




Knowledge Management for the Digital Transformation of Enterprises – Literature Based Trend Analysis

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Abstract. The digital transformation of companies and society is progressing. The rapid realization of projects or the accelerated implementation of new “disruptive” technologies endanger aspects of sustainability. A sustainable aspect can be seen in the knowledge management of companies: The digital transformation, new technologies and the new production factor knowledge are putting established models for knowledge management under pressure. This paper presents the current state of research on knowledge management in relation to digital transformation. It could be worked out that knowledge management must gain more importance in companies. The way in which knowledge management is operated is changing at the same time, which makes new rules necessary. Due to the plurality of concepts and models, knowledge management is difficult to apply holistically for companies. Enterprises experience a technological upgrading which makes learning of the organization together with technology and humans possible. New forms of access to knowledge enable more target-oriented access in each situation.

Keywords: Digital transformation · Knowledge management · Literature research

1 Introduction

The digitization of work is continuously progressing in various societies around the world. Companies are confronted with a multitude of challenges. A special aspect in the context of a sustainable digital transformation can be seen in the knowledge management of a company. The rapid realization of projects or the accelerated implementation of “disruptive” technologies can result in the loss of knowledge. But the importance of knowledge gained in projects is increasing. Especially if you want to conduct research through project management in the future and at the same time the profession of the project manager has to constantly expand its knowledge and this is enhanced with individual experience. [1] Experience knowledge is capital for a company. For example, there is discussion

of a new production factor “knowledge”. [3] The sustainability of technologies and processes that have been established in the company in the context of digital transformation, for example, could disappear with the leaving of project employees. The company cannot generate value in knowledge, which helps to quickly adapt business processes in a dynamic market environment. In view of this, established knowledge models can come under pressure and be modified or expanded.

In the research project “Healthy work in pioneer industries” (German Federal Ministry of Education and Research (BMBF), 02L14A073), case studies were conducted on the introduction of technology related to the digital transformation. Based on these case studies, the question of aspects of a sustainable digital transformation of companies was asked. One factor came into a special focus: the management of knowledge in relation to the introduction of technology or the modification of business processes as a result of digital transformation. Increasing complexity and interdependence of IT solutions, coupled with new technological possibilities, can result in new requirements for the knowledge management of companies. At this point, we want to focus on the following questions within this paper: 1. Is the topic of knowledge management to support the digital transformation of companies in the scientific domain identifiable? 2. Which methodological approaches are currently present in the research literature regarding the digital transformation of companies and knowledge management? 3. Which challenges and issues can be derived from the research literature for future work?

The consideration should not include further terms from other scientific disciplines, like system theory etc., in the analysis, because this represents a further theoretical work, which can generate an extra value from the comparison of the different approaches.

The following Sect. 2 takes a look at the state of the art. Then, various terms related to knowledge management will be set and classified in Sect. 3. As a result, queries are made in specific databases in Sect. 4. The research results will be presented afterwards in Sect. 5. In addition, Sect. 6 discusses the results on the basis of theses, where there are possibilities for further research for knowledge management in relation to digital transformation. In the last Sect. 7 a summary of the work will be given.

2 State of the Art

There is a multitude of different models for knowledge management. One of the most common models comes from Nonaka and Takeuchi [10]. It is known as SECI model. Through processes of externalisation, combination, internalisation and socialisation, knowledge is created that can be transferred from a person to a group or company. The knowledge should be made available to an organization, because an organization cannot create knowledge itself, but rather its members. Therefore, preconditions must be created to enable this in the company.

Another model for knowledge management is, for example, the model of “Building Blocks of Knowledge Management”. It is a practical approach that tries to provide a practical framework for companies based on defined standards for knowledge management - compatibility, problem orientation, comprehensibility, action orientation and appropriate instruments. The blocks in the cycle model represent activities that are directly knowledge-based. An internal cycle consists of identification, acquisition, development, distribution, preservation, and use of knowledge. An external cycle still has goal-setting and measurement, which focuses on goal-oriented interventions [11]. In the model, however, the focus is strongly on management control. But teams are increasingly working independently.

In addition to models for knowledge management, the current research literature contains explanations on new technological possibilities in interaction with a better distribution of knowledge for humans and machines. For example, Rettinger et al. outlines that semantic technologies are the prerequisite for “Knowledge 4.0”. Knowledge graphs can enable value creation by making unstructured content accessible to machines and people simultaneously [13]. Knowledge is important as a resource for companies. Therefore, so-called knowledge workers must be able to analyze and interpret complex phenomena and define suitable measures. Kohlegger et al. see in this and in the interaction with digital tools new possibilities for a better creation of value [6]. New technologies such as data analysis, process mining and text mining open up new possibilities for the externalisation of knowledge in companies. Experience can be shared more easily through simpler interfaces. Targeted information can be enabled by IT systems that know what an employee needs and when [9].

Research on knowledge management is conducted from different perspectives and there are a number of publications on this. With regard to digital transformation, which is understood as a process that changes the whole enterprise, it has been difficult to find generalizing treatises. However, there is a multitude of models and different concepts for knowledge management.

Technological possibilities and knowledge work, are only partial aspects in the research literature. For example, cultural factors are also at work in a globalised world, where people can work together in virtual teams. Jelavic et al. outlines the understanding about eastern and western views of knowledge can make a significant contribution to efficient knowledge transfer [5]. In this context it seems necessary to draw attention to different concepts of digital transformation: Industry 4.0 in Germany and Society 5.0 in Japan.

In addition, digitized companies are becoming more and more dependent on the software they use. Also here knowledge management is essential, as Maciel et al. explains. They see knowledge management as a major challenge, especially for software development companies, as the quality of software products depends to a large extent on it. The work referenced here has carried out a Systematic Literature Review in order to get an overview of approaches for the diagnosis of knowledge management in software companies [8].

There are different approaches, theories and models that deal with knowledge management. In view of the digital transformation of companies, there is a lack of a generalizing view of knowledge management, which combines different theories and models and takes new technologies into account. This work would like to contribute to this with its research.

3 Term Search

During an initial term search, it was observed that the topic of knowledge management is practiced in various scientific disciplines and has a special focus depending on the subject, as can be seen with some examples in Table 1.

Table 1. Examples for research disciplines and research interests

Research disciplines	Research interests
Computer Science	Improved data models and their representation in IT systems
Business Economics	Optimization of productivity of the company
Sociology	System theory

As the table shows, sciences have different focuses on knowledge management, information management or data management. This makes interdisciplinary research more difficult. This can be very important in view of the digital transformation, because knowledge management is subject to several influencing factors, which are especially technologically determined. However, this variety of focal points with regard to knowledge management is reflected in various model and concept terms and the lack of a generalizing model. This paper focuses on knowledge from the perspectives of computer science and economics: Data and information that define knowledge in enterprises for value creation.

Since the digital transformation is also changing the input and output devices for the users in companies, it may also be useful in the future to include ethnological aspects, as the handling of knowledge and the behavioral use of employees can be a special focus. This is only mentioned under the keyword human-technology interaction.

From the focus and from a first search the following terms could be identified, which can be considered for a literature search. In addition, it was possible to classify the terms independently, as can be seen in Table 2.

Due to the large number of model and concept terms relating to the topic of knowledge management, the present literature research was initially limited to this terms for the queries.

Table 2. Terms for research

Basic terms digital transformation	Concept terms digital transformation	Basic terms knowledge
Digitalisation	Industry 4.0	Data management
Digital transformation	Society 5.0	Information management
		Knowledge management

4 Data Collection

Two scientific databases were selected for the search, which provide specified search options and can deliver specialized results. The keywords identified in the term chapters are queried via the databases. As knowledge management should refer to digital transformation, the terms of knowledge are always queried in connection with the terms of digital transformation. The result is limited knowledge management, which refers to digital transformation.

4.1 IEEE Xplore

The IEEE Xplore is a research database that provides technical knowledge in the fields of electrical engineering, electronics and computer science. Publications on knowledge management were requested in relation to Digital Transformation with the following search query:

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("digitalization" OR "digitalisation" OR "digital
↪ transformation") AND ("knowledge management" OR "
↪ data management" OR "information management")
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A result of 71 database entries was found.¹ The emphasis of the publication focuses especially on the last years. Topics include for example innovation management, the application of big data technologies, industry 4.0 topics and other challenges.

4.2 ACM Digital Library

The ACM Digital Library is a research database primarily addressed to researchers in the field of computer science. Similar to the IEEE Xplore search query, the following search query was used for the ACM Digital Library:

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+("digitalization" "digitalisation" "digital
↪ transformation") +("knowledge management" "data
↪ management" "information management")
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¹ <https://ieeexplore.ieee.org>, Access on 9 march 2019.

A result of 1540 database entries was found.² Compared to the IEEE Xplore database, considerably more entries were found. This may be due to the fact that the ACM Digital Library also recorded data from presentations. In comparison to IEEE Xplore, more results from the 1990s are also listed. Thematically, for example, the last entries show publications on social networks, models, neural networks or challenges for organizations.

5 Evaluation

In Fig. 1 you can view all results from the two research databases. The period from 1990 to 2018 is shown here. In the period under consideration new contents on the topics of knowledge management, information management and data management were published. After 2009 and 2012 highlights were reached, the publication rate apparently decreased, in order to achieve 2018 almost again a high publication activity. Apparently, the topic of knowledge management is of great importance in the current debate.

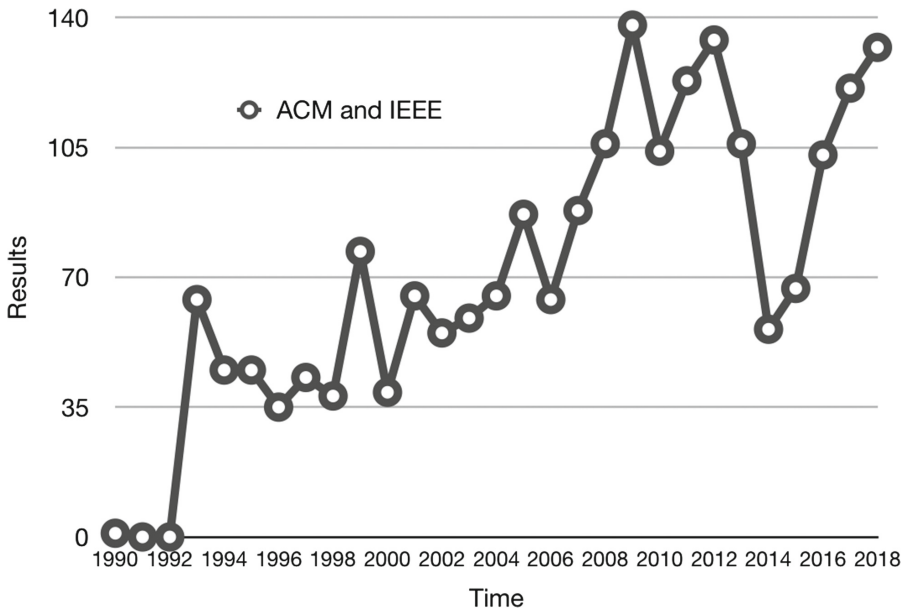


Fig. 1. Results in the research databases

In Fig. 2 the topics data management, information management and knowledge management are presented. Also here a trend can be found in the period 1990 to 2018 with all three individual topics, which allows conclusions to be

² <https://dl.acm.org>, Access on 9 March 2019.

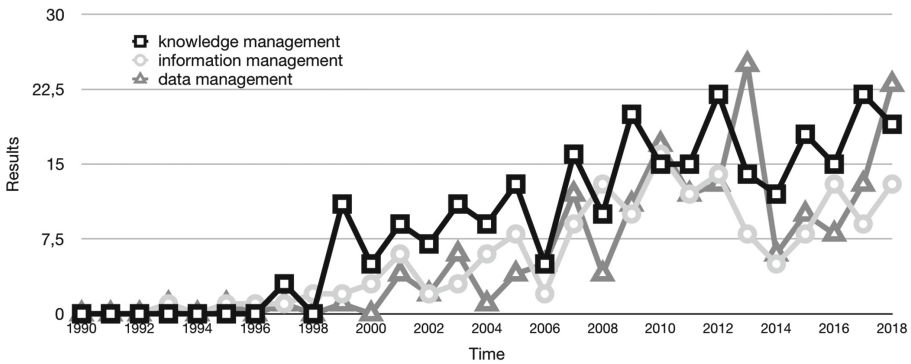


Fig. 2. Development of data management, information management and knowledge management

drawn about an increased research activity in these areas. It is also noticeable that knowledge management tends to achieve a higher publication rate than data and information management, which, however, can be justified by the fact that data and information management can be integrated into knowledge management in terms of content. Another conspicuous point is that data management, in contrast to information management, has experienced a special publication push in the last two years, whereas information management has not risen as much in comparison. This may be due to the fact that data science is recognised as a driving factor for innovation and the economy. In addition, data science is also developing fast because it integrates seamlessly into life, as Longbing Cao explains [2].

The concept terms industry 4.0 and society 5.0 could not be queried in the exported spreadsheet files because the ACM Digital Library did not export the abstracts also. With a query of the concept terms it should be quantitatively reviewed whether publications in the context of industry 4.0 and Society 5.0 concern themselves with the knowledge management.

6 Discussion

In the following chapter, the qualitative and quantitative state of research on knowledge management in relation to digital transformation will be discussed on the basis of theses and conclusions will be drawn for further research activities in this field.

In Fig. 3 the discussed theses can be seen in the overview, which influence on the knowledge management is based on the digital transformation.

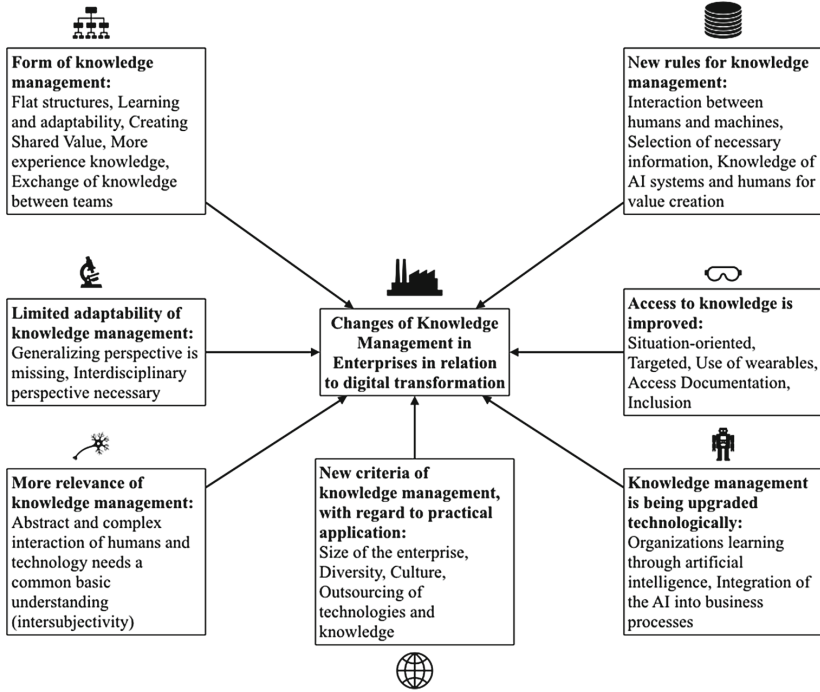


Fig. 3. Changes in knowledge management in relation to digital transformation

1. Digital transformation has an impact on the way knowledge management is applied in enterprises.

Enterprises established on the market have developed structures. Through digital transformation, these established enterprises are challenged by new start-ups in competition, which with flat structures and agility can successfully attack value creation models of established enterprises faster than in the past. Therefore, many established enterprises today try to consolidate hierarchical levels and work in teams on tasks similar to start-ups [14]. But this also changes knowledge management: 1. Hierarchies make information move only slowly and filtered. In flat structures, information moves fast and there is potentially a lot of redundant information. 2. This results in adjustments to employee competencies. With hierarchical structures, management and control of the work are in the focus. With flat structures, continuous learning and the willingness to adapt as well as the ability to adapt. 3. In the hierarchical structure, much depends on individual productivity, which also results in competition among one another. In the flat structure, the focus is on creating common value, where the mutual achievement of tasks with differentiated talents and knowledge focuses. 4. Ultimately, hierarchical structures also have other knowledge focuses because here assessments must always be made on known assumptions for advance planning. In flat structures, the focus is on

trying out and learning, building knowledge from mistakes. 5. One focus is the transfer of knowledge between teams. This is where experiences are collected that must be made available to other teams. New technologies must support this exchange. Previously, information in companies tended to run along the hierarchies in silos. A consideration of the vertical and horizontal exchange of knowledge could mean new results for research.

2. The adaptability of knowledge management is limited in practice.

There is a lack of a generalising perspective and a lack of transferability to practice. Due to the different consideration of knowledge management in different scientific disciplines, many different concepts, models and concepts result, which make it difficult to take a comprehensive analytical perspective on the knowledge management of enterprises in the light of the digital transformation.

Organizational intelligence, Knowledge-based theory of the firm, learning organization, common knowledge construction or collective intelligence. Different terms which can be found in different scientific disciplines in the context of knowledge management. Although specific terms and specific modelling in the respective science sharpen the contour of the respective analytical dimension of knowledge management, a more interdisciplinary analysis of knowledge management is often complicated. But this is necessary because digitalization requires the digital transformation of companies. Not only the use of technologies, but also the handling of information in the organization is changing in relation to the knowledge of enterprises and employees. Therefore, it is essential to take a generalizing look from different scientific disciplines, because Digital Transformation is a global issue for companies. Individual perspectives help companies with knowledge management only to a very limited extent. A comprehensive view of knowledge management in connection with the changed technological, structural and social aspects in particular is necessary.

3. Due to the digital transformation, knowledge management in companies is becoming more important.

As seen in Fig. 1, publication on knowledge management has increased in recent years. The digital transformation increases the share of technologies and information technology solutions in enterprises [9]. The dependencies between IT systems (system integration) and people (human-technology interaction) are becoming ever greater and the resulting relationships more complex. In addition there are new programming languages, artificial intelligence and other new technologies or processes which make more and more data and information possible in enterprises. (As seen in Fig. 2, publications on data management are increasing.) In order for this to remain controllable for employees and the management of companies, measures for understanding complex interrelationships [6] must be increased. One example is the creation of intersubjectivity, which is necessary if people are to collaborate on an abstract problem. The increase in the production of intersubjectivity will have to be done by companies through higher internal communication efforts.

4. **The transfer of previous knowledge models into companies is difficult for companies due to the size of organisations, the focus of topics and the abstract character. There are new criteria for knowledge management with regard to practical application.**

The application of knowledge models in companies can be difficult due to the size of the company. Small and medium-sized enterprises have different information requirements than large enterprises. (analogous to the tendency of large companies to mature at an advanced stage in industry 4.0 topics [12]) In addition, aspects of diversity and internationality may be more relevant for large enterprises than for smaller, more local market participants. For example, the handling of knowledge can be viewed differently in different cultures. (as outlined in [5]) For a globally operating company, this results in special demands on the skills of employees and processes that take these cultural differences into account. Small and medium-sized enterprises also tend to rent or buy information and data services as well as specific technologies from third-party companies because of the smaller number of employees. In such a case, the small or medium-sized company also gets rid of the knowledge management for the technology. On the other hand, market observation and the company's own value-added processes, which build on the purchased or rented technologies, remain relevant. The more technologies are outsourced, the less knowledge management the company has to operate on its own in relation to the respective technology. Regardless of the size of the company, whether large or small, the models of knowledge management are to abstract from their own problems and complex in day-to-day business for a practical application that is understood by different target groups.

Knowledge management can only be successful in collaborative networks if the employees with different talents and competencies are familiar with a minimum standard for knowledge management. If knowledge management is operated in a fragmented way and only from specific thematic aspects, there are knowledge deficits and knowledge imbalances in the organizations. Value creation that results from the knowledge of employees and management is thus sometimes not taken into account. This can be solved by general knowledge management concepts that are known to all members of an organization and are lived in everyday business. This is also a question of corporate culture, which should enable the exchange of knowledge within the organization.

5. **Knowledge management is being upgraded technologically: Organizations can learn through artificial intelligence.**

With the SECI model, the view is that an organization can learn through its members. The model is also designed to ensure that the knowledge of its members is converted into knowledge for the organisation. There are four modes: socialisation, externalisation, combination and internalisation. (as outlined [10]) New technologies and their combination with existing technological solutions now enable a company to learn independently. Artificial intelligence, for example in the form of an API as a service [7] connected to individual or in future all business processes, can store knowledge in interaction with a company's data storage systems of employees and management and expand it

through machine learning. A company can no longer learn only through members, but also independently with artificial intelligence. Initial approaches can be seen, for example, in automatic information and consulting systems such as a chatbot or a language assistance system. It is therefore necessary to integrate artificial intelligence in companies into the various business processes and to allow them to interact with each other.

6. Access to knowledge is improved, as it can be more situation-oriented and targeted.

New devices enable new forms of interaction and thus new possibilities for targeted access to knowledge [9]. This has to be considered especially in the background of collaborative forms of work - for example digital teams or virtual teams. Context-based access to information is particularly important in the area of wearable computing. Targeted information that is relevant in the respective business process can be communicated to the users. It also offers the possibility of inclusion. People who have been overburdened with certain tasks because they did not have the knowledge, experience or competence to do so can be equipped with the appropriate devices and the information and competences necessary for the business process. In interaction with new devices, knowledge can be purposefully shared in organizations. This can also increase the willingness to document, as hurdles can be compensated by new knowledge input and knowledge access. As a result, reworking can be reduced.

7. Knowledge management with digital technologies needs new rules in organizations.

The potential availability of data and information in enterprises results in a potential knowledge (for example knowledge acquisition through projects [1]), which can be available for specific business processes and individual employees with different competences and talents. Ultimately, wisdom can also be formed through the interaction of human and machine. (as outlined in the DIKW pyramid in [4]) The role of knowledge management in digital transformation is: 1. To establish rules for the interaction between humans and machines, so that enterprises can focus on individual determinants, which enable the targeted exchange of knowledge, as the topic becomes more complex. 2. From the potential availability of data and information, differentiated solutions must be researched which take into account enterprises with different characteristics and different enterprise purposes as well as value creation projects, so that the further development of the enterprise and the quality of the products and services can be optimized as well as the enterprises which can access differentiated rules of knowledge management. 3. Rules must be developed on how knowledge of AI systems and humans can be generated from this data and information. This knowledge should in turn be available to different people with different requirements and enable a meaningful activity that increases the value creation of the organisation.

7 Conclusion

The paper showed that knowledge management is an essential aspect of sustainability in the digital transformation of enterprises and is becoming more and more important. At this point, the questions from the Sect. 1 will be answered.

Within the 1. question, the introduction asked, is the topic of knowledge management to support the digital transformation of companies in the scientific domain identifiable. Both qualitative sources and quantitative queries of databases have shown that knowledge management as a field of research has been actively practiced in recent years. Even in the present, the topic seems to be relevant in science, as the increasing publication entries in the databases demonstrate recently. In addition, qualitative literature research has also shown that knowledge management is a significant factor in the digital transformation of enterprises. However, there is a lack of global approaches and publications that focus on practical application in companies.

Our 2. question asked, which methodological approaches are currently present in the research literature regarding the digital transformation of companies and knowledge management. There are individual approaches, but none that view knowledge management as a global topic in the enterprise. Different results from different scientific approaches could provide new findings here. The human-technology interaction, caused by new devices, or questions about the increase in complexity in enterprises and autonomous programs, through the use of AI services, as well as the behavior of employees, such as new technologies are used with which motivation, can enable new conclusions about an optimized knowledge management in the age of digital transformation for enterprises.

Related to 3. question some challenges and issues for knowledge management in relation to digital transformation can be derived from the research literature for future work. In the Sect. 6 some theses could be made and discussed on the basis of the previous research. Thus, the way in which knowledge management is to be carried out changes in companies in relation to the digital transformation. The companies have difficulties with the application of knowledge management, because a generalizing point of view is missing, which is understandable to all members of an organization. Knowledge management is technologically upgraded and organizations can learn with artificial intelligence. New technologies provide new access to knowledge for members of companies. This in turn makes new rules for handling knowledge in companies necessary.

In order to further optimise quantitative research, it may be recommended to classify the found sources, whether the publications address models, procedures, case studies, etc. It may also be useful to include other scientific databases such as Google Scholar. Furthermore, the multitude of concept and model terms for knowledge management from different scientific disciplines can be included.

In addition to the processing of some qualitative sources, the work was also able to realize a quantitative research and to discuss these in the Sect. 6 on the basis of theses. From this it can be deduced that the models of knowledge management have to be extended or adapted. Specific requirements of the digital

transformation should be considered. In this way, a basis for practice could be created. It has also been found that a generalizing view of the topic can generate new findings. Furthermore, future research activities can also empirically research practical approaches to knowledge management in companies.

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