual views, keyword-based and full-text search). The developed prototype application has been linked to an existing project management as well as a quality management application and provided promising results in the sense that it improved collaborative development and sharing of knowledge throughout an experimental roll-out period. Nevertheless, the authors also claim that "[c]reating a knowledge-sharing culture as part of an SME knowledge management system is of vital importance". Figure 1 groups the findings from the aforementioned papers into advantages, disadvantages, requirements and prerequisites. Based on that

illustration we conclude that having a central information repository may be one of the predominant advantages of a KM tool for SME. This may also reduce time needed to retrieve relevant information. However, user-training needs to be conducted, security and confidentiality issues have to be carefully taken into account and content migration may be a genuinely challenging task. In order to leverage its full potential a KM tool for SME has to provide easy access to its content and needs to be easy to use in general. Cross-company and cross-boundary integration capabilities, tracking and revision features as well as appropriate, ideally (semi-)automatic indexing is also required. Finally content clustering features and advanced search functionality are important. However, establishing a knowledge sharing culture is a prerequisite to successfully leverage every KM tool and one of the topmost important critical success factors for every knowledge management endeavor to succeed as Wong and Aspinwall found out [35].

5. Commercial KM tool offerings

Information technology is a predominant factor of industrial and social change [9]. By nature, the scientific research process takes time. Especially design-oriented research may take substantially more time than it takes an contemporary agile industry company to build and offer a tool. With respect to this observation, the stated research goal of this work and the scarcity of identified scholarly contributions on KM tools, we decided to conduct a structured qualitative analysis in order to derive the industry state of the art on KM tools. For that purpose we have employed a web search strategy using Google search with various keyword combinations. We than processed every first result page as suggested for instance by Flick [14]. We only took organic search results into account. Organic results are those entries on the Google result page that are not influenced by paid advertisements and do not appear on the top or the right side of the search result[1]. Our analysis process is shown in figure 2.

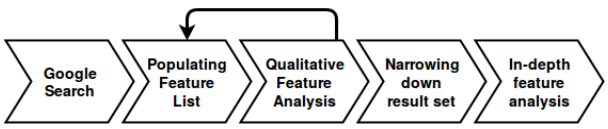

Figure 2: Industry tool analysis process

We have decided to search for German as well as English terms. Our keyword list included "Anwendungssystem", "Wissen", "Wissens-management", "Wissensmanagementsystem", "kleine und mittelständische Unternehmen" and "KMU" as well as the respective English keywords "application system", "knowledge", "knowledge management", "knowledge management system" and "SME". Apart from the Google search, we also conducted a complementary search on Wikipedia for the terms "Wissensmanagementsystem", "knowledge management system" and "knowledge management software" and also used a comprehensive list of KM tools that we found during one of our searches[2]. The final list of KM tools included 34 applications.

Following the process in figure 2 we went on by populating the feature list. For that purpose we took the first candidate application and reviewed their website, marketing material and publicly available documentation in order to populate it. We further iterated on towards the n+1 KM tool on our list and extended the feature list if necessary. In order to limit subjective judgments on features, we challenged the classification with the review of a second researcher. Where necessary and advisable, we bundled more granular features to a wider feature class. Our objective was to reach an overall limit of seven feature classes as proposed by [22]. The German applications have been classified by mapping the German terms (e.g. "Wissensmanagement") to their English translations (e.g. knowledge management). We finally ended up identifying the following major feature classes:

- Knowledge management / knowledge database
- Collaboration
- Wiki
- Save, bundle, share knowledge
- User interface friendliness
- Link and connect data
- Productivity controlling

After we derived the aforementioned seven feature classes, we reassessed all 34 KM tools and evaluated whether a KM tool addressed a certain feature class. By doing so we ended up with a feature density graph shown in figure 3. We could not identify any application that served more than 5 out of 7 feature

1 see https://en.wikipedia.org/wiki/Organic_search for details

2 http://www.capterra.com/knowledge-management-software/

classes. However, approximately 40% (13 out of 34) of the applications served at least 4 feature classes.

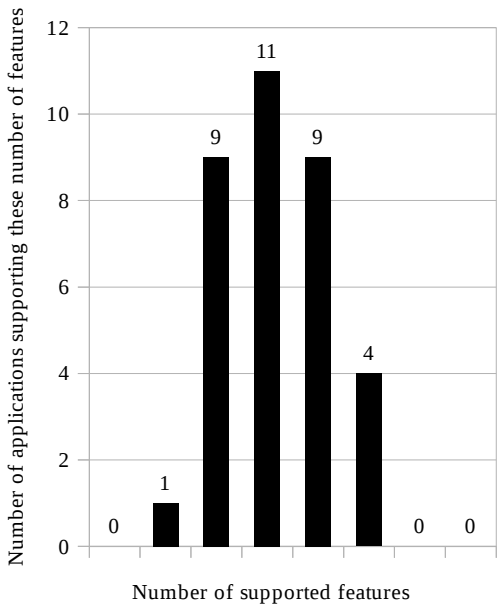

Figure 3: Feature density graph

As implicitly expected due to the used keywords, the applications mostly address feature classes such as “knowledge management / knowledge database” (76%), “collaboration” (71%) and “save, bundle, share knowledge” (82%). “User interface friendliness”, “Wiki” and especially “Productivity controlling” were less often or almost nowhere mentioned. The relative KM tool feature coverage can be found in table 1.

Feature class	Sample share of applications addressing that feature class
Knowledge management / knowledge database	76 %
Collaboration	71 %
Wiki	15 %
Save, bundle, share knowledge	82 %
User interface friendliness	29 %
Link and connect data	41 %
Productivity controlling	3 %

Table 1: Share of covered feature classes

Within a second iteration we looked closer at each of the identified KM tools in order to derive a more detailed comparison of feature class and application system coverage. The pool of scientific articles and books provides a relatively large list of application system classes and features that are frequently mentioned in relation to KM. For instance, Völker et al. mention groupware, document management (DMS), workflow management (WMS) and data warehouse (DW) [33]. O'Connor and Basri claim e-mail, skype (i.e. chat) and blogs to be part of the informal communication tool chain in knowledge intensive industries [26]. As mentioned earlier in this article, Wikis are often mentioned / used among the first tools to support KM [16; 31]. In that regard, “tagging” relevant knowledge has been identified to be an important feature by Dotsika and Patrick [12]. Maier emphasizes the need for knowledge localization and skill management features [20]. By iteratively analyzing the websites and publicly available documentation of our sample of 34 KM tools we added "search", "information filtering", "telephony", "virtual teaming" and "data mining" to this list. We attributed each application with an "**S**" if the KM tool under investigation supported the mentioned feature natively (e.g. search, tagging) or contained the common functionality of this class of application systems (e.g. DMS, WMS). If the evaluated KM tool offered an interface instead of implementing the functionality itself, we marked this with an "**I**". Finally we calculated the relative share of the out of the box coverage as well as interfacing capabilities of all the 34 KM tools we identified with our search. The results are shown in table 2.

Feature / application system class	Supported out of the box (S)	Providing interfacing capabilities (I)
Search	65 %	0 %
Groupware	59 %	0 %
Data mining	53 %	0 %
Filtering	44 %	0 %
Document Management	38 %	12 %
Virtual teaming	26 %	3 %
Workflow Management	21 %	0 %
Wiki	6 %	15 %
Data Warehouse	15 %	0 %
Tagging	12 %	0 %
Chat	12 %	3 %
Weblog	12 %	0 %
Skill Management	3 %	0 %
(Video-) Conferencing	0 %	3 %
Telephony	0 %	0 %

Table 2: Share of application system class support / interface capabilities

Due to the second, more detailed feature comparison, we were able to eliminate seven tools from our sample because they did neither implement nor integrate any of the features / application system classes from table 2. Among the remaining 27 KM tools, only four provided a relative feature / application system class coverage over 50 %. The detailed feature coverage for these four KM tools is depicted in table 3.

	Alpha	Beta	Gamma	Delta
Search	S	S	S	S
Groupware		S	S	S
Data mining	S	S	S	S
Filtering	S		S	S
Document Management	S	S	S	
Virtual teaming		S	S	S
Workflow Management			S	S
Wiki	I			S
Data Warehouse	S	S		S
Tagging			S	
Chat	I		S	
Weblog		S	S	S
Skill Management		S		
(Video-) Conferencing	I			
Telephony				
Coverage Ratio	**53 %**	**53 %**	**67 %**	**60 %**

Table 3: Detailed feature / application system class coverage for leading KM tools

6. Discussion of findings

Knowledge management, knowledge management systems and KM tools as such are not new. However, the body of literature as well as the availability of commercial KM tools focusing on SME are relatively sparse and do not draw a picture of maturity and completeness. The limited body of publications on SME-related KM tools is to a large extent the result of case studies conducted in or with the focus on SME. These articles investigated KM tool application in particular environments. For instance cases have been studied in an engineering context [2; 28], an IT context [27], a financial services context [12] or cross-context [13; 19]. The articles merely focus on the challenges of information processing in contemporary, fast moving and flexible SMEs. They ascertain requirements such as ease of use, simplicity, advanced search, filtering and tagging capabilities, the development of an appropriate knowledge sharing culture the integration of communication / collaboration processes and the

information storage as well as “affordability” as being pivotal to KM tool success in SMEs [2; 27]. Inadequate management awareness / support and cost / budget constraints are influential hindering barriers that have to be especially addressed by SME KM tools [15; 19; 35]. But also the more informal nature of SME due to insufficient technical, managerial as well as IT expertise needs to covered by special SME KM tools [10; 12; 19]. In addition, the notion of KM tools as single point of information seems to be supported by scholarly research. Interestingly, Wiki systems seem to play a more important role in scientific publications as they do in commercial offerings.

Only 21% of the commercial KM tools that we found during our qualitative market analysis integrate with or implement Wiki functions. This might be due to the fact that Wikis are mostly open source based application systems with the most well known (i.e. MediaWiki) originating from the Wikimedia foundation itself. Due to that reason there might be no sufficient market potential for commercial offerings to evolve and therefore no willingness to invest. However, commercial KM tools just like most scientific findings unveil a certain concentration on search, data mining, filtering and collaboration features. Out of 15 different application system classes and features, we found only four commercial tools that support more than 50% of these feature (see table 3). Especially advanced information “tagging” and the integration of different communication channels such as chat, video conferencing, telephony into a consistent KM tool seem to be out of scope for the time being. A common reason behind many if not most KM activities is to foster explication, transfer and creating new knowledge in order to establish the “knowledge-creating company” [24] or to overcome the organizational risk of losing knowledge when employees leave the company.

With that regard we found “skill management” to be supported by only one of the four most feature covering SME KM tools. Various scientists proposed to integrate KM tools with richer data such as supply chain data, customer relationship data, project management data or enterprise resource planning data [8; 28]. None of the four tools that are detailed in table 3 implements an own supply chain, CRM, ERP or a project management. Only in case of Gamma a data connector to various industry tools (e.g. SAP, Navision, SugarCRM) exists. However, no further details have been provided on the website of the tool vendor or in any publicly retrievable marketing material. None of the SME KM tools we have identified and further detailed in table 3 offers either a method or a concept to build and establish a knowledge sharing culture. Even if “strategy / purpose”, “culture” and “processes / activities” have been identified to be critical success factors of KM in SME [35] and these factors may be supported by obtaining a more “methodological” perspective on KM tooling, this aspect has not yet made inroads to any of the market offerings and therefore remains a substantial gap.

7. Conclusion, Future Research and Limitations

Within this paper the relatively sparse set of scholarly publications on KM tooling focusing on SME, is complemented and subsequently compared with a qualitative market survey, conducted on commercial SME KM tools. Our paper, to the best of our knowledge, contains the first research combining these data sources and puts them into a comprehensive comparison. Our work clearly shows that KM tools, specially focusing on the needs of SME is far from being mature in terms of research as well as market offering. Related literature uses a variety of different research methods such as exploratory case studies, action as well as design-oriented research and quantitative analysis methods, yet not following a common and clear research focus.

For instance there is only one contribution that uses action research to describe the process an SME took to improve its own KM tooling. None of the papers identified, analyzes or even mentions any of the commercial tools that were identified in our qualitative market search. No previous research article pulled together most or all of the identified requirements, we have depicted in figure 1 into an either survey-based or even better design or action research based research approach. Wikis and more generally social software has been identified to foster knowledge sharing cultures by flattening hierarchies and destroying impediments of a sharing culture. However, most of the commercial tools still seem to focus on rigid, more workflow or groupware-based interpretations of KM tooling. As already mentioned none of the most visible four commercial tools provides an integrated methodology or concept to overcome this problem. Research focusing on this very matter with regards to SME is largely missing as well. Commercial tools mostly focus on document management, search, data

mining and filtering. The integration of further communication channels such as chats, videoconferencing and telephony or social software in general doesn't seem to be on the agenda of commercial vendors yet.

There is a lot of research that still needs to be conducted. For instance it should be interesting to study the integration or linkage of the aforementioned communication tools, social software in general as well as a methodology to establish a knowledge sharing culture into a holistic KM tool. Such a tool does not only need to support common, company-size and scope independent requirements such as data integration, it also needs to match the “easy access” and “ease of use” requirements as well as budget and resource constraints of SME. Todays KM tools seem to be understood as “managerial overhead” instead of compelling today’s knowledgable workers to actively share their knowlegde. Research on effective incentives and reward systems using, for example, gamification may hence be a promising scientific research goal to secure management support as well as establishing a knowledge sharing culture. A plethora of additional technical as well as theoretical challenges need to be solved on that way. For instance semi- or fully automated tagging of knowledge artifacts may add to the accessibility requirement. Augmented reality technology may ease information accessibility by delivering the right information just-in-time and place. Devising a consistent, yet extensible knowledge artifact meta-model may improve combination, knowledge analytics and further allow better comparison of research results. The sheer and rapid growth and availability of relevant data and information sources is a relevant challenge for SME oriented research as well.

Finally our work has various limitations. For instance we only used Google's search engine to retrieve commercial KM tools. It may be possible though, that other on-line catalogs, search engines and survey based approaches may reveal more and other results. The available body of knowledge with special focus on the constraints and requirements of SME is sparse and the distribution of research methods and scope is comparably huge. We draw our conclusions on a very limited body of knowledge and sparse market offerings. This clearly limits the generalizability of our work. In order to improve that, we call for a more design and action oriented future research agenda that takes theories derived from larger enterprises as well as prior KM research into account but focuses more on the necessary capabilities of tools to foster and establish a knowledge sharing culture in SME.

8. Acknowledgement

This work has been done within the frame of the MACKMA research project funded by the German Ministry of Education and Research (Grant Number: 01IS15057A). The authors thank for the funding.

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