Designing Innovative Digital Technologies for Knowledge Management and Data-driven Business: A Case Study

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ABSTRACT

This paper presents a case study on co-designing digital technologies for knowledge management and data-driven business for an SME. The goal of the case study was to analyse the status quo of technology usage and to develop design suggestions in form of mock-ups tailored to the company's needs. We used both requirements engineering and interactive system design methods such as interviews, workshops, and mock-ups for work analysis and system design. The case study illustrates step-by-step the processes of knowledge extraction and combination (analysis) and innovation creation (design). These processes resulted in non-functional mock-ups, which are planned to be implemented within the SME.

CCS Concepts

•Human-centered computing → Interaction design process and methods; •Software and its engineering → Requirements analysis; •Information systems → *Enterprise information systems;*

Keywords

Innovative digital technologies, design, mock-up development, knowledge management, data-driven business

1. INTRODUCTION

Knowledge management (KM) typically deals with capturing, storing, organising and managing organisational data in order to be able to effectively use them for companies' daily business [17, 25, 27]. While knowledge management and corresponding technologies are well known, data-driven business (DDB) is an upcoming research area with the goal to enhance conventional knowledge management. Data stored in KM systems are not longer seen as information sources only, but are used and analysed to derive new insights or trends, future customer behaviour, or new selling opportunities and therefore to stimulate innovation [15]. This novel emergence opens up the opportunity to design new innovative digital technologies, which aim at increasing the productivity and competitiveness of companies. This is also in line with North et al. [19] who said that it is possible *"[..] with a holistic approach of knowledge-oriented company management, in which the cooperation of the human factor, organisation, and technique were appropriately taken into consideration, to achieve long-lasting competitive advantages."* [1]. Companies that strategically see innovation as a means to stay in business are therefore now interested in the opportunities that data-driven business may offer, and how these would relate to their existing business processes and models.

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2. MOTIVATION

Knowledge management with the help of ICTs has the task to capture, store, develop and share organisational knowledge. Despite technological progress, these remain challenging today [13]. The goal of knowledge management defined by Probst [21], and which corresponds with the authors' understanding, is *"[..] to improve organisational capabilities through better use of the organisation's individual and collective knowledge resources"*. This organisational knowledge consists of explicit as well as implicit (tacit) knowledge. While explicit knowledge is well described, explicated and can be stored within the company's knowledge bases, implicit knowledge is intrinsic knowledge available only in each single individual employee. In Nonaka and Takeuchi [16], they present their SECI model (Socialization, Externalization, Combination, Internalization), which is seen as base for knowledge management in general. They describe a way on how to continuously transform implicit to explicit knowledge, in order to bring individual to organisational knowledge with the goal to use and store it.

Since 1990 knowledge management has become a fixed component in modern management. Therefore a lot of research focussed on how to organise, store, manage and retrieve organisational knowledge in a meaningful way [25, 27]. The main goal of knowledge management was to ensure, that each employee, department or organisation has access to all data relevant for performing well on their tasks.

In the recent years, the research changed from typical knowledge management methods and theories to more data-driven

[1]German text: "[..] mit einem ganzheitlichen Ansatz wissensorientierter Unternehmungsführung, in dem das Zusammenwirken von Mensch, Organisation und Technik angemessen berücksichtigt wird, nachhaltige Wettbewerbsvorteile zu erzielen sind"

approaches, where the focus is now put on the content of data instead of how to organise and store them e.g. [12, 17]. Data gathered and collected within companies become more important to establish good knowledge management and practices for the companies' own administration management. Such efforts are frequently adressed in efforts called big data (emphasising data analytics) and data-driven business (emphasising new business processes and models). Aamodt and Nygard [1] already described the close relationship between data and knowledge: *"The role of knowledge, in general, is therefore to play the active part in the process of transforming data into information, deriving other information, and acquiring new knowledge - i.e. to learn."* Thus, data is not longer seen as raw information only but serves also as a source of new information and knowledge. This is also in line with McAfee [15], who stated that *"The data available are often unstructured - not organised in a database - and unwieldy, but there's a huge amount of signal in the noise, simply waiting to be released"*. The new goal is to extract meaningful and actionable knowledge out of already existing data, by applying big data analytics, including techniques and methods for modelling and analysing big data as mentioned in [3, 6, 14].

Together with these new opportunities of creating and using actionable knowledge and information, the new emerging key players in organisations are the "data scientists". Davenport et al. [7] define them as *"... a high-ranking professional with the training and curiosity to make discoveries in the world of big data"*. These approaches together with the new key players sound very promising and interesting not only for big enterprises, but also for SMEs to increase their productivity and competitiveness with the help of their own data. Brynjolfsson et al. [4] found after investigating 179 companies that the productivity of companies applying data-driven decision making is 5-6% higher than would be assumed judging by other aspects of the company (e.g. ICT usage). However, as shown in [23], Austrian SMEs are still sceptical about the prospects of these topics, although the willingness and curiosity to use own data for the own productivity and value creation outweigh.

Take-up of new technologies and related new opportunities is challenging however, especially for SMEs [9]. Lack of awareness about available solutions, the lack of internal expertise to choose a suitable solution and in general a lack of existing solutions that are appropriate for SMEs are seen as key barriers (ibid).

This is the challenge adressed by our work. In this paper we describe a successful knowledge transfer case study in which a systematic mix of analysis and design methods was used to transfer innovative technologies and business concepts to an Austrian SME. These activities led to a mock-up that is planned to be implemented by the SME in question.

3. BACKGROUND: MOCK-UPS FOR INNOVATION CREATION AND KNOWLEDGE TRANSFER

In the mid-1990s popular companies started adopting paper prototyping as part of their product development process, but the methods summed up by the term paper prototyping are not useful for designing only [24]. Pfister and Eppler [20], for example, underpin all the benefits of sketching for knowledge management with existing literature that highlights the various possibilities sketching provides for knowledge creation, sharing and documentation. Additionally, Katz and du Preez [11] reported from a case study about innovation that *"prototypes and mock-ups are a cost effective way of testing innovative concepts and gathering information in order to make important decisions."*. The advantages of paper prototypes are generally manifold: They overcome any language and professional barrier and therefore can be created by all types of people without requiring any specific skills [2, 8, 24]. This allows multi-disciplinary teams to collaborate, which is crucial for fostering innovation, as Buur and Bødker [5] already assessed the *"meeting of different competencies"* as *"the most important source of innovative design"*. Furthermore, paper-based mock-ups are cheap, easy and quick to create. They allow contextualization considering real-world scenarios and actual needs of the people concerned [8], which promises better acceptance of the final implementation of the proposals [2]. Especially the possibility of contextualisation plays an important role, as Rosenqvist and Heimdal [22] observed that their session participants continuously incorporated elements from reality in their drawings. Based on this, the authors claimed that reality serves as a foundation for new ideas and simplifies the communication of ideas to other people.

4. CASE STUDY DESCRIPTION

4.1 Setting

Company A is a software company mainly dealing with web-design, digital marketing and customer relationship management. The first pillar of the company's success, is their self-developed customer relationship management tool (CRM Tool), and the second pillar is the design, creation and marketing of tailored web presences and web shops. The company consists of 20 employees (16 full-time, 4 part-time) and 3 freelancers, working in three areas, namely project management, office and marketing&sales. Altogether the company serves about 2000 customers.

4.2 Participants

3 employees (2 male, 1 female) filled in the demographic questionnaire and participated in the interviews; two were aged from $20-29$, and one from $30-39$. All of them work full-time in company A. One of the interviewees was the CEO, one was an experienced programmer and project manager, the third interviewee was a software developer.

5. METHODOLOGY

To achieve the development of business solutions with regard to digital technologies, we employ requirements engineering and interactive system design methods. All methods used are kept as general as possible in order to be applied in different company settings and to extract information on different topics as well.

Generally we split our approach in two phases, the work analysis and the design phase. The work analysis phase is started with the interviews for knowledge extraction and is followed by a workshop and bi-lateral talks for combining the extracted knowledge with new knowledge. The design phase proceeds with mock-up development and iterative mock-up refinement as innovation creation step and ends with the concluding innovation application step. All phases includ-

ing the steps of knowledge extraction, knowledge combination, innovation creation and innovation application and the corresponding methods are depicted in Figure 1.

5.1 Work Analysis

The work analysis phase consists of two steps, knowledge extraction and knowledge combination.

5.1.1 Knowledge Extraction

In the beginning, an appointment for face-to-face interviews with all participating employees of the company is set up. The interviews take place at the company's site in order for the researchers to additionally get individual impressions about the company itself and its working environment. Each participant is interviewed separately to ensure a conversation atmosphere that allows giving honest, unaffected opinions and gathering all viewpoints individually. Before, the participants are asked to fill in a consent form and a short demographic questionnaire. The interview guidelines are thoroughly prepared with the goal to extract as much relevant information out of the company as possible. They aim at gaining first insights about the state of affairs of the company with regard to the used digital technologies and the investigated topics (in our concrete case KM and DDB) as well as possible attached challenges, opportunities for improvements or problems. Thus, the interview starts with general questions (e.g. type of departments, number of employees, number of customers) about the company. They are followed by questions focussing on the specific topics to determine their current state of the art and to start with the development of new ideas, nice to have features and possible improvements. The latter questions are organised according to individual (micro), organisational (meso) and superior institutions (macro) levels, in order to extract knowledge on different levels. Altogether the questions aim at receiving a good overall picture of the company. The questions of the interviews are presented in Table 1. All interviews are recorded and afterwards transcribed to facilitate the evaluation of the complete information provided. The answers of the interviews are then analysed and summarized to get a solid understanding of how the company generally works, and specifically how the company deals with knowledge management and data-driven business including the used technologies and according difficulties or challenges.

5.1.2 Knowledge Combination

Subsequently, a workshop is conducted at the researcher's site, where other SMEs, who are interested in knowledge management and data-driven business as well, can be invited too. The goal of this workshop is twofold: First, the most relevant interview results are presented and enriched with examples of possible applications of KM and DDB tools or strategies extracted from previous research projects. Second, presentations are given on KM and DDB by experts on these topics. These shall provide basic know-how grounding as well as present the general state-of-the-art and best practices already applied in other projects. All this information serves as starting point for discussions and triggers the knowledge combination process. The results of this discussion including the different viewpoints of other companies on how to deal with KM and DDB as well as the presented basic know-how serve as a foundation for company A's internal discussions on how to proceed with their KM and DDB.

Table 1: Interview Questions: general, knowledge management and data-driven business questions

Level	**General Questions**
Micro	How large is your company and how many employees does your company have? What departments are there in your company? What professions are there in your company? What roles are there in your company?
Meso	With which and with how many stakeholders do you work together? Can you subdivide your external stakeholders in large sectors or groups?
Macro	With what parent institutions or authorities do you work together or do you have something to do as a company?
Level	**Knowledge management questions**
Micro	How does your official management strategy look like, if there is one? Which technological tools do you use for your knowledge management? Which difficulties arise for you out of the use of these technologies? How does the data maintenance take place?
Meso - Macro	Which technological tools do you use for your knowledge management in relation with external partners or superior institutions? What happens with information from external stakeholders or superior institutions - how are they managed, maintained and integrated into your knowledge technologies? How are internal and external stakeholders informed about new data and whom is this information made available to and in which timespan?
Level	**Data-driven business questions**
Micro	Which data/types of data do you manage? What is the scale of this data? How quickly does the data change (daily, monthly, yearly)? In which form is the data available? Do you gain any valuable additional information out of your data such as trends useful for your clients or other potential future areas of interest? And if so, how? If not, could you imagine to extract useful information out of your available data?
Meso - Macro	What data/types of data do you receive from external partners/suppliers/customers or superior institutions? What is the scale of this data? How quickly does the data change (daily, monthly, yearly)? In which form is the data available? What data is collected over competitors? What information/trends do you extract from these data?

5.2 Design

The design phase consists of the steps innovation creation and innovation application. It starts with bilateral talks, followed by mock-up development and a mock-up workshop.

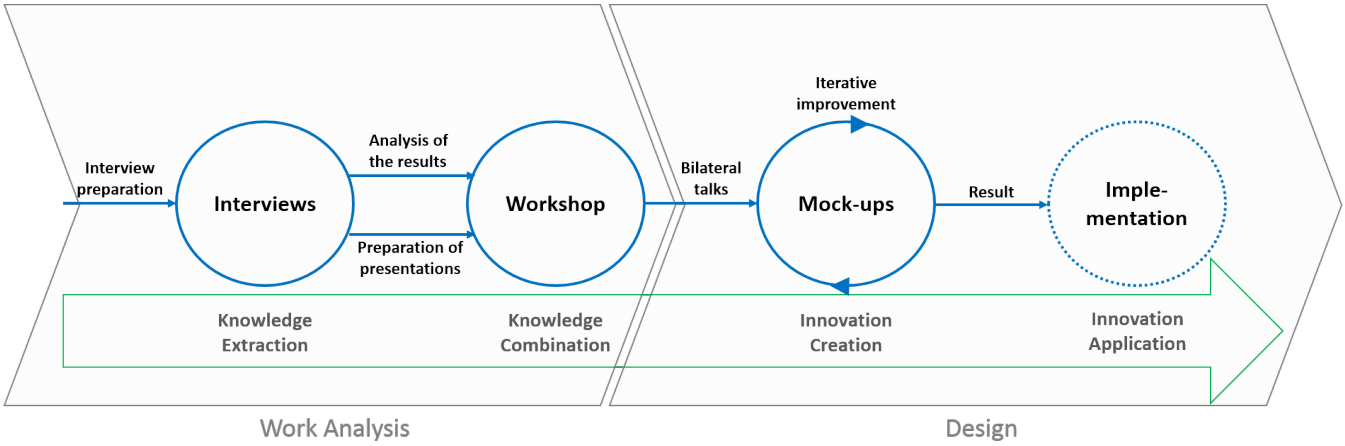

Figure 1: Requirements engineering and interactive system design methods

5.2.1 *Innovation Creation*

In order to start the innovation creation process, bilateral talks are initiated between the researchers and the company to address the company's individual needs and challenges with regard to KM and DDB. These discussions build upon the interview results, the given presentations and the ideas the company has created on the basis of this information and can be held by telephone and/or email. The goal is to make a decision on where to focus future improvements and which innovation potential to exploit for the company. Based on the ideas emerging from these talks the researchers develop teaser mock-ups of digital technologies that can help the company to manage their challenges with regard to KM and DDB. During this development all information collected beforehand about the company is taken into account including contextualization by integrating screen-shots of existing tools used in the company and familiar example data. Afterwards another workshop is organised, where the created mock-ups and ideas occurring during their development are presented to the company. Feedback and additional ideas of the participants are welcome and the mock-ups are further refined and adjusted in the course of the workshop, until they best fit the company's demands.

5.2.2 *Innovation Application*

The actual implementation of the final, collaboratively elaborated innovation ideas lies outside the scope of the described project, which ends with detailed but non-functional mock-ups.

6. RESULTS

6.1 Knowledge Management and Data-driven Business

In general the interviews provided insights about how the company addresses its knowledge management and data-driven business including storage, maintenance and information retrieval issues of data as well as the corresponding technological infrastructure. For knowledge management, the employees of company A use their laptops and computers to store data belonging to projects they are working for. Additionally they use cloud storage systems (e.g. Dropbox) for data which is not highly sensitive. The company-specific characteristic of their knowledge management lies in the usage of their own self-developed CRM tool, which is at the same time one of their main products. With the help of this tool company A manages all customer and project administration as well as the corresponding data (contacts, communication artefacts, tasks etc.). Beside this tool, the second pillar of the company is the creation of tailored web presences and web shops for their customers, which requires a lot of programming effort to fulfil the requests of their customers. In the area of data-driven business, the employees confirmed that they do not exploit the potential of their available data. They serve 2000 customers and for each of them they own 100 - 200MB of data depending on the related projects. This data is currently used for project management and administration purposes only, however, they are aware that this data could also be used for trend analysis, up-selling or cross-selling opportunities, or project controlling. This was also explicitly stated by the CEO *"We could do more on this. For example, the customer owns this and therefore the customer of the same group needs this too - but we do not do this."* [2]

6.2 Mock-ups

After having conducted the interviews, the workshop and bilateral talks, two more concrete ideas for the mock-up development process emerged. The CEO summarized these ideas in an email as follows: *"It would be good to integrate a forum in the CRM system (original name replaced), where 'general' knowledge can be stored in. Because we store our knowledge directly to the project."* [3] and *"... it would be cool to have an app, which presents to me my customers in the vicinity. We have this in the CRM system, but only web-based, no app."* [4]

[2]German text: *"Wir könnten noch mehr machen. Also wir könnten zum Beispiel sagen, der Kunde hat das und deshalb braucht der andere Kunde in der gleichen Gruppe das auch - das machen wir nicht."*

[3]German text: *"Gut wäre eine Integration eines Forums in das CRM System (originaler Name ersetzt), wo 'generelles' Wissen abgelegt werden könnte. Weil wir unser Wissen ja immer direkt zum Projekt ablegen"*

[4]German text: *"... hier wäre es cool wenn es eine App*

For the first idea, the storage of "general" knowledge especially for source code snippets, the mock-ups illustrated the integration of a forum into company A's CRM tool (see Figure 2). This forum was enhanced by providing a possibility to easily add pre-defined, source-code related tags relevant for storing source code snippets (e.g. HTML 5, PHP). Using such tags also as structuring entity allows users to easily retrieve already existing code snippets according to the attached programming language tag. Thus, a general knowledge base for programming solutions and the like can be built up without any overhead to the usual work routine and facilitate employees' future work.

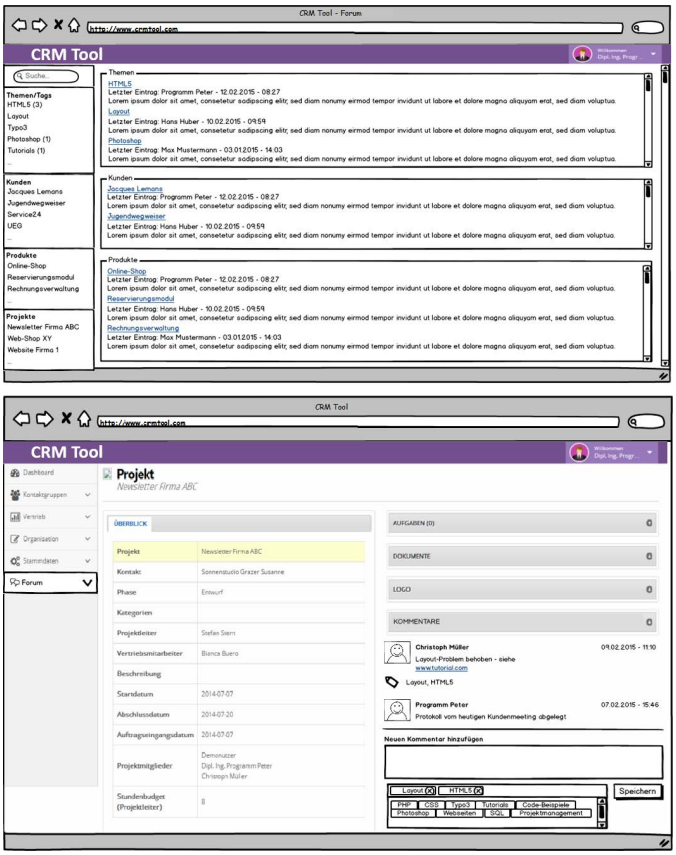

Figure 2: Knowledge Management: Teaser mock-ups of the forum idea

The second idea is a mobile application (see Fig. 3) which uses GPS data out of the CRM System as basis for presenting customers in the user's current vicinity (based on the user's current physical location tracked via GPS sensors in the mobile phone). When getting closer to the customer's location, corresponding information is automatically presented in the app. This information encompasses current project status or if some urgent tasks are required (e.g. a missing payment, sign a contract). Additionally to this, the system in the back-end analyses similar customers for upcoming trends and up-selling or cross-selling opportunities, which can serve as further points of reference for sales activities during the customer visit.

geben würde die mir meine Kunden im Umkreis angezeigt. Wir haben das im CRM System (originaler Name ersetzt) zwar, aber nur web-basiert, keine App"

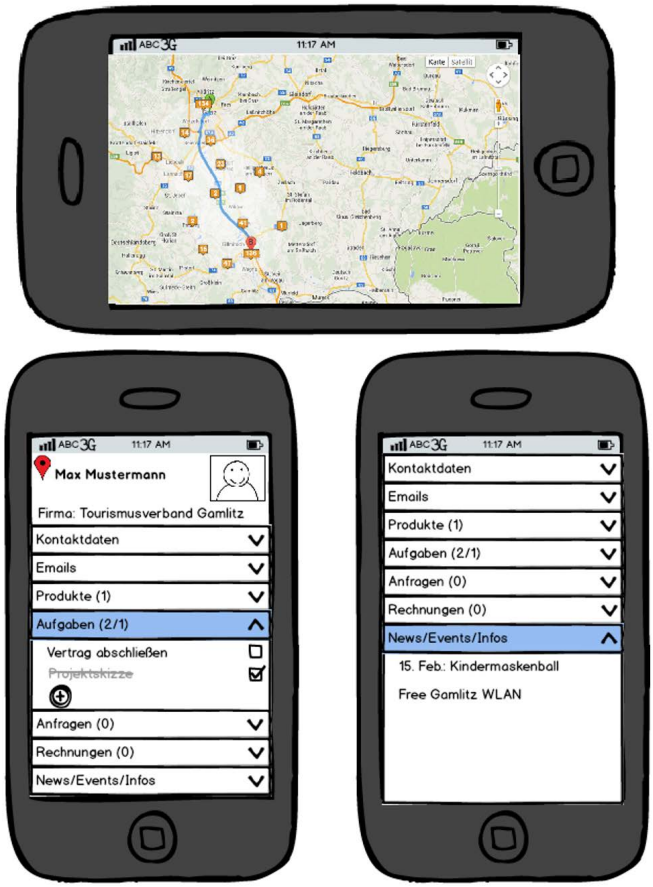

Figure 3: Data-driven Business: Teaser mock-ups of the mobile application

When presenting the teaser mock-ups to the CEO and the employee, both perceived them positively, but also eagerly provided constructive suggestions on how to refine them in order to meet their requirements even better. Their feedback collected afterwards in an online survey said *"The mock-ups were preprocessed so well, that we can hand them over directly to a developer."*. [5]

7. DISCUSSION

This case study illustrates the successful application of requirements engineering and interactive system design methods, by combining and employing well-known methods like interviews, workshops and mock-up creation for supporting the development of mock-ups with regard to knowledge management and data-driven business. All used methods are rather uncomplicated to apply, but in combination they accomplish to initiate meaningful knowledge transfer and finally end with concrete, innovative mock-up development.

[5]German text: *"Die Mock-ups waren so gut aufbereitet, dass wir diese direkt einer Entwicklerin übergeben können."*

7.1 Method

7.1.1 Knowledge Extraction

To extract as much information as possible of a company and their employees, three important factors have to be considered: First, the preparation of the interviews in advance plays a crucial role [10]. The questions of the interviews have to include the main topics of interest, in our case KM and DDB, on all three levels of analysis (micro-meso-macro). This means that the posed questions cover all levels of stakeholders the company is dealing with (employees, customers, and superior institutions if existing) right from the beginning. Second, a top-down questioning strategy has shown to be a good procedure for knowledge extraction. The interview questions should start with open questions in order to prompt employees for general information. During the interview the questions posed need to become more and more specific in order to receive deepened information about important facts. This strategy provides the interviewees the possibility to address issues that are relevant for them during their work. The interviewers can extract as much information as possible including not only explicit knowledge but also implicit knowledge [16]. These results can be used to discover first directions of starting points for the mock-up development. And third, the diversity of the interviewees is of high relevance. They should come from different levels of the organisational hierarchy, departments, working responsibilities and experience. All opinions count and such variety provides insights from different perspectives. All three factors were applied when conducting the interviews at company A. These extracted information were the first pillar for the knowledge extraction process.

The diversity of persons (coming from different hierarchical levels, departments and experience) involved in the whole process of one company as well as the different levels of knowledge management and data-driven business addressed (micro, meso, macro) played an important role not only for the interviews but also for the whole presented case study. Only gathering and connecting of all those varying viewpoints can result in a complex picture about the company and its processes, challenges and difficulties. This is very important, because emerging problems can more easily be solved, if all relevant requirements and view points of all persons involved, can be considered right from the beginning. In the case of company A, for example, the concept of a general knowledge base in form of a wiki already existed, but hardly anybody ever used it. Reasons for this include bad maintenance of the wiki, missing its integration into their CRM tool and the lack in promotion from the management to use it. Therefore to ensure a good user acceptance, processes and tools must be seamlessly integrated into one's own working routine with as little additional effort as possible. It is also desirable that new approaches are not only driven by either the management or the employees, but by both parties together, which makes it so important to involve all concerned stakeholders in the requirements engineering process.

7.1.2 Knowledge Combination

Presenting the interview results in the workshop served as platform for exchanging and combining knowledge. The general presentations given by experts of these two topics provided them with new information as well as best practices applied in real world setting. The resulting combination of own knowledge with external viewpoints and know-how of researchers helps to overcome boundaries of hierarchy and organizational structures. This is what many companies are looking for in order to establish new ways of knowledge exchange and learning, so they can improve their creation of value from their existing knowledge and data [18]. Additionally by sending out the workshop materials, the employees of company A had time to reflect about the new information and to combine their own knowledge with the general presentations regarding KM and DDB in order to develop possible solutions for themselves.

7.1.3 Innovation Creation

The created mock-ups proved to be a very useful tool for creating and communicating ideas of how to improve KM and DDB. Generally, the mock-ups were perceived very positively and as easy to understand by all involved parties. Mock-up development as viable means of knowledge illustration and transfer shows two advantages worth being mentioned: First, possible future users can be directly and easily involved in the mock-up design process. The participants welcomed this opportunity to co-design as well as the contextualization of mock-ups by using company relevant example data or screens of tools that were already in use and familiar. That way, the participants could easily imagine and understand how the suggested tools or processes would be applied in their working environment. Second, the individuals' as well as the company's requirements and suggestions can be quickly and iteratively considered. The initial combination of a detailed context and requirements analysis on the company's side as well as the technical knowledge and know-how of the authors' side made only little refinements necessary, until the mock-ups satisfied the company's expectations and needs.

7.1.4 Innovation Application

Company A decided to start the implementation of at least one of the mock-ups. Key success factors were to take into account different viewpoints and the organisational level, as well as the collaborative design of mock-ups which allowed a deep understanding of technology potential.

7.2 Knowledge Management and Data-driven Business

Knowledge management is a well established process in the case of company A by using their own CRM system. While KM works fine within company A especially for project and customer administration, data-driven business approaches have not been addressed yet, although company A is aware of the hidden potential their already collected data might have [15] especially with regard to upcoming trend detection, up-selling or cross-selling opportunities. This finding is also in line with the other participating companies and a lot of Austrian SMEs in general [23].

8. CONCLUSION

In this paper we presented a case study on co-designing innovative digital technologies for knowledge management and data-driven business. We applied well-known methods out of requirements engineering and interactive system design, such as interviews, workshops and mock-up development in an SME. The results in form of non-functional mock-ups

presented innovative digital technologies especially designed and tailored for the company's needs with regard to knowledge management and data-driven business. From this case study the following lessons learned could be derived: First, taking into account the micro (internal stakeholders: employees), meso (external stakeholders: customers, suppliers, cooperation partners etc.) and macro (superior institutions) level with regard to KM and DDB right from the beginning provides a solid understanding of how the SME works. Second, the interviewees should encompass employees from various departments, different organisational hierarchies and newbies as well as senior practitioners in order to get as many different perspectives as possible [10]. Third, for knowledge combination it is important to provide new information from outside, which serve as additional triggers for the innovation creation process.

There exists no standard procedure on how to best introduce digital technologies into SMEs, as researchers follow alternative ways [26]. The contribution of this work lies in presenting one way that proved successful in its scope under real-world circumstances and may serve researchers as well as designers/developers as a practical example of how to design innovative digital technologies for and in cooperation with an SME. As a basis served the initial combination of retrieving detailed knowledge about context information and requirements engineering on the company's side with the technical know-how of the researchers. This way of considering the company's needs, available technologies and goals regarding KM and DDB in all steps right from the beginning facilitated the successful creation of mock-ups, which were easy-to-understand, especially tailored to the company's needs and are planned to be implemented in the company's CRM tool.

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