MATURE

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D1.2
Results of the representative study and refined conceptual knowledge maturing model

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List of Abbreviations

KM	knowledge maturing
KMA	knowledge maturing activity
KMI	knowledge maturing indicator
KMM	knowledge maturing model
LMI	labour market information
MAS	maturing activity system
SBU	strategic business units

1   Executive Summary

This document provides an overview of the results produced by WP1 during year 2. WP1's objective is to explore theories and models that help understand and build a common knowledge base about knowledge maturing, to explore current knowledge maturing practices empirically and to develop a reference model for knowledge maturing.

Three main areas of acting were part of year two's activities: (1) the planning, performing, analysis and reflection of an empirical study involving 126 representatives of medium-sized and large European organisations and employing a complementary set of quantitative, statistical methods and qualitative, interpretive methods, (2) to contribute to the software design and development activities and to impact on the evaluation activities in MATURE and (3) the reconciliation and revision of the knowledge maturing model.

The deliverable reports the findings of the second in a series of three MATURE empirical studies about knowledge maturing phases, activities and indicators which the consortium agreed as most relevant for broadening the scope of studied organisations to get a more varied picture of perceptions held in companies and to further explore corresponding assumptions underlying the knowledge maturing model and MATURE design activities. Moreover, WPs 2, 3 and 4 have been interested in the current software support and barriers for fostering knowledge maturing to discuss which software tools MATURE tools need to extend, replace or with which they need to interact. Also, knowledge maturing activities and indicators have been used as boundary concepts between engineering-oriented design activities in WPs 2, 3 and 4 and interpretive empirical activities in this WP. Results build a much more detailed conceptual basis for evaluation (WP6) and help prioritise prototype development for Year 3. Interviews with representatives of organisations that had no previous exposure to MATURE partners helped dissemination of the project's concepts and activities.

The fostering of knowledge maturing phases was evaluated to be equal across all organisations regardless of size, sector or knowledge-intensity. The barriers which may hinder the maturing of knowledge were very much in line with those expected, e.g., lack of time, lack of usability and low awareness of the value and benefit. Some barriers, such as fear of disgrace affect earlier phases of the KMM more than later phases. Although perception of success is very similar between sectors, the phase 'distribution in communities' is perceived more successful in service-based and in medium-sized organisations than others. The phase 'appropriating ideas' is perceived more successful in knowledge/technology-intensive organisations. Portfolios contrasting importance/success and support/success concerning knowledge maturing activities revealed that the KM activities "reflect on and refine work practices or processes" and "find people with particular knowledge or expertise" are most interesting for the MATURE project. Both are deemed to be important, whereas less supported and less successfully performed activities. The evaluation of the KM indicators revealed that process-related indicators had a higher rate of agreement than indicators of the dimensions digital resources or persons. In addition to indicators having been fed continuously into parallel activities in demonstrator and evaluation teams factors extracted by a factor analysis aid in restructuring indicators for further take-up in Year 3 developments of the KMM and Demonstrators. Three types of organizations were identified by clustering organizations according to their success of performing knowledge maturing: "best performing maturers", "people- and awareness-oriented maturers" and "hesitant formalists". Knowledge maturing stories supported the analysis of additional barriers for accepting collaborative knowledge maturing at all and further contextual factors and complementary initiatives, e.g., the innovation management "regime" within or the innovation "ecosystem" beyond the organisation, that also need to be taken seriously when further developing tools and concepts in the MATURE project.

The results have been taken on board of parallel activities performed in MATURE, most notably in the demonstrator teams (WPs 2, 3 and 4), the definition of maturing services (WP 4) and the process of formative evaluation of demonstrators (WP 6). The take up of the results was supported not only by frequent presentations of interim results in personal and Flashmeetings, early release of work-in-progress within the consortium, transferred by email and particularly in the Wiki, and discussions of their impact,

but also by the fact that we continuously kept the close cooperation between those MATURE members that did empirical work and those who performed design and development activities with several persons belonging to both groups.

2 Introduction

In the second year, MATURE built on the knowledge base of concepts and theories as well as practices of knowledge maturing that had been developed as part of Year 1 activities in MATURE. This means in the case of WP1, we primarily built on (1) the results of the ethnographic study performed in Year 1, (2) the knowledge maturing model v2 and its conceptual detailing laid out in D1.1, furthermore (3) the design artefacts produced in the design studies, (4) cross-feeding interim results and reflecting interim results of WP1 activities together with the demonstrator teams as well as (5) on the one hand impacting the formative evaluation with concepts developed in WP1 and on the other hand taking up the results of the evaluation. This points to the fact that there were again several parallel strands of activities in the project, most importantly conceptual, empirical, design, development and evaluation activities. The role of WP1 in Year 2 was (1) to coordinate the on-going development of the knowledge maturing model, its conceptual, design, demonstrator, integration and evaluation artefacts on the basis of the results of these activities, (2) to prepare, conduct, analyse and reflect on the second in a series of empirical studies about knowledge maturing, (3) to continue to develop the conceptual basis of knowledge maturing in general and the knowledge maturing model in particular, (4) to contribute to the software design and development activities, e.g., concerning knowledge maturing indicators, (5) to impact on the evaluation activities providing evaluation areas and questions informing the design of the formative evaluation and (6) to prepare an in-depth study planned for Year 3. This is in line with the participatory design process that MATURE takes towards software development. Building on the results of the empirical studies, the knowledge maturing model has been revised again. Implications for design, development and evaluation activities have been collected as part of deliverables developed in WPs 2-6 and can be found there. This deliverable reports on Year 2 achievements of MATURE towards the objectives of work package 1, particularly to

- establish a *common knowledge base* about the different domains, concepts and theories required to understand and support the knowledge maturing process, specifically we have further explored on a number of theories and models, e.g., activity theory, boundary objects, innovation, sedimentation of knowledge, symbolic interactionism,

- explore current *knowledge maturing practices*, e.g., routines, processes, knowledge types and semantics, specifically with the help of the second empirical study,

- develop a *reference model* for describing knowledge maturing, specifically amalgamating the findings into version 3 of the knowledge maturing model.

These objectives are reflected in the following tasks that the consortium has worked on during the second year:

- *T1.2 Explorative empirical studies*. The bulk of work on WP1 in the second year has been associated with the empirical study performed by MATURE partners that involved interviewees representing 126 medium-sized and large European organisations,

- *T1.4 Development of the conceptual knowledge maturing model*. The results T1.2 has been taken up in refining the knowledge maturing model v2 has been as presented in the Description of Work taking on board particularly the results of the empirical study, but also the input from parallel activities in other work packages and additional feedback of application and associate partners as well as interviewees voiced in meetings, workshops, interviews or bilateral talks.

The overview given in figure 1 shows the main topics covered in WP1 in year two and their primary use within this work package and concerning other work packages and the corresponding deliverables represented by arrows.
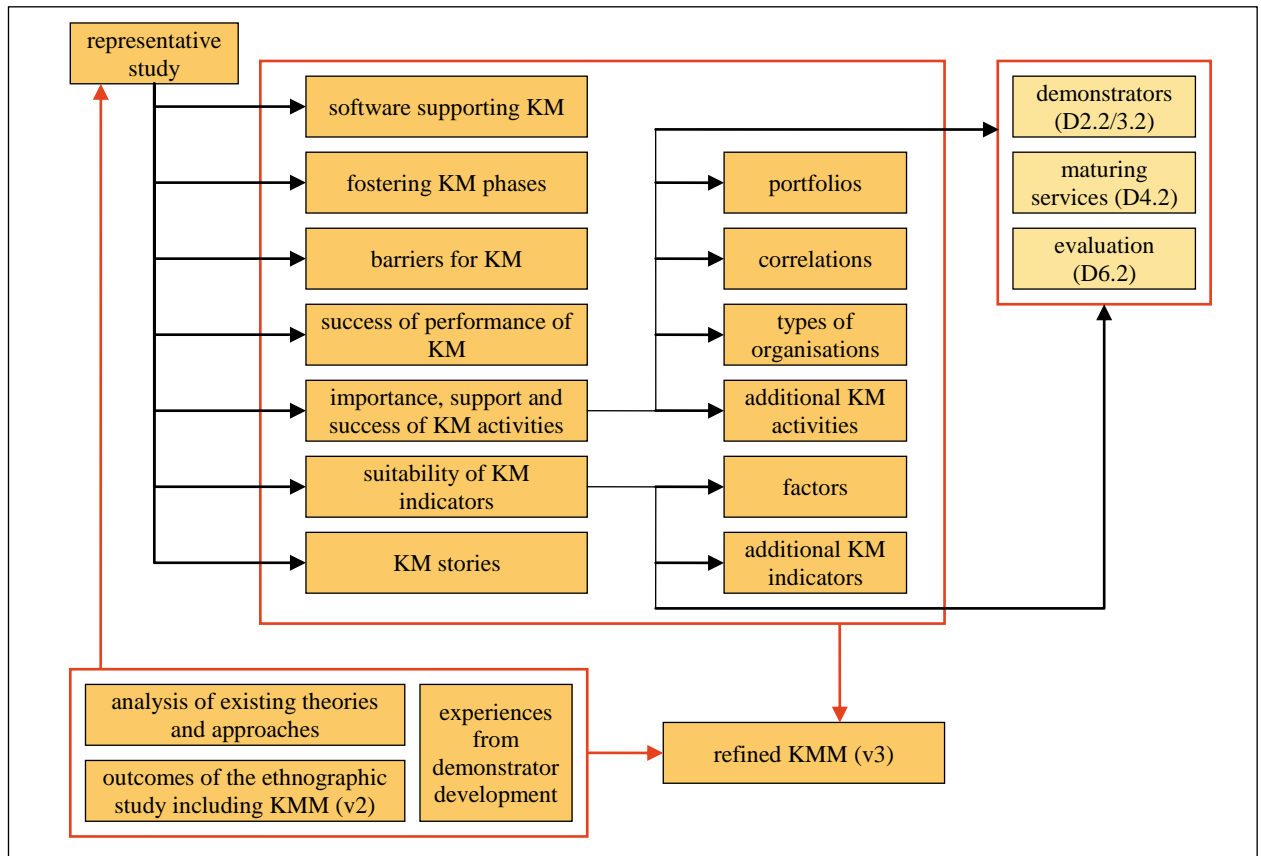
Figure 1: Overview of topics covered in WP1

Each major topic is represented by an orange box. Outgoing black arrows indicate outcomes of activities related to one topic feeding into activities related to another topic. Red rectangles group topics and red arrows show outcomes of activities related to a group of topics feeding into another topic. Starting in the lower-left corner, the figure shows the primary foundation upon which the representative study was designed, i.e. existing theories and approaches, ethnographic study and experiences from demonstrator development wrapped by a red rectangle. The figure also gives a detailed overview of the most important results from the representative study, also surrounded by a red rectangle. Both red rectangles impacted the refinement of the knowledge maturing model v3. Knowledge maturing activities and indicators were the primary boundary objects impacting demonstrator development, maturing services and the formative evaluation.

The deliverable is structured as follows. Section 3 reflects on the design of the representative empirical study and presents the study's procedure, research model, interview guideline, sampling strategy, methods and timeline. Section 4 then presents and discusses the results of the study. Specifically, after an overview of the response (4.1) and a discussion of background information on the interviewees and the organisations they represented (4.3), the major results are presented and discussed in detail, structured into knowledge maturing phases (4.4), activities (4.5), indicators (4.6), the results of a cluster analysis according to perceived success in knowledge maturing (4.7) as well as rich stories about knowledge maturing that we could collect from a substantial number of interviewees (4.8). The chapter then discusses imitations (4.9) and summarizes the most important results (4.10). Section 5 presents the results of the conceptual activities on knowledge maturing. It starts out with a brief summary of our definitions of knowledge (maturing) and the knowledge maturing model v2 and an overview of the procedure taken to revise the model (5.1). Then, implications of selected complementary theories on the knowledge maturing model are discussed (5.2), as well as the links to and experiences from the demonstrator development (5.3) before the extensions and refinements are amalgamated into the new version 3 of the knowledge maturing model (**Fehler! Verweisquelle konnte nicht gefunden werden.**). Section **Fehler! Verweisquelle konnte nicht gefunden werden.** concludes the deliverable. The appendix contains

material used in the representative study together with the detailed results of statistical and qualitative analysis that are discussed in this deliverable.

3 Study Design

The representative study is the second in a series of three empirical studies that are conducted in MATURE. In the following, the study design is illustrated. In section 3.1 an overview of the conceptual and empirical base is described. Furthermore, the focus areas and the timeline are provided. After introducing the research model and important concepts (section 3.2), the interview guideline and its usage are explained in section 3.3. Section 3.4 describes the collection of additional contextual data. A pre-study conducted to improve the interview guideline is depicted in section 3.5. Section 3.6 elaborates on the sampling of the study.

3.1 Overview

Building on the results of the ethnographically-informed study laid out in D1.1, the representative study aims to broaden the scope of organisations that are investigated in order to get a varied picture of perceptions held in companies of differing size, sector and knowledge intensity about selected results of the ethnographically-informed study. In the following, we briefly summarise the conceptual and empirical base which we drew on when designing this study, the study's focus areas, some aspects of methodology and methods employed in the study as well as the timeline.

Conceptual and empirical base

The ethnographically-informed study and the analysis of the state-of-the-art conducted in year one (see D1.1) led to different kinds of results targeting knowledge maturing in studied organisations (see Figure 2).

codes / code areas	frequently used KM routines	hot knowledge maturing areas	scenarios useful to be supported	change in knowledge maturity stories	long running KM cases	indicators for knowledge maturing

knowledge maturing practices	knowledge maturing cases	(primary) personas	knowledge maturing model (v2)

ethnographically informed study	state of the art
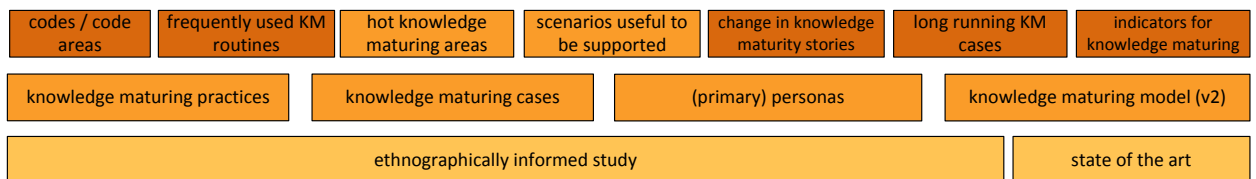
Figure 2: Inputs from D1.1

Based on the primary data collected in the ethnographically-informed study (knowledge maturing practices), several results were derived. On the one hand, codes and code areas, created by coding the field notes emerged which were aligned to several dimensions. Besides the primary observed knowledge maturing practices and personas developed for enriching use cases, several other cases describing knowledge maturing were collected. These led to a collection of frequently used knowledge maturing routines which are abstract representations of situations deemed most important in the respective ethnographic context and the identification of scenarios which were deemed useful to be supported. Besides cases and situations studied within the course of the ethnographically-informed study which were rather short-termed, additional long running cases were collected in order to analyse knowledge maturing with respect to success factors. The evaluation of collected stories and cases was taken up in identifying indicators for knowledge maturing. All of these results formed a rich conceptual and empirical basis which the design of the representative study could draw from. Several of these results, however, have primarily influenced design, development – and evaluation – of the demonstrators and due to the limited amount of time one could expect interviewees to spend with interviewers, they could not all be touched on in the representative study.

Focus areas

Thus, in the consortium meeting that took place in Karlsruhe in April 2009, the consortium agreed that the representative study should focus on three subject areas: the phases of the knowledge maturing model (v2), knowledge maturing activities and knowledge maturing indicators, based on the needs for the further development both on conceptual and technical level. With respect to the knowledge maturing model, information was sought on the perception of importance, support from organisational and ICT measures, tools and infrastructures, barriers and motivational factors involved as well as perception of

success. All six phases of the knowledge maturing model, version 2, were considered in order to help verify whether the barriers found in transiting between the phases in the ethnographic study would materialize as important for a wider variety of organisations.

Methodology and method

There are complex relationships between developing concepts and theories in a behavioural science-based research paradigm and developing design artefacts in a design science-based research paradigm (Hevner et al., 2004). Interpretive research has become more important (Walsham, 2006) due to its perceived advantages with respect to producing deep insights into human thought and action in social and organisational contexts in order to study work practices including information systems (IS) phenomena through social constructions such as language, consciousness, shared meanings, documents, tools, and other artefacts (Klein, 1999). This is why we started out with the MATURE ethnographically-informed study of knowledge workplaces with the conceptual goal to inform the revision of the knowledge maturing model and the design goal to inform the requirements gathering, design and evaluation procedures for the MATURE demonstrators. Empirically-based IS concepts and theories should be implementable, synthesise an existing body of research or stimulate critical thinking among IS practitioners (Benbasat and Zmud, 1999). Along these lines, interpretation of empirical results was continuously geared towards design and thus results were transformed into artefacts that were considered valuable for designing MATURE software services, demonstrators and concepts helpful for supporting the implementation of those in businesses and organisations. Methodologically, we continued our stance of bridging positivist and interpretive behavioural science research paradigms and constructivist and engineering design science research paradigms when designing our representative study. We used a mixed method approach consisting of quantitative, statistical and qualitative, interpretive methods. Consequently, we applied the design goals that we aimed at with MATURE solutions as filter for selecting those questions that should be used in the interview guideline, for selecting interviewees according to their job positions and roles, for elaborating on qualitative aspects raised in individual interviews and for digging deeper into the analysis of results of the study.

Methodically, the study employed semi-structured interviews based on an interview guideline, that was sufficiently open so that individual interviewers and interviewees could elaborate on aspects of knowledge maturing deemed important. The interview guidelines are not restricted to certain phases of the knowledge maturing model and thus cover the entire model. For reasons of willingness to participate and accessibility we could get the perception of one single person per organisation, a standard limitation of broad empirical studies. As interviewees were asked to report on importance, support and success of these activities from the perspective of the organisational unit that they wished to speak for, we might have overlooked the heterogeneity on the level of individual knowledge workers. In order to get a complete picture of supposed stronger differences between individuals handling activities, we will concentrate more on these when selecting individual knowledge workers in the in-depth study.

Timeline

Figure 3 provides an overview of the timeline that has been agreed for the empirical study. Activities in the study started with preparing for the study. We determined the population of companies to be looked at and decided on using a stratified sample of companies to be interviewed, agreeing on who will interview how many companies in what country and concerning what size, sector and knowledge intensity. We put in a lot of effort to cover companies in as many European countries as possible. We conducted a focused literature study as well as analysis of the results of our ethnographically-informed study as part of the activities on hypotheses generation and interview design. Much effort was spent by the partners involved in WP 1 to design the interview guideline so that it could be used in all countries involved which proved to be much more difficult than we had expected. Also, it turned out that in some countries interviewees could be expected to spend one hour at most for an interview and so we had to substantially shorten the original interview guideline containing all questions put forward by the consortium as interesting from 12 pages to the 4 pages that the interview guideline that was finally used. In a first series of consultations, the concepts to be studied as well as the wording of the questions to be asked were refined in a series of consultations supported by weekly Flashmeetings.
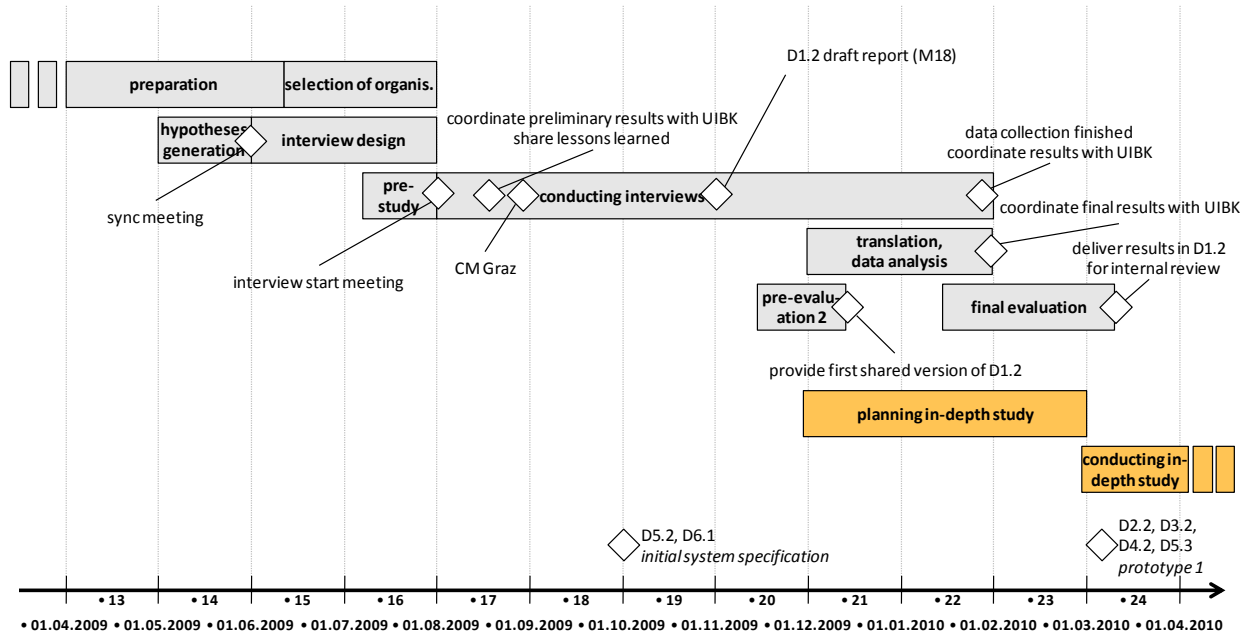
Figure 3: Timeline year 2

Once a first version of the interview guideline was agreed on, a pre-study was conducted with selected individuals representing heterogeneous types of companies in different countries, helped to improve understandability of the questions. While conducting interviews, it turned out extremely difficult to keep to the stratification of the sample. We had to limit our activities to contacts already established by partners in the consortium in several countries (e.g., United Kingdom), as cold calling companies that had no previously established relationship with the calling institution was not allowed by institutional (University) policies in those countries. Even with these limitations to already established contacts, several partners found it extremely difficult to get their contacts to agree on conducting an interview with them. In other countries, however, (e.g., Austria, Germany, Italy, Switzerland) we could collect all interviews as planned. Substantial effort was spent and several additional rounds of activities were performed by several partners to get interviews and we extended the deadline for collection of data several times. After it seemed virtually impossible to get any more interviews, we terminated data collection and turned to data analysis. Before we turn to the results, we will now present the study design in detail in the following sections.

3.2 Research Model

Our knowledge maturing model provides a new[1] and distinct lens for studying phenomena of knowledge conversion. Consequently, the empirical studies conducted in MATURE are exploratory in nature. This means that the representative study aims at hypotheses generation rather than testing and combines quantitative with qualitative elements in a mixed-method approach, so that phenomena of knowledge maturing, specifically about phases, activities and indicators are investigated in more detail (see section 3.3). However, some initial assumptions about relationships between concepts will also be studied.

The concepts "perceived importance", "perceived support" and "perceived success" are investigated with respect to *knowledge maturing activities* (see section 3.3.4) as this is the most fine-granular description of knowledge maturing that is also closely related to parallel design and development tasks performed by the demonstrator teams. Knowledge maturing activities have been explained to interviewees as activities of individuals or groups of individuals that contribute to the development of knowledge which can occur

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[1] There have been a number of models and theories for describing, analysing and studying knowledge handling in organisations, e.g., Nonaka's (1994) SECI model, Wiig's (2003) model for situation handling from a knowledge perspective or Sveiby's (2001) knowledge conversions to create business value. However, none has an explicit focus on knowledge maturing.

within one phase, e.g., "distributing in communities", or between two phases, e.g., from "distributing in communities" to "formalizing". Importance asks to what extent interviewees think that an activity is important in the organisations they represent. Support refers to organisational or information and communication technological instruments that help individuals or group of individuals perform an activity so that it contributes to the development of knowledge. Finally, success captures to what extent interviewees believe that a knowledge maturing activity has been performed successfully in the organisations they represent[2]. The concepts importance, support and success have not only been investigated with respect to activities, but also with respect to phases and overall for KM in general. Figure 4 describes some assumed relationships between concepts that will be investigated in the study and are described in the following.
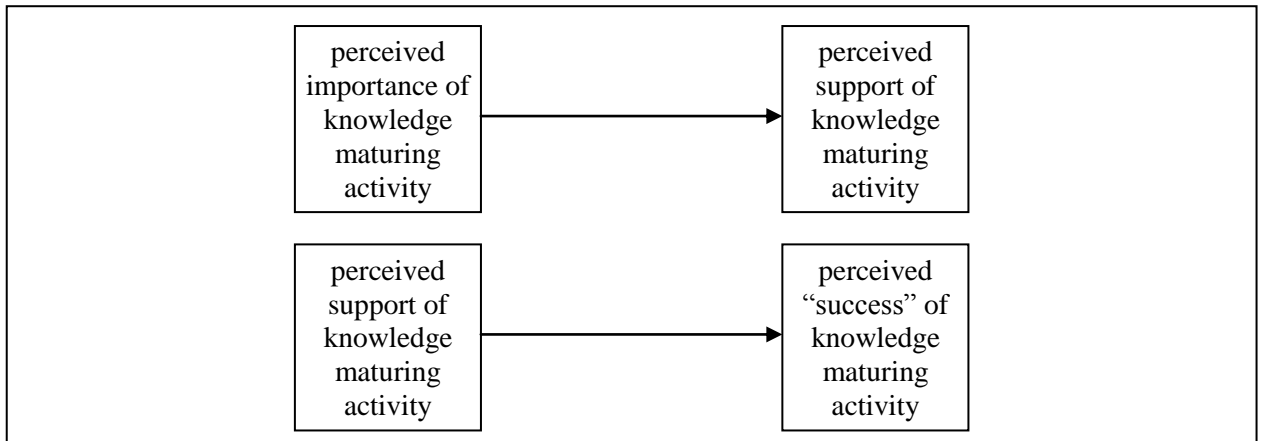
Figure 4: Research model

- Proposition 1: The more important knowledge maturing activities are perceived, the more they are supported.

Concerning proposition 1, we assume that organisations differ with respect to what activities they deem important for knowledge maturing. Depending on the importance they assign to a certain activity, they assumedly allocate resources to support it. By contrasting perceived importance of selected knowledge activities found in the ethnographically-informed study with perceived organizational and IT support, we also analyse which of the activities are deemed important, but currently not perceived as well supported and thus would be candidates for activities that need most support.

- Proposition 2: The more an organisation supports knowledge maturing activities, the more successful it is regarding knowledge maturing.

Concerning proposition 2, we assume that organisations differ with respect to the extent of support they offer for knowledge maturing activities and that those activities that are well supported, are also the ones in which knowledge maturing is performed successfully. With respect to proposition 2, one would be particularly interested in the conditions that moderate the relationship between perceived support of knowledge maturing activities and perceived success. However, this cannot be explored during the limited time frame of an interview and is a candidate for further exploring in the in-depth study to help us identify success factors and barriers that mitigate the supposedly beneficial effects of support of

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[2] Each concept has been operationalised with the help of one statement per activity for which interviewees could mark to what extent they would agree to this statement on a 7-point Likert scale. We are well aware that the concepts of importance and all the more support and success would deserve a much more thorough investigation with the help of a number of variables that should be questioned for each of them, see e.g., (DeLone and McLean, 1992, DeLone and McLean, 2003). However, we are confident that the depth of these concepts has been explored in the course of the interviews by interviewer-interviewee dialogues that appropriated the concepts to the context of the organizations that the interviewees represent.

knowledge maturing activities. Perceived success of the organisation with respect to knowledge maturing also allows us to select organisations which perceive themselves as most successful for the in-depth study.

Additionally, we are interested in interviewees' perceptions of the suitability of knowledge maturing indicators that we found in the ethnographically-informed study and which were additionally subjected to discussion in the whole consortium and were then filtered with the help of a pre-study, i.e. an online questionnaire, conducted among the MATURE associate partners. On this basis, we expect to identify those knowledge maturing indicators that are most suitable when designing maturing services (WP4) that automatically determine their values in order to help to guide knowledge maturing.

3.3 Design of Interview Guideline

In this section, we briefly review what artefacts were used by whom and for what reasons in the representative study (section 3.3.1) and then explain the contents of the interview guideline in detail (sections 3.3.2 to 3.3.5).

3.3.1 Artefacts used in the interview

Figure 5 gives an overview of the documents that we used in the representative study, divided into those that were considered public and handed on to potential interviewees (marked as sent to interviewee in the figure) and those that were kept internal and confidential (marked as used by interviewer).

Interview Guideline upfront version:
- if possible: send to interviewee as PDF after first contact to provide first impression
- one page, explains the basics of Knowledge Maturing

Interview Guideline (IG):
- if possible: send to interviewee as PDF before interview to be used during interview
- 4 pages; contains all questions

Interviewer's Explanations (IE):
- used by interviewer during interview for explanations and examples
- contains, e.g., example stories describing KM and descriptions for KM-Activities
- interviewee should not be provided with this document

Interviewer's Form (IF):
- completed by interviewer during interview
- upload after interview to MATURE SVN

Additional Data:
- created by interviewer reflecting on interviews
- contains, e.g. stories

Figure 5: Documents used in the representative study

The *Interview Guideline upfront version* was sent out most as every potential contact who showed interest in participating in the study got one of those. This activity of informing many individuals in European organisations about the aims and procedure of MATURE can also be seen as a considerable dissemination activity.

The *Interview Guideline* was designed for interviewees as an additional medium during the interview so that they could follow the questions read to them by the interviewers. Many interviewees had the guideline prepared for the interview which helped to overcome limitations otherwise experienced in telephone interviews concerning absorptive capacity of interviewees. This procedure was considerably successful, primarily with respect to those questions where one question applied to a large number of

items that would then not have to be read to interviewees over and over again which substantially sped up interviews.

We agreed on both variants of interview guidelines in an English-language version first and then translated this version into other languages required by interviewees, e.g., into German or Spanish.

The *Interviewer's Explanations* was a 10-page document that contained the reasoning behind each question, definitions of terms as well as examples that made abstract concepts more easily understandable. The latter were found very helpful in relating knowledge maturing activities and indicators to the context of the interviewee's organisation. Separating the interview guideline from interviewer explanations substantially shortened the guideline and thus prevented the interviewee from being overloaded by information because the interviewer could give additional explanations only in cases in which they required further understanding. We could also start with open questions as laid out in the interview guidelines and inject ideas in case the interviewee had questions or predefined categories, e.g., in the case of barriers, so that we did not ex-ante restrict interviewees to certain categories and yet could make sure that those that were found important in previous studies were not forgotten by them.

Additionally, the interviewer's explanations contained five example stories of knowledge maturing which could be used by interviewers to jointly develop an understanding of what knowledge maturing meant in the context of the interviewee's organisation. The stories were provided by several members of the consortium from several countries with different types of organisations in mind. The stories covered all six phases of the knowledge maturing model and described an end-to-end process of knowledge maturing and had their roots in the long-running knowledge maturing cases identified in the ethnographically-informed study, for the following initial situations:

- a newly employed product manager triggered the development and introduction of a new product which later became standardized within the organisation,

- employees of a franchiser were asked to develop a concept of an e-business solution in order to provide a standardized selling platform for franchisees,

- in response to new developments, a training department adapted parts of its training offering,

- an employee of the human resources department triggered the further development of a personnel policy document,

- in a medium-sized company, existing products are developed further.

Last, but not least, if interviewees indicated that they would like to receive further information on the survey results or the MATURE project, interviewers could offer several forms of association with MATURE which turned out as most successful as many individuals stay tuned to MATURE newsletters and associate partner events. The forms to be offered were:

- be part of the associate partners which would mean participation in associate partner meetings (annual)

- participate in the in-depth study which will include a site visit by MATURE partner(s) as well as a detailed evaluation of the results of the study presented back to the company which would require that MATURE partners are allowed into the site as well as given access to key individuals within the organization.

This information was not evaluated and the data was stored separately so that we could guarantee anonymity.

The *Interviewer's Form* was an Excel sheet representing all questions in the interview guidelines and was designed to ease capturing of data given by interviewees. The form was designed so that it could be used during the interviews for immediately capturing particularly the quantitative data for the closed questions. Additional qualitative data was partly inserted into these forms, partly handled separately, e.g., in the report on open questions or the MATURE Wiki. Also, the interviews were recorded where possible and

thus could be consumed repeatedly in order to complete the forms and to reflect on individual aspects raised during the interview.

The *Report on open questions* was an additional document that was designed to hold all available reflections and interpretations in addition to the ones already captured in the interview guideline and were the primary sources for the qualitative data analysis.

All artefacts used in the representative study can be found in appendix 8.2 and 8.3.

The guideline was divided into four parts (1) background information, (2) knowledge maturing phases including motivational factors, (3) knowledge maturing activities and (4) knowledge maturing indicators which will be discussed in detail in the following.

3.3.2 Background Information

The goal of the introductory part of the interview guideline was to collect general data on the interviewee and the studied organisation. This data allowed for assigning the interview to categories defined in the sampling according to stratification criteria, in order to characterise the sample and the respondents. Also, the data was used to define indicators needed in order to judge, whether there are correlations between answers and characteristics of interviewees. Six questions were created in this part, three of which focus on the interviewee and three of which focus on the studied organisation.

1. What is your position (job title) in your organisation and how long have you held it?

Interviewees were selected according to a certain profile consisting of a minimum duration of work in the profession and with the company as well as a list of preferred responsibilities of interviewees deemed sensible so that we could select individuals capable of answering the complex questions in the interview guideline for the organisational unit that they represent (section 3.6.3). The first question asked for the specific field of work in order to have a detailed account of the level of hierarchy and domain which the individual interviewee represents. This included a brief description rather than just the name of the job title. This was especially important due to job titles being not comparable between organisations of diverging sizes, industry sectors and countries, i.e. the fact that the same responsibilities of members of organisations may lead to different job titles, as well as the fact that interviewees having the same job title may have different responsibilities.

2. What is your professional background and how long have you been working in your profession?

Besides the current profession / field of work, the (educational) background of the interviewee and the general amount of professional experience and the level of expertise of the interviewee are of interest.

3. How long have you been working for your organisation?

Furthermore, it was asked, for how long interviewees had been a member of the current organisation in order to ensure that they knew their organisation sufficiently well (see section 3.6.3)

4. What part of your organisation will be the focus of this interview (e.g. factory, subsidiary, local office, organisation or entire corporate group)?

Although it was aimed at selecting interviewees who were able to speak for the whole organisation, in (very) large organisations with possibly numerous subsidiaries, an individual often could only speak for that subsidiary or for the subsidiaries in their country in case of multi-national organisations. Therefore, an explanation was needed on what parts of the organisation the interviewee felt comfortable on reporting. However, we aimed at the maximum scope that the interviewee could talk about and would avoid focusing only at a team or department level because many important aspects of innovation and

collective learning processes can only be studied when looking beyond the boundaries of such organisational units.

5. To what sector does your organisation belong?

The question aimed at the interviewee describing the main industry sector(s) of the organisation. If the interviewee spoke about only a part of the whole organisation (see question 4), then the answer was collected about both, the whole organisation and the part the interviewee spoke for. Especially for companies with several business areas, this was important in order to relate the interview to the dimensions of stratification (see section 3.6.2).

6. How many employees does your organisation have?

The question aimed at the interviewee providing the number of employees of the organisation. If the interviewee spoke about only a part of the organisation (see question 4), then the answer was collected about both, the whole organisation and the part the interviewee was speaking for. This was important to relate the interview to the dimensions of stratification (see section 3.6.2).

3.3.3 Knowledge Maturing Phases

The Knowledge Maturing Model (KMM, see section 5) comprises the main concepts used in this project in order to describe and support knowledge maturing. Therefore, several areas of interest were identified and needed to be evaluated with respect to the specific phases.

7. Which locally installed or web-based software is used for each phase?[3]
   a) "officially" endorsed by your organisation
   b) "informally", i.e. software which is not supported by your organization

This question was aimed at any kind of software used for the respective phase, locally installed on a desktop PC (individual) or on company servers (organisational). Furthermore, due to the growing importance of web services and cloud computing, web-based software which is accessed over the Internet, was also included.

As many companies impose regulations and policies on installation and use of software as well as provision of help desk and maintenance services on company computers, a distinction between "officially endorsed" and "informally used" software was made. Officially endorsed refers to software supported by the organisation, e.g., users are encouraged to use the software, users get help in case of problems with the software, the software is purchased, leased, rented or paid per use etc. "Informally used" software is used by the initiative of individual users. Users do not get any support with this software. This is software that is not prohibited in the organisation, but the use is also not encouraged. There might also be software that is banned, but still used, a category which was also of interest.

8. To what extent do you agree or disagree to the following statement? "My organisation encourages this phase and is open to quickly take up its results."

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[3] The questions about the software in use might be particularly interesting for follow-up questions in the in-depth study. For this, we intend to use (adaptive) structuration theory (Giddens, 1986, DeSanctis and Poole, 1994) as the framework. Particularly, we intend to explore on the differences between the intended use of certain software tools and the actual use in organisations concerning activities or phases of knowledge maturing. The theoretical concept explaining this is so-called appropriation moves. An example would be that one interviewed organisation has appropriated an open-source ticketing solution for usage in idea management. A systematisation of appropriation moves could provide MATURE with interesting gaps in software supply that require costly and cumbersome appropriation moves that might be reduced by MATURE services.

This item was asked in order to collect data on how the interviewees evaluated the stance of their organisation concerning the respective phase according to a seven-point Likert scale.

9.   What barriers do you think affect this phase being performed in your organisation?

The findings of year 1 (see D1.1) provided us with different concepts of motivation, influencing factors and barriers, that can appear at the individual, cooperative and workplace level. Aspects like "personal interest" or "need for experiencing autonomy" for individual level, "resistance to change" or "team culture" at cooperative level, and issues like "lack of resources" or "workload" at workspace level have been found. The representative study was used to derive more insight of the importance of these different aspects.

We also need to take into account that there exist barriers that hinder motivation of employees (Ahlert et al., 2006). Research has found a variety of different barriers, e.g. (Riege, 2005) found three dozen of such individual, organisational and technological barriers. On the other hand Ahlert et al. (2006) identified collaborative (social), technological, cognitive and motivational barriers. An extensive analysis of this research provided us with six key barriers, which are mentioned very often in scientific research and are broad enough to subsume other barriers as well (Fank and Katerkamp, 2002).

- **Lack of time**: This is a common sharing barrier when struggling with time constraints. A "natural" solution to this barrier would be to offer more space, but usually routine tasks, workload and project stress will counteract. Not having enough time here is the key aspect.

- **Fear of loss of power**: This can be considered as weakening the individual's position by sharing information.

- **Lack of usability**: A true technological barrier that challenges people and organisations and hinders effective work.

- **Fear of disgrace**: Usually a very personal barrier that can arise e.g. from former negative rating of expressed ideas.

- **Low awareness of value and benefit**: The lack of understanding and low awareness for organisational matters can be reflected here.

- **No interest**: Finally a very motivational barrier which is closely linked to the lack of motivation and acceptance, but also just by pure laziness and possibly missing incentives.

We wanted to assess with the representative study the quantitative importance and the universal frequency of these six key barriers, according to our knowledge maturing model. Additionally we also wanted to know by qualitative means if the other mentioned barriers in D1.1 are also perceived by the companies. By this we wanted to become a real-world overview of motivational barriers that is not only based on theory and can therefore be of help for the further development of our Demonstrators.

Therefore, it was decided to ask question 9 in two steps: (1) an open question and (2) the interviewee should be provided with predefined categories (only for those, which were not mentioned by the interviewee in step 1)

10. To what extent do you agree or disagree to the following statement? "I think that this phase is performed successfully within my organisation." [4]

While question 8 asks about the input, i.e. whether the phase is supported, this question asks about the outcome, i.e. whether it is performed successfully. This is done using a seven-point Likert scale.

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[4] Note that questions are discussed according to the topics and not sequentially and thus question 9 is discussed in the next section.

11. *If you have agreed or fully agreed to the phases in question 10:* Please could you explain why you think these phases are performed successfully in your organisation.

This question is a refinement of the closed question 10 and asks for a short explanation why a specific phase of the KMM was rated as successfully performed within the organisation.

3.3.4 Knowledge Maturing Activities

Generally, the term activity is used in a number of contexts with more or less profound and precise definition(s). In management theory, business process management makes extensive use of the activity concept. A business process consists of

- an interconnected, closed and repeating series of

- activities

- necessary in order to fulfil a business purpose, particularly the creation of value.

- Activities are accomplished by agents (human or computer)

- in organisational units

- using required resources (production factors) (after (Scheer, 1998), (Staud, 2006)).

The term activity thus has a connotation of value creation and consequently is at the centre of business process models, e.g., it has goals assigned to it, is performed by an agent with the help of resources and transforms input into output. Due to the repeatable nature of business processes, process modelling describes routine work solving structured problems that primarily aims at exploitation or application of knowledge. However, knowledge work or knowledge maturing does not fall into this category. Consequently, an alternative concept is needed. Still, processes describe the details of an organizational value chain that provides the main concept to ensure that activities in the organization are targeted towards creating customer value.

Activity theory has been proposed to provide a means to analyze knowledge work (e.g. Blackler, 1995) and to guide the design of information systems, especially group support systems, but recently also knowledge infrastructures (see, e.g. Sachs, 1995, Kuuti, 1997, Clases and Wehner, 2002, Hasan and Gould, 2003, Collins et al., 2002).

Acquisition of knowledge in modern learning theories is not a simple matter of taking in knowledge, but a complex cultural or social phenomenon. Thus, some authors suggest not to model knowledge as an object with its connotations of abstraction, progress, permanency and mentalism as proposed in the extensions to process modelling, but as processes of knowing and doing which take place in (socially-distributed) activity systems (e.g. Blackler, 1995, Riss, 2005).

Figure 6 shows the elements of activity systems. These systems provide a unit of analysis for the dynamic relationships among individuals (called agents or subjects), their communities and the conception(s) they have of their activities (called object; inner triangle in figure 6). These relationships are mediated by instruments and concepts (e.g., language, technologies) used by the agents, implicit or explicit social rules linking them to their communities and the role system and division of labour adopted by their community (outer triangle in figure 6; (Engeström, 1987)).
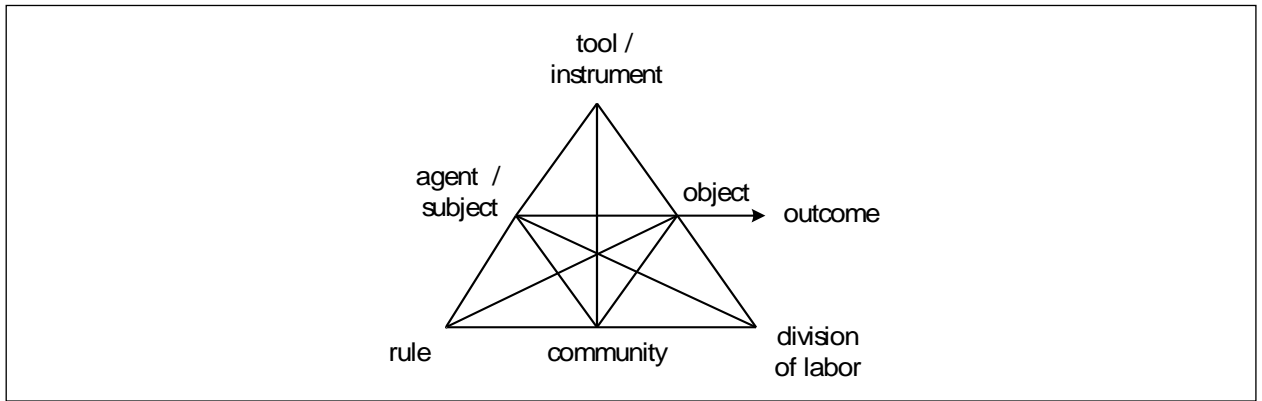
Figure 6: Model of the socially-distributed activity system based on (Engeström, 1987), see also (Blackler, 1995), (Engeström, 1999)

Activities have a hierarchical structure (see figure 7): They are driven by common motives which reflect collective needs (Engeström, 1999). They are accomplished by actions directed to goals coupled to the motives. There is a many-to-many relationship between activities and actions: an action could belong to multiple activities and the object of an activity could be reached by multiple alternative actions (Engeström, 1999). Actions in turn consist of orientation and execution phase. The first comprises planning for action, the latter performing the action by a chain of operations (Kuuti, 1997). The better the model upon which planning is based fits the conditions, the more successful the action will be. Actions can collapse into operations, if the model is sufficiently accurate, so that planning is unnecessary. Operations are executed under certain conditions and are the most structured part easiest to be automated.
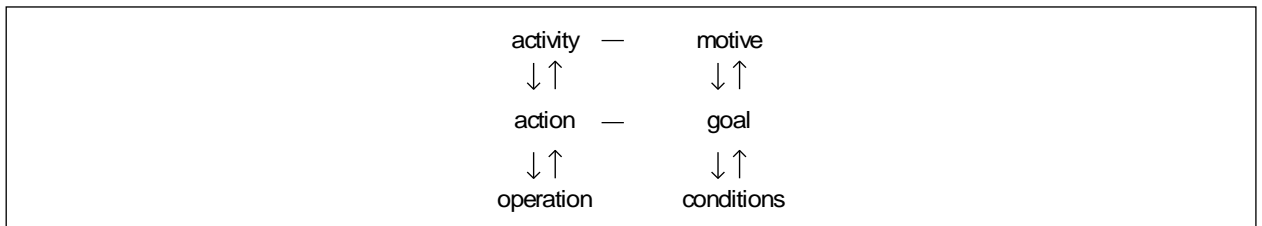
Figure 7: Hierarchical structure of an activity (Kuuti, 1997)

An important feature of activity theory is the dynamic relationship between the three levels. Operations can again unfold into actions, e.g., if conditions change, as well as actions can become activities. Elements of higher levels collapse to constructs of lower levels if learning takes place. They unfold to higher levels if changes occur and learning is necessary.

The concepts provided by activity theory are well suited to analyse the creative, unstructured and learning-oriented practices of knowledge work. Activities primarily operationalise exploration as strategic focus. They aim at the joint creation of knowledge that is then applied in business processes. We deem the concept of activity also beneficial to analyse knowledge maturing because practices of knowledge maturing are a subset of practices of knowledge work. Practice is the concept used in this paper to describe, analyze and later on design IS-supported knowledge work (Orlikowski, 2000) focusing on commonalities across professions, positions and industries. (Blackler et al., 1993) recommend to study knowledge work by focusing on work practices. This strong empirical focus on what people do rather than on what they know and, one might add, why and how they do what they do, calls for a thorough investigation which is why we performed an ethnographically-informed study first instead of merely relying on questionnaires and interviews.

In MATURE, knowledge maturing activities (KMA) are defined as individual or group activities that contribute to the development of knowledge within the organisation. The selection of activities used in the interview guideline has three strands: use case areas, codes and review of literature.

Use case areas: The second iteration of collaboratively defining use cases conducted in year one of the project resulted in 47 rich use cases descriptions. These use cases were clustered into nine areas (see table 1) which were utilized as a first strand. [5]

Codes: The qualitative evaluation of data gained through the ethnographically informed study in year one (see D1.1) resulted in 65 code areas. 31 of these 65 code areas are related to the coding dimension of activities performed by knowledge workers were used as the second strand. A list of all code areas along with clustered codes can be found in D1.1.

Literature Review: Knowledge activities in general have their roots in the perspective of practice of knowledge work as described above. Practice is the source of coherence of a community due to mutual engagement, joint enterprise and shared repertoire (Wenger, 1998). Practices formed by individuals that are part of semi-permanent work groups are examples of how knowledge work can be framed as a social process (Daskalaki and Blair, 2002). Knowledge work is characterized by practices such as acquiring, creating, gathering, organising, packaging, maintaining, systemising, communicating and applying knowledge (Davenport et al., 1996, Kelloway and Barling, 2000, Holsapple and Whinston, 1987) and roles such as data gatherer, knowledge user and knowledge builder (Snyder-Halpern et al., 2001). However, the practices proposed so far need to be detailed in order to offer starting points for IS design. Schultze identifies informing practices in an ethnographic study of knowledge work in a large Fortune 500 manufacturing firm (Schultze, 2000): (1) ex-pressing, i.e. self-reflexive converting of individual knowledge and subjective insights into informational objects that are independent of knowledge workers, (2) monitoring, i.e. continuous non-focused scanning of the environment and the gathering of useful "just in case"-information, and (3) translating, i.e. creation of information by ferrying it across multiple realms and different contexts until a coherent meaning emerges and later adds (4) networking, i.e. building relationships with people inside and outside the company that knowledge workers rely on (Schultze, 2003). Especially the work performed by (Hädrich, 2007), i.e. a series of 31 interviews with knowledge workers building on Schultze's practices, was deemed useful to inform our activities to design a list of knowledge maturing activities that are deemed important to be supported by MATURE software and services. In an empirical study, Hädrich identified 69 knowledge actions performed by knowledge workers, grouped into the following general knowledge activities:

- Access refers to regular checks of internal and external sources of information. It may be oriented towards the access of codified knowledge as well as towards the use of communication media.

- Collect comprises gathering of potential topics of meetings as well as of meeting registrations. It is relevant for creating an agenda of individual meetings and of a group as a whole.

- Converge is concerned with creating consistent results within a group. It is characteristic for (co-)authoring where individual contributions need to be merged into a coherent whole.

- Coordinate includes communication with co-authors as well as management of shared repositories used for storing preliminary and final versions of joint results.

- Create deals with generation of documented knowledge, i.e. writing activities, e.g., based on templates or similar documents and also editing, annotating and generalising contents.

- Discuss is direct knowledge sharing between one or more individuals, e.g., to resolve a problem related to work tasks. It may involve making appointments or documenting communication.

- Distribute disseminates documented knowledge and comprises classifying, storing, forwarding and releasing contents as well as organising structures and access privileges of storage systems.

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[5]   For more information about the clustering see MATURE wiki: http://wiki.mature-ip.eu/index.php/Second_Iteration_of_Use_Cases

- Evaluate is appraisal of knowledge, e.g., through conducting examinations of agent results, help received in support calls or quality of training courses.

- Identify is search and detection of people characterized by required competencies or by interests that make them potential candidates for their invitation into a group.

- Inquire is concerned with identification, retrieval and use of documented knowledge, e.g., digital training units, contents acquired from internal knowledge sources or identified with a Web search.

- Network is establishment and development of contacts with the goal of knowledge sharing. This includes informal socialisation as well as participating in formal meetings.

- Prepare sets up a knowledge action, i.e. specifies criteria and acquires relevant resources, e.g., determining learning goals, required competencies or potential co-authors.

- Request is concerned with getting help and advice. This may involve identification of individuals or opening of support tickets that specify a problem to be solved.

- Review evaluates and enhances documented knowledge. In contrast to "evaluate", it typically is part of authoring and involves requesting feedback about contents and their formal release.

These knowledge actions provide the third strand for development of our set of knowledge maturing activities.

For selecting an initial set of knowledge maturing activities, UIBK took use case areas as a starting point. In particular, the use case areas were used as a pattern for a classification of code areas and knowledge actions. Each use case area became the name of one class. In a first step, based on descriptions of use cases, codes and explanations provided by (Hädrich, 2007), the code areas and knowledge actions were mapped to the defined classes. As it was not possible to classify all code areas and knowledge actions, it was deemed necessary to further detail some of the predefined classes (e.g., discover, refine, and execute processes) and, furthermore, to introduce one new class (i.e. assess, verify and rate). Table 1 provides an overview of the development of the initial set of knowledge maturing activities into the set that was finally used in the interview guideline.

name of use case area	initial set of KMA	set of KMA used in interview guideline of representative study
find relevant artefacts	find relevant artefacts	find relevant digital resources
collect and structure information	collect and structure information	embed information at individual or organisational level
awareness of changes	stay aware of changes	keep up-to-date with organisation-related knowledge
getting an overview	get an overview	familiarise oneself with new information
gardening	gardening and assure quality	reorganise information at individual or organisational level
discover, refine, and execute processes	discover, refine and execute processes	reflect on and refine work practices or processes
	reflect work practices	
create, develop, and share content	create and (co-)develop contents	create and co-develop digital resources
	share and manage access to contents	share and release digital resources

		restrict access and protect digital resources
finding people	find people	find people with particular knowledge or expertise
communicating with people	communicate and collaborate	communicate with people
	assess, verify and rate	assess, verify and rate information

Table 1: Development of knowledge maturing activities

Discussions within the consortium and particularly the pre-tests with candidate interviewees representing diverse types of organisations in several countries helped us to reformulate the knowledge maturing activities while keeping the essentials of what concepts they represent which were rooted in our and other empirical studies. Regular Flashmeetings were used to discuss critical points with partners who had already been part of the ethnographically-informed study and thus had a deep understanding of activities performed by knowledge workers. Finally, this consecutive procedure resulted in an agreed and comprehensive list of knowledge maturing activities along with examples facilitating their explanation (see right hand side column of table 1 as well as table 2)

KMA	example provided by interviewer
find relevant digital resources	Search for information, e.g. documents, web pages or images.
embed information at individual or organisational level	Include the information into one's own knowledge base, which could be a (personal or shared) file system, a (personal/team/corporate) wiki, or similar.
keep up-to-date with organisation-related knowledge	making sure that oneself or another person stays up-to-date regarding a certain topic
familiarise oneself with new information	Making oneself familiar with e.g. a topic or a community or processes
reorganise information at individual or organisational level	Restructure collections (file systems, wikis, …), consolidate different approaches to collective structuring, removing outdated items, improving findability through assigning metadata, "gardening" of wikis, vocabularies etc., rearrange contents or files, clean-up work spaces and assure quality of a collection of digital resources
reflect on and refine work practices or processes	This reflects process maturing from discovery of task or process patterns, the analysis thereof to improving practices and/or processes. The knowledge maturing activity thus comprises practices (i.e. not formally specified), procedures (informal or endorsed) as well as processes (specified, defined)
create and co-develop digital resources	Generate new or update existing contents by oneself or together with others. Note: co-development is a form of collaboration.
share and release digital resources	Share denotes the informal, release the formal or official part of granting access to contents for a specified or unspecified group of people.
restrict access and protect digital resources	Restricting access to contents.
find people with particular knowledge or expertise	identify a contact person, e.g. by skills

communicate with people	interact with others, e.g. face-to-face, by phone, by mail
assess, verify and rate information	Evaluate contents with respect to certain quality criteria like accurateness, up-to-dateness, usefulness or people with respect to their capacities or behaviour

Table 2: Examples for describing knowledge maturing activities

Due to time restrictions of the survey, topic areas had to be prioritised. This led to the decision that the representative study focused on examining knowledge maturing activities in relation to the concept of knowledge maturing in general. Relevant further investigations of knowledge maturing activities in more detail, e.g., along the phases of the knowledge maturing model and analysing them, e.g., with respect to why, by whom, how often, with which tools and with what results they were performed were planned for the in-depth-study in year three.

3.3.5 Knowledge Maturing Indicators

Knowledge maturing is a complex, multi-faceted phenomenon and it is hardly directly observable. We have not found any direct measures yet that help to assess whether and to what extent knowledge maturing has happened. However, finding at least indicators that help to assess knowledge maturing are important for MATURE for two reasons which also reflect two very different levels of granularity that our knowledge maturing indicators (KM indicators) adhere to:

Management level

The management level is important as we envision the knowledge maturing concept as not only a merely descriptive concept, but one that individuals in organisations can act upon when deciding on how to guide or what measures to apply or what tools to use in order to support goal-oriented learning on a collective level, in other words, knowledge maturing. The old management saying that "You can only manage what you can measure" (often attributed to Drucker or Kaplan/Norton) resonates with many practitioners that we talked to in preparation of our study. We were frequently asked about how we would think one should go about measuring that knowledge maturing has happened which in turn would make it possible to traceably reflect on the impact of interventions into improving knowledge maturing. The measures sought after at this level are coarse-granular, aggregate and value-oriented.

IT Service level

We explore KM indicators also in order to (semi-)automatically recognise that organisational knowledge has matured. Knowledge maturing indicators are highly relevant for maturing services (see D4.2) for detecting and supporting knowledge maturing. We envision IT services that automatically analyse the combined workspaces of knowledge workers or a part of them and present the results of the analysis in the form of one or a set of indicators. The measures sought after at this level are fine-granular, atomic and oriented towards the media and portion of the digital space that they analyse.

As knowledge can be related to different media (Maier, 2007a), KM indicators are structured according to knowledge that is embedded in a digital resource, held by a person and embedded in processes. Additionally, KM indicators depicting combinations of those three different types of media were investigated.

We have not yet found any direct measures for knowledge maturing and due to our definition of knowledge maturing and we doubt that we will be able to find directly observable measures in the near future. Thus, we need to rely on indicators that do not directly measure knowledge maturing, but instead the indicators measure observable changes in state or new states with respect to persons, processes or digital resources involved in knowledge maturing. Thus, they measure competence development of people or quality improvements in documents to mention a few which certainly are only indirect indicators that knowledge maturing might have happened. There have been situations in our series of studies in which these were positively related to the perception that knowledge maturing actually has happened.

An initial set of knowledge maturing indicators was collaboratively collected during the ethnographically-informed study conducted in the first year of the project (see D1.1). Based on this comprehensive set a stepwise refinement of the KM indicators was performed (see table 33 in appendix 8.4.1).

All KM indicators were revisited and backed by examples that facilitated their explanation. We made sure that we improved the list with respect to the accessibility of KM indicators. Thus, we asked if the real-world happenings addressed in the KM indicators leave digital traces behind that could be automatically analysed and aggregated into the indicators. They thus are mostly somewhere in between the management and the IT service levels with respect to the level of granularity.

Moreover, a study using an online questionnaire with a preliminary version of the set of 37 KM indicators gained through the ethnographically-informed study (see D1.1 section 3 and D1.1 section 4.3.5) was conducted investigating opinions of all associate partners of the MATURE project. Primarily, the aims of this survey were threefold: (1) to get a deeper understanding of the associate partners' opinion regarding the suitability of the knowledge maturing indicators identified during the ethnographically-informed study; (2) to select the most promising of these 37 knowledge maturing indicators according to the application partners' opinion for further research and (3) to possibly collect additional knowledge maturing indicators that might be interesting for further research during the representative and in-depth study of the MATURE project.

On June 2nd 2009 all MATURE associate partners were invited to take part in an online survey about knowledge maturing indicators. Therefore, an email was sent out containing descriptions and a link to an online questionnaire. The descriptions of knowledge maturing and of the knowledge maturing model (see section 8.1.1) were provided as PDF (attached to the email) in order to foster a common understanding and improve comprehension of the questions.

The online questionnaire (see section 8.1.2) contained a short explanation of knowledge maturing indicators, six closed and seven open questions. Through the closed questions, the associate partners were asked to what extent they agree to the statement that the respective Knowledge Maturing Indicator is a good indicator for maturation of knowledge that is embedded in digital resources, that resides in a person or that exists in processes. With the help of the open questions, additional knowledge maturing indicators and a feedback to the survey were collected.

The online questionnaire was available from June 2nd to June 8th. Due to requests for an extension of the deadline, the questionnaire was made available again on June 16th, and the deadline was postponed to June 19th.

After a quantitative and qualitative evaluation of data gained through this study (see appendix, section 8.1.3), a small number of additional KM indicators was identified. Furthermore, based on answers of respondents, KM indicators and examples for their explanation were rephrased in order to increase understandability by the target group of interviewees.

Finally, during the design phase of the interview guideline for the representative study, all engaged partners provided valuable input for further enhancement and language editing. Table 3 contains all 38 KM indicators together with examples that became part of the interview guideline of the representative study.

	KM Indicator	example
A digital resource that…	has been accepted into a restricted domain	article published on company's intranet
	has become part of a guideline or has become standard	pdf file became part of user manual
	has not been changed for a long period after intensive editing	wiki article remains unchanged since its last major editing
	was selected from a range of resources	specific document was chosen out of list of search results
	became part of a collection of similar information	folder containing documents on the same topic
	was created/refined in a meeting	word document reworked during project meeting
	was prepared for a meeting	PowerPoint presentation prepared for project meeting
	was created by integrating parts of other digital resources	presentation created using information from two sources
	was made accessible to a different user group	access to a document restricted to administrative users
	was presented to an influential audience	report presented to the board of directors
	is referred to by another resource	wiki article referred within a protocol
	has been the subject of many discussions	several emails sent between parties about structure of document
A person that…	has acquired a qualification or attended a training course	employee attended a training course
	has a central role within a social network	employee often refers requesters to potential problem solvers
	changed its role or responsibility	employee took on the role of project manager
	has contributed to a project	employee is member of project steering committee
	has contributed to a discussion	employee participated in workshop
	has been a member of the organisation for a significant period	employee was with company for three years
	has significant professional experience	employee has 10 years work experience in career
	is an author of many documents	user created 20 wiki articles
	is approached by others for help and advice	employee gets an emails with request for help
A process that…	was certified or standardised according to external standards	a process was certified according to ISO 9000 standard
	was internally agreed or standardised	an internal guideline describing how the procurement process has to be executed was created
	was changed by adding or deleting steps	process was changed to include check of information examples for steps are: creating, checking or using information
	was documented	process was verbally described and depicted in process model

	was improved with respect to time, cost or quality	execution time or costs were reduced
	was changed according to the number of cycles (loops)	number of call-backs necessary to complete a user request was reduced
	has been successfully undertaken a number of times	process was executed successfully four times
A digital resource has been changed after a person had learned something		employee changed document after return from training
A digital resource has been accessed by a different group of persons		document is now also used by another department
A digital resource has been assessed by a person		forum entry rated helpful by a colleague
A digital resource has been edited by a highly reputable person		document was changed by an expert in the domain
A digital resource has been used by a person		person used prepared presentation
A digital resource describing a process has been changed		process model of pre-existing workflow was changed
A digital resource has been changed as the result of a process		manual edited during complaint handling
A person has been involved in a process a number of times		employee took part in process 60 times
A person has been involved in a process for a significant period		employee took part in process for six years
A person has been the owner of a process for a significant period		employee was responsible for process for six years

Table 3: Knowledge maturing indicators – as used in representative study

Summing up, the list of KM indicators as used in the representative study has been developed on the basis of the ethnographically-informed study. Specifically, they have been observed and reflected in the context of what might be termed knowledge maturing events[6]. The indicators have been developed in a multi-step process together with the ethnographers and thus have been internally validated against the ethnographers' experiences in the cases. They have also been externally validated with the help of our associate partners. Then they have been subjected to discussion, extension, reformulation in our consortium before we have included them in the interview guidelines. They were more broadly validated in the representative study.

3.4 Collecting additional Contextual Data

An important opportunity of (semi-structured) interviews is the engagement in a discourse with the interviewee in which the interviewer can typically receive rich explanations, context descriptions and other input beyond answers to closed questions and potentially not related to open questions in the guideline. These contextualised narratives are an important source of learning for the project as a whole, including the knowledge maturing model, but also the conceptual and development work going on as part of the demonstrators. More specifically, we expected to (i) get a better understanding of the role/aspects of context/culture we need to take into account, (ii) identify contextual factors of knowledge maturing indicators (also following the result of the study with associate partners), (iii) get a deepened understanding of motivational barriers and their contextual dependencies.

That is why we decided that in addition to collecting the quantitative data, the interviewer also *writes down interesting explanations or examples* if they appear. If these comments are directly related to questions, these were to be integrated into the interviewer forms; for the remaining narratives, each interviewer could select the format of choice. For the latter, the interviewers will try to *aggregate and*

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[6] We have allocated a lot of time to understand the context of these events, i.e. the who, why, where, when, what and how, and we are not aware of a study that went to the trouble of doing this for finding indicators for knowledge maturing apart from ours.

summarize their results as stories about knowledge maturing in companies, and these will be analysed comparatively.

Of particular interest, were the following aspects:

- *Context-specific stories of knowledge maturing (on non-maturing).* When explaining and discussing the concept of knowledge maturing and the phase model, interviewees come with their own translations or anecdotes that are deeply embedded into a certain context. So it is important to capture that context so that we are later able to learn about the role of context (work organization, domain, …).

- *Software tools, their importance, and adequacy.* In addition to software tools that are used, the interviewee gives a valuation on their effectiveness, or importance. You get reflections on the corporate culture around the issue of formal/informal software tools, but also about the limited perspective.

- *Knowledge maturing indicators.* Interviewees give examples, modifications, or even little stories about the indicators that help us identify contextual conditions and combinations of indicators.

- *Motivational barriers.* Interviewees answer those questions by telling stories, giving more concrete examples, but also reflecting on the organizational culture.

3.5 Pre-Study

Once a first version of the interview guideline was agreed, a pre-study was conducted with selected individuals representing heterogeneous types of companies and helped to improve understandability and "askability" of the questions. Table 4 provides an overview of conducted pre-study interviews.

partner	Pre-study with
FZI	1 interviewees representing an organisation and 1 telephone interview expert
UIBK	2 interviewees representing 2 organisations
UPB	1 interviewee
UWAR	1 interviewee

Table 4: Pre-Study overview

The pre-study was followed again by a series of consultations for agreement of the final wording of the questionnaire. One aim was to balance the qualitative and quantitative parts of the study in order to benefit on the one hand from material that can be easily compared between interviews needed for further exploring assumptions generated in the ethnographic study and clustering the companies with more rich qualitative material that provides more in-depth knowledge on knowledge maturing in the companies.

3.6 Sample

The purpose of the study was to provide an overview of knowledge maturing throughout Europe and throughout all sectors. The mapping of partners and European countries in which interviews were planned is described in section 3.6.1. Section 3.6.2 describes what further stratification criteria were introduced. As a broad overview of the company was needed to complete the interview, the study aimed at specific contact persons which are described in section 3.6.3. The specific procedure suggested for handling contacts is described in section 3.6.4.

3.6.1 Countries

The aim of the study was to draw a picture of knowledge maturing throughout Europe. As not all European languages were available in the project, the distribution of interviews had to be balanced with respect to language skills in the consortium. Besides the language, the number of contacts of the partners

had to be taken into account. Table 32 (see appendix 8.2.3) depicts the planned number of interviews with respect to partner and country as agreed upon in the consortium meeting in Karlsruhe.

3.6.2 Organisations

Generally, all types of organisations and sectors where of interest for the study. However, in order to facilitate the equal distribution described in 3.6, more criteria were needed. As these criteria had to be transferable between the countries the study would take place in, it was decided to utilize the European standard NACE (Eurostat, 2008).

Three criteria were chosen for stratifying the sample: size, principal economic activity and classification regarding knowledge or technology intensity of business sector.

Size

The size of an organisation was measured according recommendations for innovation surveys. (OECD and EUROSTAT, 2005):

- *Small*   *10 to 49*

- Medium   50 to 249

- Large   250 and more

However, organisations designated as 'small', having 10 to 49 employees were not part of the study. This was due to the assumption that medium and large companies have more systematic activities concerning knowledge maturing, potentially with designated roles that can provide a reflected perception of importance, support and success of activities concerning knowledge maturing in their organisations.

Principal economic activity of the organizational unit/company

The classification of principal economical activity is based around the hierarchical structure provided by NACE v.2 (Eurostat, 2008). The codes in this hierarchy are mapped to either:

- (Manufacturing) Industry

- (Knowledge-Based) Service.

We decided to use the 2-digit level codes rather than 3-digit codes which would have been too detailed for an aimed sample size of n=200.

Classification regarding knowledge or technology intensity of business sector

Eurostat provided further aggregations of manufacturing industries and knowledge-based services: Industries are aggregated with regard to technology-intensity whereas the knowledge-intensity is distinguished in the services sector. Although four levels of technology-intensity/knowledge-intensity are available, we decided to aggregate them to only two levels with regard of the size of strata.

- Low (technology/knowledge-intensity)

- High (technology/knowledge-intensity).

Table 5 provides an overview of all original stratification criteria and planned distribution of interviews.

country	medium				large				sum
	industry		service		industry		service		
	Low	high	low	high	low	high	low	high	
Austria	2	2	1	1	1	1	1	1	10
Belgium	2	2	1	1	1	1	1	1	10
Eastern Europe	1	1	1	1	1	1	2	2	10
Slovenia	1	1	1	1	2	2	1	1	10
France	1	1	2	2	1	1	1	1	10
Germany	5	5	5	5	5	5	5	5	40
Greece	1	1	1	1	2	2	1	1	10
Ireland	2	2	1	1	1	1	1	1	10
Italy	1	1	2	2	1	1	1	1	10
Portugal	1	1	1	1	1	1	2	2	10
Scandinavia	1	1	1	1	1	1	2	2	10
Spain	4	4	4	4	4	4	3	3	30
Switzerland	1	1	2	2	1	1	1	1	10
UK	3	3	4	4	4	4	4	4	30
Sum	26	26	27	27	26	26	26	26	210

Table 5: Stratified list of planned interviews

3.6.3 Interviewees

The study aimed at getting an overview of knowledge maturing of entire organisations, rather than single departments or workgroups. Therefore we defined several criteria interviewees should meet. In order to ensure, that interviewees know the organisation they are speaking for and have a general understanding of the sector, the company is mapped to the following selection criteria were defined:

- has been with the organisation for at least one year

- has professional experience of at least three years.

Furthermore, as there is no standardised scheme for defining jobs and job descriptions throughout several sectors and countries on the one hand, and organisations may be organised in varying ways, on the other, a number of topics were defined which should help to select a feasible contact person with regard to knowledge maturing. Therefore, contact persons who would have responsibility in one or more of the following topics were preferred:

- knowledge management (preferred),

- innovation or organisation,

- change management,

- human resources (development)

- or, in medium-sized enterprises, this could be the CEO.

3.6.4 Procedure for contacts

Within the study, two main means of getting contacts were used.

Ideally, it would have been desirable to enlarge the foundation of our concepts and thinking about knowledge maturing to organizations without close relationships to either one of us. This procedure was partially followed. Additionally to conducting "cold calls" with a sample following the stratification criteria laid out above, organisations representing a purposive sample were also contacted. The latter was due to the following considerations: it was discovered that cold calling hundreds of employees would be in breach of at least one partner's ethical policies on two counts: such an approach would inflict reputational damage on the university; it would contravene notions of 'informed consent' (particularly as a respondent starting a conversation may find they are in breach of the company's compliance policy regarding to responding to surveys).

Partners that were not able to do cold calling, pursued an alternative approach that was ethically acceptable and used an appropriate social science methodology - purposive sampling. Subjects are selected because of a particular characteristic - they have something useful to tell us about knowledge maturing. Patton (1990) has proposed purposive sampling is useful for the following reasons:

- to deal with relatively low numbers per case (country);

- possible to select extreme cases - learning from highly unusual manifestations of the phenomenon of interest, such as outstanding success/notable failures;

- able to find intense cases where individuals or organisations give us access to information-rich cases that manifest the phenomenon intensely;

- able to search for Maximum Variation - Purposefully picking a wide range of variation on dimensions of interest...documents unique or diverse variations that have emerged in adapting to different conditions;

- identifies important common patterns that cut across variations; able to Snowball or Chain - possible to identify cases of interest from people who know people who know people who know what cases are information-rich, that is, good examples for study, good interview subjects;

- theory-based and testing an operational construct - finding manifestations of a theoretical construct of interest so as to elaborate and examine the construct (knowledge maturing);

- Confirming or Disconfirming - elaborating and deepening initial analysis, seeking exceptions, testing variation;

- Opportunistic - Following new leads during fieldwork, taking advantage of the unexpected, flexibility.

Even though this method was well suited to our overarching purpose (learning more about knowledge maturing processes), nevertheless we stuck in parts to our original plan of a stratified sample of organisations as well as of contacting organisations that had no prior relationships with us so that we had the chance to broaden our empirical base well beyond the reach of the ecosystems of MATURE partners. Also, this turned to be a primary opportunity for dissemination and for spreading the word about MATURE and its concepts to approximate 1,000 practitioners responsible for knowledge management, innovation management, change management or human resource management, the primary target group for introducing MATURE ideas into their organisations. This mixed approach is justified as a combination of methods as we could not predict which approach would be more helpful and the original suggestion could not be implemented with some partners, e.g., in the UK, because of more stringent ethical guidelines.

Cold calls were planned to be conducted in two countries: Germany and Spain. For Spain, 300 addresses were bought. For Germany, 1,500 addresses were bought by Creditreform Austria. As the addresses were bought including NACEv2 sectors, it was possible to specifically focus on sectors being underrepresented in the purposeful sample. Within each strata, the sample was selected based on an list in alphabetical order from which each 5th entry was chosen.

After finding the right contact person within the company, the goal of the study was explained to him/her. Furthermore, the results of the study were promised to the (prospective) interviewee. After succeeding in getting an appointment for about 60 minutes, a one page descriptions of MATURE was sent via E-Mail in order to provide a first impression (see appendix 8.3). The interview guideline (see appendix 8.2.1) was sent to the interviewee beforehand. This also provided a reminder for the interviewee, especially, if the appointment was made several weeks ago.

For some interesting cases, the interview was recorded with prior notice to the interviewee in order to capture particularly the additional narratives accurately. Depending on the interview and the interviewee, the interview form was either filled out straight away, or completed afterwards. After completing the interview form, it was uploaded to the project's SVN.

As Part IV (see 3.4.5) was designed as optional, it was planned to neglect it, in case time would run short in an interview. As a backup solution, an online version was created. In case of its usage, the interviewer would provide a short introduction to knowledge maturing indicators and then send the customised link including the interview id to the interviewee via mail. Typically, the data then was copied back into the respective interview form.

4   Results

This chapter presents the results of the study. Section 4.1 gives an overview of the study, characterises the sample and reflects on the challenges we had to overcome when rolling-out the study design as described in section 3 as well as the preparatory steps that had to be taken on the data material before it could be analysed. Results of the analysis of data are given in sections 4.3 to 4.8 which is structured along the main parts of the interview guideline: background information (4.3), knowledge maturing phases (4.4), knowledge maturing activities (4.5), knowledge maturing indicators (4.6), the results of clustering organisations (4.7) and the rich stories that we could collect about knowledge maturing practices in the interviewed organisations (4.8). The chapter then discusses the study's limitations (0) and concludes with a short summary and visualization of the combinations of methods applied for the analysis as well as the parallel activities in the other MATURE work packages that took up results while the study was still on-going (4.10).

4.1   Overview and Preparation

This section gives an overview of the steps we took to analyse the sample, exclude interviews that did not fit our criteria and how we dealt with missing data. Table 6 represents all interviews conducted according to the stratification criteria (see section 3.6). The figures in the table show the number of planned interviews against the number of actual interviews e.g. 0/2 shows that no interviews were conducted, but 2 were planned. Two additional strata were introduced. The classification with regard to knowledge or technology intensity and principal economic activity excludes several codes in two mainly business areas: utilities and construction. According to Eurostat (see appendix 8.6) these sectors were not unambiguously classifiable to either industry or service and too high or low knowledge intensity. Therefore, they have been mapped to "not assignable".

Country	Medium					large					sum
	industry		service		not assign-able	industry		service		not assign-able	
	low	high	Low	high		low	high	low	high		
Austria	0/2	0/2	0/1	6/1	0	3/1	3/1	0/1	1/1	0	13/10
Belgium	0/2	0/2	0/1	3/1	0	0/1	1/1	0/1	0/1	0	4/10
Eastern Europe	0/1	0/1	1/1	0/1	0	0/1	1/1	0/2	1/2	0	3/10
Slovenia	0/1	0/1	0/1	0/1	0	0/2	0/2	0/1	0/1	0	0/10
France	0/1	0/1	0/2	0/2	0	0/1	0/1	0/1	2/1	0	2/10
Germany	0/5	2/5	2/5	4/5	0	4/5	7/5	9/5	10/5	2	40/40
Greece	0/1	0/1	0/1	4/1	0	0/2	0/2	0/1	3/1	0	7/10
Ireland	1/2	0/2	0/1	0/1	0	0/1	0/1	0/1	1/1	0	2/10
Italy	0/1	0/1	0/2	1/2	0	1/1	4/1	0/1	4/1	0	10/10
Portugal	0/1	0/1	0/1	3/1	0	0/1	0/1	0/2	0/2	2	5/10
Scandina-via	0/1	0/1	0/1	0/1	0	0/1	0/1	0/2	0/2	0	0/10
Spain	2/4	0/4	3/4	2/4	0	2/4	2/4	1/3	4/3	3	19/30
Switzer-land	2/1	0/1	1/2	2/2	0	2/1	1/1	1/1	2/1	0	11/10
UK	2/3	0/3	1/4	1/4	0	1/4	2/4	1/4	3/4	1	12/30
Sum	7/26	2/26	8/27	26/27	0	13/26	21/26	12/26	31/26	8	128/210

Table 6: Interviews conducted

In total, 139 interviews were conducted. As Table 6 shows, a total of 128 interviews met the criteria defined in section 3.6. Ten interviews were conducted which were either not in Europe or related to organisations with fewer than 49 employees. The additional eleven interviews were not included in the statistical analysis, but were used for gaining contextual insights, for qualitative analyses and for purposes of comparison.

Of the 128 interviews in the sample, 43 were with representatives of medium-sized organisations and 85 were with interviewees representing large organisations. 43 organisations had their main area of business classified as industry, whereas 77 organisations were classified as service. Eight organisations were mapped to "not assignable". With regard to knowledge/technology intensity, 80 organisations were regarded as having high knowledge/technology intensity, whereas 40 organisations were considered having a low intensity on knowledge/technology. Again, eight organisations could not be mapped.

Out of the 128 interviews, two had to be omitted because the interviewees terminated the interviews during interviewing[7]. Thus, 126 cases remained in the sample. These had an amount of at maximum 7.6% of missing data per case concerning those closed questions that were quantitatively analysed. As less than 10% of missing data per case can generally be ignored (Hair et al., 2006), all 126 cases are part of the quantitative evaluation later on.

In spite of the large number of questions that were asked about complex matters, we succeeded in having low rates of missing data. This and the fact that there were no visible patterns (e.g., concentration on specific set of questions or attrition at the end of the interview) might result from interviewing participants instead of collecting data by using questionnaires and again shows how beneficial it was that we got all feedback by interviews and not by questionnaires.

Overall, not more than 4.8% of data is missing per variable with respect to all closed questions. On a variable basis, different approaches exist of how to cope with missing data. As the percentage of missing data is lower than 10%, a broad range of imputation methods can be applied (Hair et al., 2006). Because the missing data are in a random pattern and the valid data are an adequate representation, we decided to use only valid data and consequently to not replace any missing values. Hence, two approaches can by employed (Hair et al., 2006):

- Complete case approach (exclude cases listwise in SPSS): In each analysis only those cases with complete data for all analyzed variables are included.

- All-available approach (exclude cases pairwise in SPSS): This method imputes the distribution characteristics or relationships from every valid value and hence, maximizes the pairwise information available in the sample depending on the type of performed analysis.

Depending on their pros and cons (for more information see Hair et al., 2006), both approaches were used in the following analyses and have been marked there.

The sample mirrors the partially significant challenges in getting interviews with organisations of certain types in some parts of Europe, e.g., the United Kingdom. For example, people contacted felt unable to answer questions on knowledge maturing, had concerns about confidentiality, were willing to be interviewed, but unable to commit the time or were unable to get permission from their organisation. To illustrate the intensity of the challenges, out only one interview resulted of 200 people being contacted in one initiative. Another challenge was due to the fact that not all countries that we aimed for were represented in the consortium and naturally it was more difficult to get interviews in countries that we had no direct connection and no member in the consortium who spoke the language. We feel that the sample allows for a substantially broadened empirical base well beyond the reach of the ecosystems of MATURE partners. Due to the combination of sampling following the stratification criteria and purposive sampling, some strata are over- and some are underrepresented compared to the ideal stratification that we developed in section 3.6. However, we feel comfortable that the sample now consists of a sufficiently

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[77] This number excludes part IV of the interview which was optional. The two interviews which were not completed had 56% and 74% missing values.

broad variety of organisations with respect to size, sector, knowledge intensity and country (for a more detailed analysis see also section 0 on limitations of the study).

4.2 Qualitative Data Analysis Methodology

The qualitative data analysis took as a basis all interviews (139 in total) that were conducted and encompassed (a) comments to closed questions, and (b) open questions. While excluded in the quantitative analysis, small companies were included in the qualitative analyses as they have been included in the qualitative analysis because these organizations were part of purposeful sampling and considered for their interest or experience in knowledge maturing. It should be noted that there were only 6 small companies included in the qualitative analyses.

The general approach to analyzing the data was following a standard procedure in qualitative data analysis. The collected data, structured according to the fields in the questionnaire was fed into a Microsoft Access database for further processing. In a first iteration, codes were added collaboratively to responses to get an overview of the topics addressed (by FZI + UWAR), both globally and per question. Based on this first iteration, used codes were defined or described in the wiki, grouped according to the different questions. In further iterations, the coding was refined by (a) adding more detailed codes for those that appeared very frequently, (b) merging codes for those with very few responses, and (c) new codes that were the result of an evolved understanding. The result was also a more differentiated coding, which formed the basis for identifying interesting aspects that were then interpreted using the original data.

There were some variations in the general approach depending on which part of the data was analyzed:

- **Barriers** (question 9). During the analysis, we encountered inconsistencies in the interview forms: some interviewers have ticked barriers in the closed part if they were already mentioned in the open part, some not. This was harmonized where open answers could be unambiguously related to the closed part barrier categories by (1) coding the open part, (2) creating a query for potentially conflicting entries, (3) manual correction by ticking in the close part where appropriate, (4) removing the respective code so that the analysis of the open part does not interfere.

- **Knowledge maturing activities** (questions 12, 13 and 14). For activities, we have observed that we have a relatively low number of responses, which furthermore varied across the question commented so that a uniform analysis for all activities did not make sense. So basically we selected from the quantitative analysis those activities with a high variance or exceptionally low/high ratings (in the end, these were two activities). The comments for those activities were coded and interpreted in order to derive explanations for that rating.

- **New knowledge maturing activities** (question 12, 13, 14) were coded in interaction with a systematization of the activities and with the clear goal of formulating new activities.

- **Knowledge maturing indicators** (question 15). For those, comments for all indicators were coded with the goal of identifying contextual factors. A global and per-indicator analysis of the frequency of codes helped to spot interesting ones and was compared with histograms from the quantitative analysis.

- **New indicators** (question 16) were approached in a similar ways as new knowledge maturing activities: coding in interaction with a systematization that was based on project internal discussions in the course of the second year's knowledge maturing model development.

Furthermore, **knowledge maturing stories** were created from mainly the responses to 7-11 by the interviewers and collected in the Wiki, amalgamating the interviewee's narratives about their organisation with respect to knowledge maturing. These stories were the analysed and clustered.

4.3 Background Information

Background information was used to characterize the interviewed organization as well as the representative of the organization. The data on organizations was needed to clarify the organization's characteristics with respect to stratification criteria and also was used in order to check whether there were significant differences between different types of organizations with respect to knowledge maturing. The data on the representatives was needed to check whether they fulfilled our expectations with respect to position, experience and background, but also to check whether employees with different backgrounds also would differ in the perceived importance they would assign to knowledge maturing activities or indicators.

The *first question* asked for the current job position and how long the interviewee held it. As job positions and descriptions could be characterized as having a certain degree of ambiguity, it was decided to use a coding procedure for handling the information provided. Based on the answers provided for question 1, an initial coding was done by UIBK for all interviews. Two types of codes were introduced, "level of the job position" and "job area". "Level" is used for picturing on what level of the organizational structure the interviewee is (e.g., CEO or head of department). The "job area" relates to the field of work the interviewee is responsible for (e.g., HRM or knowledge management). This initial solution was consolidated and sent to the responsible interviewers. All codes were documented together with descriptions in the project wiki[8] which could be used as a reference. The list of codes used can be found in appendix 8.5.2.1. The feedback from the interviewers, which was collected by mail, or in case of any questions, via Skype or phone, was then integrated and consolidated. Based on the completed codes, all answers were recoded. Its goal was to improve the distinction between codes within job area and job position. 14 codes for job position and 32 codes for job area were finally used. For further evaluation, these codes were then reduced by assigning broader code areas to them. The mapping of codes to code areas is listed in appendix 8.5.2.1 in Table 35 and Table 36.

The code aggregations relate to the fields of work, which were deemed to be of interest in selecting the interviewees (see Table 7). A part of the code areas for job area relate back to the fields of work which were deemed to be of interest in selecting interviewees (see section 3.6.3). Most of the interviewees (36, 28.6%) were operating in human resources, e.g., personnel development. The area 'business' was used as a general classification for interviewees working in fields like CRM or controlling and was used 26 times (20.6%). 18 (14.3%) Interviewees had their job area within information systems and technology. The area 'organisation', e.g., organizational development, was assigned 15 times (11.9%). Interviewees dealing with research (& development) made for 13 (10.3%) of the interviews. The area 'knowledge management' was assigned to 9 interviewees (7.1%). One (0.8%) interviewee was directly responsible for innovation in his company. Finally, 'not specified' was used 8 times (6.3%) for cases where no details were available.

job area	# interviews
human resources	36
business	26
information systems/technology	18
organisation	15
research	13
knowledge management	9
innovation	1
not specified	8
Sum	**126**

Table 7: Aggregated job areas of interviewees

Aggregations for levels of job positions (see Table 8) were created with respect to the supposed rank or level of the interviewee within the organisational hierarchy. Department heads (e.g., head of HRM) were

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[8] http://mature-ip.eu/index.php/Representative_Study_Evaluation

mapped to 'head'. With 61 mappings, this code area represents nearly half of all interviewees (48.4%). Top-level positions such as chief information officer were assigned to the area 'executive' which was mapped to 22 interviewees (17.5%). 'Employee' was used for interviewees who did not supervise other employees in 22 (17.5%) cases. All interviewees who were mainly responsible for projects related to the areas of interest were mapped to the area 'project manager' which accounts for 11 (8.7%) of the interviewees. 'Responsible' was used 10 times (7.9%), when it could not be determined, whether the interviewee was in a management position or just being responsible for this specific topic.

job position	# interviews
head	61
executive	22
employee	22
project.manager	11
responsible	10
Sum	**126**

Table 8: Aggregated levels of interviewees' job positions

From the 126 interviews used, 125 interviewees provided an answer for how long they had been in their current position. The average duration of the interviewee's position is 4.80 years. The Median is three years, whereas the standard deviation is 4.63.

Data on the amount of background experience in the respective field of work (*question 2*) was provided by 124 interviewees. On average, the interviewees had experience in their field of work for 12.13 years. The median for this question is 10 years. With 7.88, there was a high standard deviation.

Question 3, time of the interviewees with their current organization was answered 125 times. On average, they were 7.92 years with the organization they spoke for. The median is 6 years, whereas the standard deviation lies at 6.58.

Question 4 defined what part of the organization was focus of the interview. This question was necessary in order to make sure that especially in large, multi-national organizations interviewees certainly could not be expected to have a good overview of knowledge maturing in the entire company, but only in that part they were responsible for or the part they were comfortable to speak for. To get a consolidated overview (see Table 9), the answers were aggregated. 72 (57.1%) interviews related to the whole organization. A specific subsidiary, e.g., a national branch of an international company, was focus of 27 (21.4%) interviews. A department was focused in 18 (14.3%) interviews. A plant was named in 6 (4.8%) of the cases, typically within the industry sector. With 3 (2.4%) interviews, the smallest number of interviews was conducted relating to a division.

focused parts	# interviews
whole organisation	72
subsidiary	27
department	18
plant	6
division	3
Sum	**126**

Table 9: Represented parts of the organisation

Question 5 targeted the sector in which the organization of the interviewee operated. This was answered for the whole organization on the one hand (see Figure 8) and, if fitting, for the represented part of the organization on the other hand. 42 (33.3%) of the organizations were situated in the industry sector. With 76 (60.3%), the majority of the organizations were in the service sector and 8 (6.4%) organisations could

not be assigned to a specific sector. A large number of organizations (18) were within one specific area (62 - Computer programming, consultancy and related activities) which related back to the purposeful sample. Apart from these exceptions, a large coverage of the different sectors was achieved. A list of sectors and their coverage is available in appendix 8.5.2.2 in Table 37 through Table 39.

organisations by sector

industry 33,33%
na 6,35%
service 60,32%
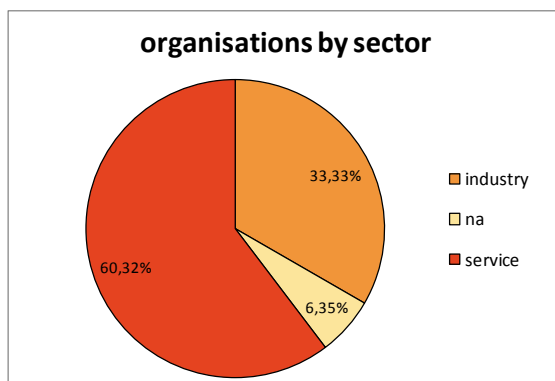
Figure 8: Organisations by sector

Question 6 asked for the number of employees of the whole organization (Table 10) and of the part that is represented (Table 11). As the size of the whole organization was used for determining to which strata an interview is mapped, it is possible, that the represented part of an organization had fewer than 50 employees. This was true for 11 (8.7%) of the interviews. The sample consists of 41 (32.5%) medium-sized and 85 (67.5%) large organizations and almost half of the organizations had 1,000 or more employees (62; i.e. 49.2%).

# employees	# interviews
50-99	24
100-249	17
250-499	13
500-999	10
1000-4999	23
5000 or more	39
sum	**126**

Table 10: Organisation size – whole organisation

The part of the organization that was represented by the interviewees was substantially smaller, but still 12 interviewees (9.5%) felt comfortable to speak for an organization or organizational unit with 5,000 or more employees.

# employees	# interviews
1-49	11
50-99	28
100-249	23
250-499	16
500-999	14
1000-4999	22
5000 or more	12
sum	126

Table 11: Organisation size - represented part

Summing up, the sample is characterized by a broad spectrum of organizations with respect to size, sector and knowledge intensity, with those exceptions that we deliberately addressed because we intended to purposefully included organisations for which we assumed that they could provide important insights because they assumedly had substantial experience reflecting the handling of knowledge. The organisations were represented by interviewees most of whom worked in the intended job areas and levels of hierarchy and all of whom were comfortable to answer the questions about the entire organisation or an organisational unit of their choice.

4.4 Knowledge Maturing Phases

Part II of the Study focused on various concepts in relation to the knowledge maturing model. The first aspect was to survey software used in the respective phases.

4.4.1 Used Software

As types on the one hand and specific products on the other hand vary, it was necessary to create an aggregation in order to increase comparability of all the specific entries. For all interviews, an initial coding was done by UIBK. Within this coding, the software products named were generalised in order to describe them in a vendor-independent way. Each software recognized was mapped to one code. For this approach, an additional spreadsheet was inserted into the interviewer forms. The codes were documented, together with examples and a description, within the project wiki[9].

Although, it was generally aimed at maintaining as much context as possible, greater generalisations had to be done for two specific codes: all answers related to portal solutions were coded as 'intranet.generic'. This was particularly necessary, as is in the nature of portals to abstract from underlying source systems, so that interviewees would not be able to name all relevant systems in detail. Similarly, all Web Services and web-based services which may have been named were aggregated within the code 'internet.generic'. Furthermore, codes were chosen to provide as much detail as possible with regard to the information that was provided by the respective interviewee. This leads to codes that may be a subset of other codes: If the answer "MS Office" was provided, this would result in the code "office.generic". If the answer "MS Word" was provided, this would result in the code "office.word_processing". As MS Word is part of the MS Office suite, the code "office.generic" would also be true. This approach leads to a constellation of codes, were more specified codes could also be counted towards "*.generic" codes. However, as we only could code the basic existence of a type of software, it is not possible to simply add one more specified codes to more generic ones.

After the initial coding, the proposals, consisting of the original text and the code assigned, were sent to the respective interviewers. The proposal consisted of two parts: a list of codes which were deemed OK, and a list of codes which were deemed questionable. Especially for the latter part, the codes were coordinated with the respective interviewer either by e-mail, phone or screen sharing. The feedback was then integrated. Based on this feedback, a first recoding was done in order to streamline the naming of codes.

Table 12 provides an overview of the codes used overall and per knowledge maturing phase. Codes are ordered by overall number. Within columns relating to phases, the numbers outside the brackets represent the number of code occurrences within the phase, whereas the numbers in brackets represent the rank of the code within the phase.

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[9] http://wiki.mature-ip.eu/index.php/Representative_Study_Evaluation#list_of_codes_.28question_8:_software.29

Code	# total	Ia expressing ideas	Ib appropriating ideas	II distribution in communities	III formalisation	IV ad hoc training	V standardisation	Unrelated to phases
intranet.generic	198	28 (2)	25 (3)	37 (2)	27 (3)	28 (1)	45 (1)	3 (1)
PIM.mail	177	28 (2)	29 (1)	48 (1)	19 (4)	14 (5)	19 (4)	0 (-)
office.generic	173	37 (1)	29 (1)	15 (4)	37 (1)	28 (1)	24 (2)	0 (-)
office.word_processing	107	10 (7)	10 (5)	17 (3)	28 (2)	13 (6)	24 (2)	0 (-)
internet.generic	83	18 (4)	23 (4)	3 (19)	4 (17)	2 (22)	5 (17)	1 (4)
office.presentation	82	9 (8)	8 (8)	13 (6)	16 (5)	22 (3)	13 (6)	0 (-)
intranet.wcms.wiki	69	11 (5)	10 (5)	13 (6)	10 (10)	8 (9)	8 (11)	1 (4)
Filebrowser	67	8 (10)	9 (7)	10 (9)	13 (6)	9 (8)	15 (5)	1 (4)
collaboration_tool.instantmessenger	63	5 (12)	3 (16)	9 (12)	1 (28)	2 (22)	2 (23)	1 (4)
office.spreadsheet	57	11 (5)	9 (7)	10 (9)	11 (8)	8 (9)	8 (11)	0 (-)
PIM.generic	57	8 (10)	7 (9)	13 (6)	5 (13)	6 (12)	6 (15)	0 (-)
project_management_tool.generic	53	6 (11)	5 (10)	1 (29)	13 (6)	10 (7)	13 (6)	0 (-)
intranet.social_software	46	9 (8)	4 (12)	15 (4)	4 (17)	4 (14)	6 (15)	0 (-)
DMS.generic	41	4 (14)	3 (16)	3 (19)	11 (8)	6 (12)	10 (10)	3 (1)
custom.generic	39	4 (14)	5 (10)	5 (15)	5 (13)	7 (11)	11 (9)	2 (3)
elearning_tool	32	2 (20)	2 (22)	3 (19)	2 (21)	15 (4)	7 (13)	1 (4)
collaboration_tool.conferencing.desktop	30	2 (20)	2 (22)	10 (9)	1 (28)	3 (18)	1 (31)	0 (-)
ERP.generic	27	3 (18)	3 (16)	5 (15)	5 (13)	4 (14)	7 (13)	0 (-)
intranet.wcms	27	3 (18)	4 (12)	6 (14)	5 (13)	2 (22)	3 (21)	0 (-)
desktoppublishing.pdf	25	0 (-)	1 (29)	2 (23)	4 (17)	4 (14)	13 (6)	0 (-)
modeling_tool.design_and_engineering	23	2 (20)	4 (12)	1 (29)	8 (11)	3 (18)	5 (17)	0 (-)
modeling_tool.enterprise	22	2 (20)	2 (22)	1 (29)	6 (12)	3 (18)	5 (17)	1 (4)
modeling_tool.mind_maps	21	4 (14)	1 (29)	2 (23)	0 (-)	0 (-)	0 (-)	0 (-)
modeling_tool.generic	18	1 (28)	1 (29)	0 (-)	4 (17)	0 (-)	5 (17)	1 (4)
informally.not_existent	18	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)
internet.social_software	16	1 (28)	2 (22)	2 (23)	0 (-)	0 (-)	1 (31)	0 (-)
collaboration_tool.conferencing.video	14	1 (28)	0 (-)	8 (13)	2 (21)	3 (18)	0 (-)	0 (-)
ERP.finance	13	4 (14)	4 (12)	1 (29)	1 (28)	0 (-)	2 (23)	1 (4)
suggestion_system.generic	13	5 (12)	3 (16)	2 (23)	2 (21)	0 (-)	0 (-)	1 (4)

Table 12: Types of software

Three types of software were used the most by far on a general basis: Intranet based services (intranet.generic), mail programs (PIM.mail) and office software (office.generic). These types are highly ranked (within the top 5) in each phase (a detailed description of codes is provided in appendix 8.5.3.1). However, depending on the phase, some types of software are more used than others. For example, project management tools (code project_management_tool.generic) got named more often within phases IV and V than in the preceding phases. Wikis also are under the most named software types and are especially during the early phases (Ia to II) ranked 5, respectively 6. The software type 'filebrowser' which stands for all clients which may access files stored locally or on network drives is also ranked

within the top 10 and seems to become more important in the later phases of the KMM. Interestingly, tools designed for idea management (modelling_tool.mind_maps) are named comparably more seldom (rank 14 in phase Ia).

To summarize, for knowledge maturing, intranet-based, as well as intranet-based software and services play an important role. This is also true for office applications (i.e. generic, word processing, presentation, and spreadsheet) and personal information management software.

4.4.2 Fostering of Phases

Question 8 – fostering: In the following, the opinion of all 126 respondents to the statement "My organisation encourages this phase and is open to quickly take up its results" are analysed. Figure 9 provides an overview of mean values calculated for each strata (missing values were excluded pairwise, numeric mean values calculated to create this figure can be found in table 41, see appendix).
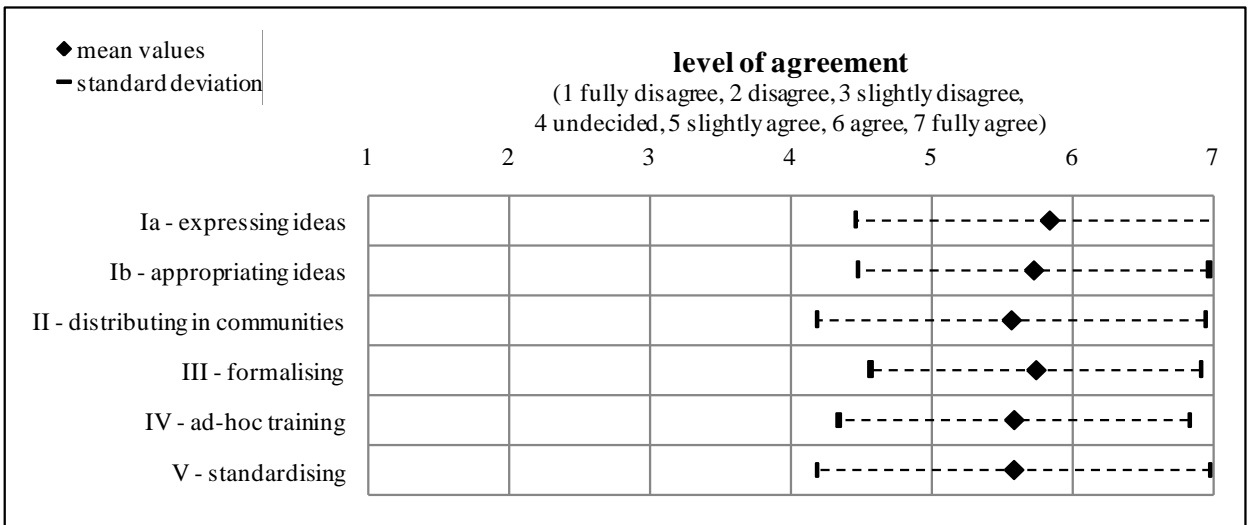
Figure 9: Fostering phases of KMM

The mean lies between 5.6 (ad-hoc training and standardising) and 5.84 (expressing ideas). The standard deviation ranges between 1.177 and 1.384. See also boxplots depicted in Figure 71 in appendix 8.5.3.2. The Friedman test was chosen for evaluating, whether fostering was different between KM phases. With p=0.044, it is assumed, that the phases of KM are considered different with regard to the level of fostering.

Figure 10 to Figure 12 show question 8 in relation to the stratification criteria.
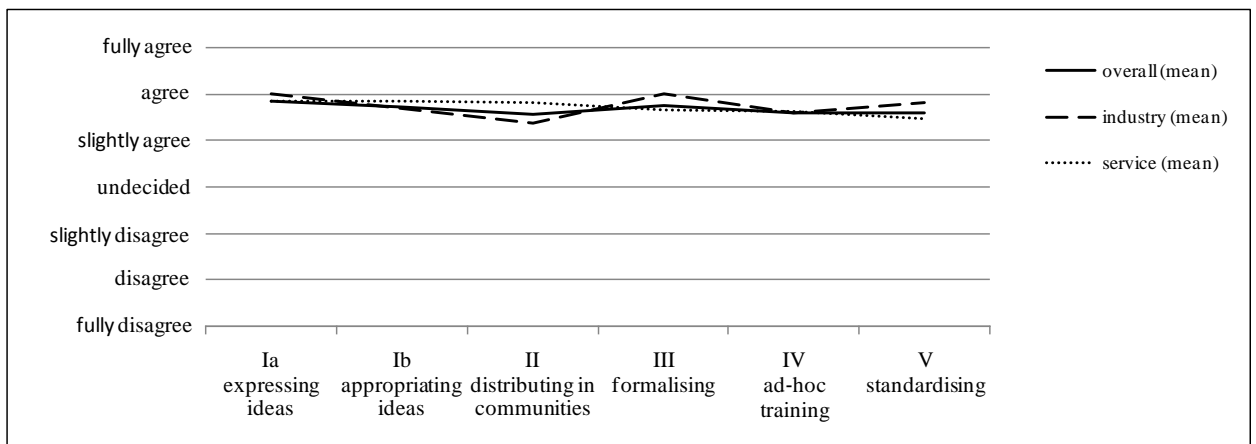
Figure 10: Fostering of phases of KMM by sector
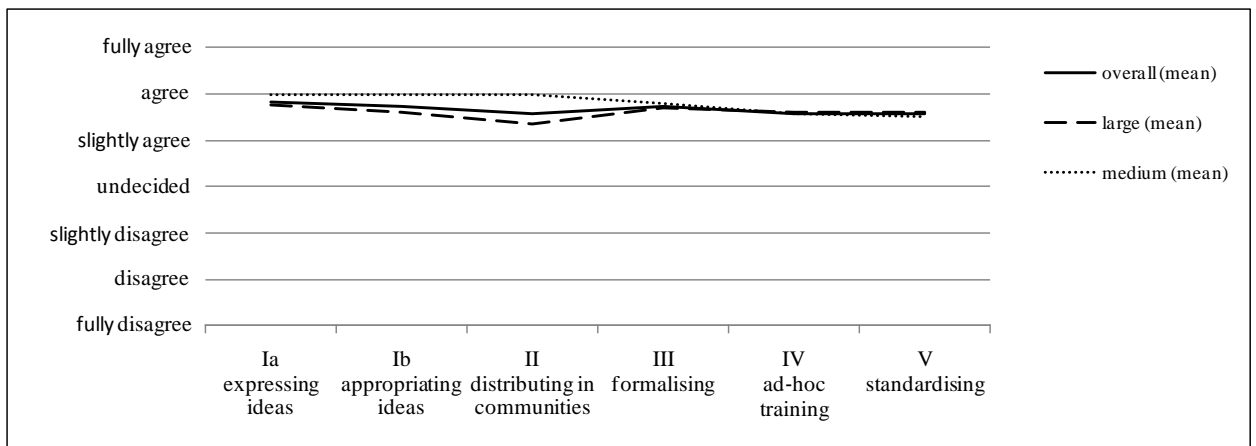
Figure 11: Fostering of phases of KMM by size
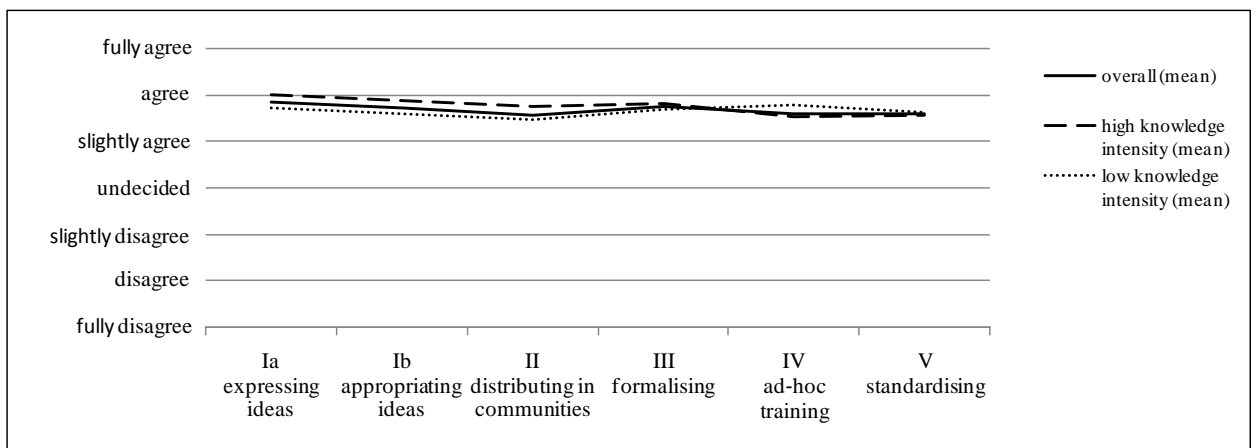
Figure 12: Fostering of phases of KMM by knowledge intensity

For testing, if differences between each strata were significant, Kolmogorov-Smirnov-test was chosen. As figures are indicating, in the three tests executed, no significant[10] result was achieved. Therefore, no differences of fostering of KM phases with regard to size, sector and knowledge intensity are assumed (for test results, see Table 44 to Table 46). This leads to the conclusion, that the fostering of the specific KM phases is not different between companies of different size, sector or knowledge-intensity.

4.4.3 Barriers

Table 13 gives a short overview of the distribution of the different barriers.

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[10] The following levels of significance were used for all tests in this document: p<=0.05 significant; p<=0.01 very significant; p<=0.001 highly significant.

	Ia expressing ideas	Ib appropria-ting ideas	II distribu-ting in communi-ties	III formalising	IV ad-hoc training	V standardi-sing
lack of time	64	64	60	58	49	44
fear of loss of power	16	11	21	14	10	12
lack of usability	17	15	25	27	19	19
fear of disgrace	15	2	9	4	3	2
low awareness of the value and benefit	32	33	25	24	21	22
no interest	21	15	16	12	11	13
Sum	**165 (20.0%)**	**140 (17.0%)**	**156 (18.9%)**	**139 (16.8%)**	**113 (13.7%)**	**112 (13.6%)**

Table 13: Barriers and phases of KMM

Also we got comments about barriers, which could not be assigned to a specific phase. Due to methodological reasons, they are excluded from further statistical analysis but mentioned for completeness: lack of time = 16; fear of loss of power = 13; lack of usability = 7; fear of disgrace = 8; low awareness of value and benefit 13; no interest = 18. This makes a sum of 75 mentioned barriers not assigned to a specific phase.

The most frequently mentioned barrier was lack of time with 339 out of 825 phase-related codes (or 355 mentions out of 900 codes including non-phase related codes.

Using the Kolmogorov-Smirnov test for the barriers and phases, we made quite interesting findings. In both cases we tested for uniformity, to see if a barrier or phase is distributed statistically significant different.

The barrier "fear of disgrace" was not statistically significant with $K\text{-}S\text{-}Z = 1.26$, exact sig. (2-tailed) $p = .06$. As Figure 13 shows, this barrier is very important in the beginning of the knowledge maturing process. This could lead to the assumption, that we need to focus attention to persons in the phase of expressing ideas and when we distribute them in the communities. Giving them opportunities in the beginning for the maturing process is highly relevant.

All other barriers were also not significant with ranges between $K\text{-}S\text{-}Z = .41$ and $.90$, exact sig. (2-tailed) $p = .32$ and $.99$. Table 14 summarizes the results for the barriers.

	Lack of time	Fear of loss of power	Lack of usability	Fear of disgrace	Low awareness of value and benefit	No interest
N	6	6	6	6	6	6
Kolmogorov-Smirnov Z	.90	.78	.41	1.26	.82	.82
Exact sig. (2-tailed)	.32	.48	.99	.06	.67	.42

Table 14: Results of the Kolmogorov-Smirnov Z for the barriers
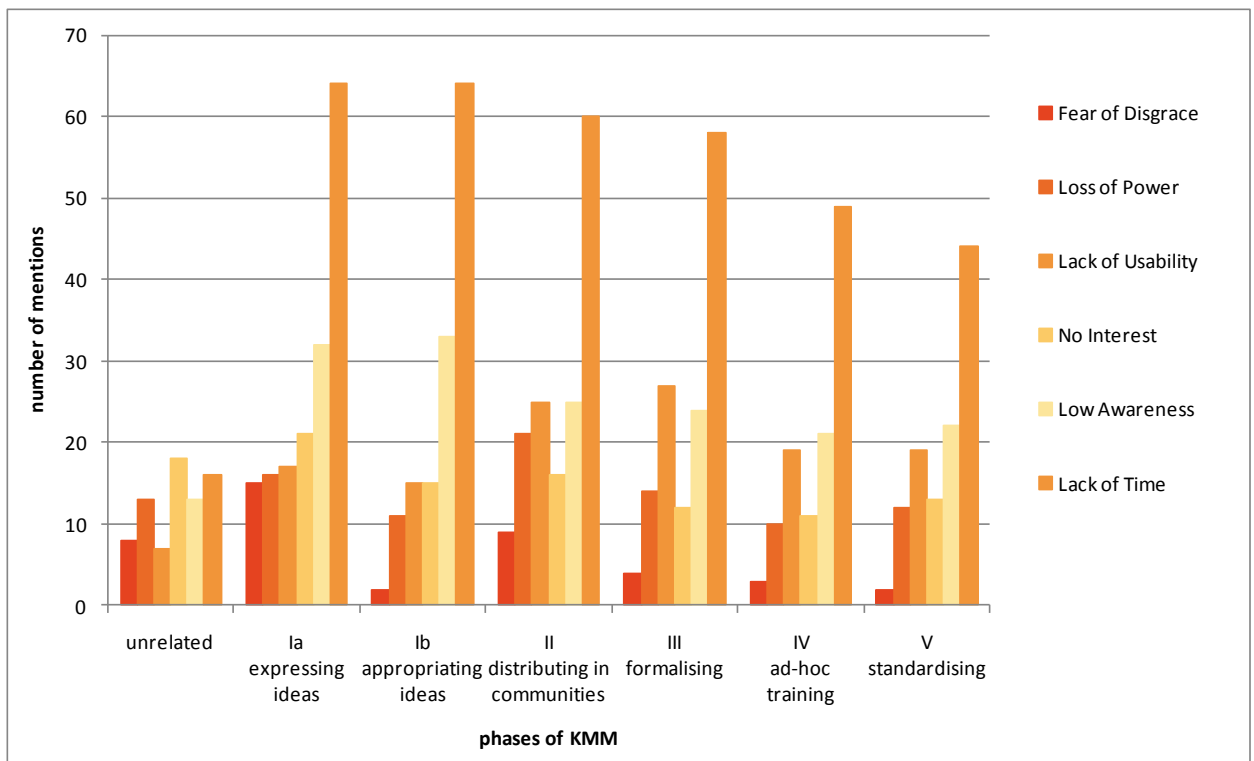
Figure 13: Barriers and phases of KMM

Not surprisingly as Figure 10 already depicts, the Kolmogorov-Smirnov test for the phases led to a statistically significant value for the first phase (expressing ideas) with K-S-Z = 1.33, exact sig. (2-tailed) p= .03, when we were testing for uniform distribution among the phases. Additionally, phase II (distribution in communities) with K-S-Z = 1.27, exact sig. (2-tailed) p= .05, was statically significant with a strong focus at fear of loss of power, accompanied by lack of time and low awareness.

As already shown in Table 13 the barriers "low awareness of value and benefit", "fear of disgrace" and "no interest" scored very high, with "fear of disgrace" already explained by the quantitative analysis of the barriers. These three barriers seem to influence the first phase very strongly. This also makes it clear, that at the very beginning all different types of barriers can occur and become important, if we assume that "no interest" is a motivational barrier, "low awareness of value and benefit" is a cognitive barrier and "fear of disgrace" is a social barrier. Table 14 summarizes the results for the phases.

	Ia expressing ideas	Ib appropria-ting ideas	II distributing in communities	III formali-sing	IV ad-hoc training	V standardi-sing
N	6	6	6	6	6	6
Kolmogorov-Smirnov Z	1.33	1.12	1.27	1.00	1.08	.88
Exact sig. (2-tailed)	.03	.12	.05	.21	.14	.34

Table 15: Results of the Kolmogorov-Smirnov Z for the phases

As well as the verification of the quantitative frequency of these six selected barriers from scientific research, the aim of the qualitative analysis was to, firstly, gain a better insight into the real world situation of these barriers and, secondly, to examine them in more detail. In addition, we wanted to verify whether there were any additional barriers that might affect the knowledge maturing phases. Indeed, we

received plenty of comments from the interviews (resulting in a total of 473 code assigments out of 473 comments) and after three iterations of coding the open comments, the following 35 different categories were used, see Table 16.

Codes	Count	Description
organisational culture	91	Organisational culture refers to patterns of shared basic assumptions and beliefs. These factors can be not been easily or quickly changed. Examples: how work is undertaken, hierarchies, bureaucracy, professional culture (white/blue collar)
lack of resources	74	lack of personnel, material, financial resources etc.
personal interdependency	51	depends on the individual
organisational structure	24	the structure of the organization, e.g., many subsidiaries, geographically distributed, reporting structures, lines of communication etc.
lack of formalization	22	no or limited formalization or standardisation of, for example, processes, documents, procedures etc.
no interest	20	closed question: no interest about participating in the KM process
lack of time	18	closed question: all aspects related to available time
fear of change	15	fear of or resistance to change
organisational environment	14	factors external to organisation, such as legal or policy context in which it is operating, that at not controlled by organisation
low awareness of the value and benefit	13	closed question: aspects where employee do not see why it is important or useful
collaboration	13	barriers to collaborative working or team working
fear of loss of power	13	closed question: individuals or teams do not share, contribute etc. because they fear losing their power (or not being able to increase it)
Workload	11	heavy workload that limits freedom; could be lack of time, but not unambiguously, or lack of support
no interest of the management	8	lack of support from the management because they do not value it, or prioritise other things as more important
fear of disgrace	8	closed question: fear of being blamed
organization - employee autonomy	8	barrier related to the degree of autonomy the employee has (either limited or too much) to, for example, manage or control their work
lack of usability	7	closed question: problems related to the ease of use and appropriateness of software tools that are in place to support the employees or the organization
leadership	7	barriers related to the leadership style of managers or individual practices
lack of incentives	6	no explicit incentives for the individual or the team
organisation size	6	problems related to size of organization (too small, too big)
lack of acceptance	5	tools, documents, process definitions are not accepted, used or implemented by employees (ignored, opposed)
external context	4	Problems related to contextual factors outside of the organisation (regulations, market conditions etc.)
organisation-external	4	collaboration with external individuals or organisations (e.g., limited because of security considerations)

collaboration		
interpersonal conflicts	3	conflicts between individuals
globalisation	2	problems related to the globalisation of the economy or the company
improvement priority	2	organisation values and emphasises the improvement of product, processes or customer relations
lack of guidance	2	more guidance from the organisation, superiors, or experts is expected and/or needed
project stress	2	stressful situations because of project work, timescales, budgets or deadlines
staff turnover	1	problems related to frequent change of position of employees or employees leaving organisation
unit interdependency	1	depends on individual units (departments) of a company, not to be generalizable
organisational goal	1	related to the organisational aims and/or objectives
usage interdependency	1	depends on the usage of artefacts etc.
work processes	1	related to the specific work processes or procedures
Total	**458**	

Table 16: Barriers – codes/categories from the open comments

The most prominent barrier to knowledge maturing has been found to be **organizational culture**. With almost 20% of comments, this code outnumbered many of the other 34 codes. Besides the general definition of organizational culture by Schein (2003) that organizational culture refers to patterns of shared basic assumptions and beliefs, we define also organizational culture as something that cannot be changed in a short period like e.g. the structure of the management or a so called "hierarchy culture" within e.g. a project leader and his team.

By examining the comments on organizational culture further, four interesting topics emerged, including:

- lack of individual autonomy
- lack of formalization and guidance (that can be considered as the opposite of lack of individual autonomy)
- lack of collaboration
- personal interdependencies.

These four topics have been categorised into the respective code when they were clearly related to this, but also left partly to the more general "organisational culture" code. Some example comments from the interviews: *"People and culture"*; *"Not enough discussion between different organizational levels"*; *"Too much bureaucracy but also too many degrees of freedom"*; *"department coordination, lack of completeness in the information provided"*; *"Background of employed persons, their character, culture in the company and the whole structure of the organisation itself can be a barrier!"*; *"inter-divisional communication: is not supported enough"*.

Also for organizational culture aspects, on the one hand, the interviewees stated that they often missed the possibility to **feel autonomy** and that bureaucracy can hinder participation in knowledge maturing. This can be seen in the following interviewee-comments: *"management structure can be restrictive"* and *"too bureaucratic"*.

On the other hand, the **lack of formalization** or standardisation of processes, especially when the organisation changes too fast or communication is not guided and encouraged by a dedicated person, is also a salient problem. If this happens, like we have seen in the comments *"Organisation changes fast, lots of changes as time goes by."* or *"This is sometimes not guided enough. I think that it is important that*

someone controls the communication and pushes it, and that this is too little in some areas.", then we truly observes a barrier for knowledge maturing.

For sure, **missing collaboration** and **personal interdependencies** are accompanied together. Missing or not enough discussions can seriously block knowledge maturing as well as misplaced employees with missing specific skills and expertise for their work. Example comments: *"lack of communication and "selling" skills of employees."* or *"no possibility for communication, culture."*

The **"lack of resources"** is the second most coded barrier to knowledge maturing and included comments around lack of (appropriate) staff, lack of resources and also lack of finances. In one interview, it was noted that the company delays salary payments to employees, which serves to demotivate employees. For a knowledge maturing atmosphere to be cultivated, employees at all levels of the organization need to be motivated and engaged in the process. Further example comments: *"lack of IT support"*; *"Lack of money and resources"*; *"Responsible's are not always willing to let personnel be trained."*

Actually we can map the motivational model from D1.1 (Figure 14) quite well to the codes from the open comments:

Figure 14: Determinants of motivation to engage in knowledge maturing activities

- At the individual level, we have, for example, the codes **"personal interdependency"** and **lack of** "**individual autonomy**". Where the former maps more to the capability factor, the latter describes more the interests and needs of the individual. In contrast, a code such as **"fear of change"** maps to the capability factor, as well as to the needs of a person, that can be reflected in the following comment *"in some cases there might be a fear of new things."*

- The interpersonal context can be mapped to codes like **"collaboration"** or **"interpersonal conflicts"**. Collaboration can be seen as a cooperative factor, which is usually viewed from a more rational point of view. Interpersonal conflicts, on the other hand, can include affective factors that are a potential danger to the quality of work relationships. In terms of knowledge maturing this means that we need to take care about comments like e.g. *"personal jealousy"* or *"lack of information flow"* and therefore try to support transparency where it is necessary, but also respect and maintain privacy.

- Finally, the work context aspect is something we got plenty of comments about. The organisational factor with the code **"organisational culture"** can be described with an interviewee-comment like e.g. *"too much bureaucracy"*. The code **"lack of resources"** is also important, which is a very prominent code at second position of the most applied categories with

comments like e.g. *"Costs and profitability"* or *"Human and technological resources limitations"*. Comments were also received on enabling factors, but rather from the negative point of view, such as when the organisational structure does not support knowledge maturing because of a geographical dispersed organisation, which hinders effective knowledge maturing activities. If a company commits itself to knowledge maturing processes, then it needs to provide enough resources, such as adequate financial backing or adequate staffing.

Of course, as already stated in D1.1, we cannot really separate these factors. Collaboration may be improved within one department, but geographically distant subsidiaries can still be problematic for communication flows. Giving an employee more autonomy for their work might also be ineffective, if it is not perceived as this because there are no changes e.g. at the underlying processes within the organisation.

To summarise, a variety of categories that can seriously hinder knowledge maturing activities of the individual and the organisation were found. We need to keep these aspects in mind and use them as a checklist when approaching application partners. Every organisation might need its own solution to successfully foster knowledge maturing. An analysis of possible barriers has brought up evidence that context is important to consider first and the often mentioned categories give some clues where to look. The initial collected issues of year 1 in D1.1 like e.g. "need for experiencing autonomy", "culture", "fear of change", "collaboration support", "workload", "lack of resources" and "no interest of the management" were reflected in our interviews and support our findings.

MATURE can provide solutions to categories like e.g. "individual autonomy" and "collaboration" by developing tools that support these categories. Obviously, a category like "lack of resources" is out of scope for MATURE, as the staffing has to be done by the organisation itself. Instead the category "personal interdependencies" should be taken into account and therefore the assessment of individuals is important to provide individual knowledge maturing tools. Also, there is a need for more general mechanisms to cope with the many different barriers at the same time, instead of tackling very specific barriers and so maybe missing the "big picture".

4.4.4 Success of Phases and Overall Success

Question 10 – successful performance: In the following, the opinion of all 126 respondents on the statement "I think that this phase is performed successfully within my organisation" was analysed. Figure 15 provides an overview of mean values calculated for each strata (missing values were excluded pairwise, numeric mean values calculated to create this figure can be found in table 47, see appendix).

The Friedman test was chosen to evaluate, whether there was a difference in the perceived success with regard to the different KM phases. With $p=0.123$, it is assumed, that there are no statistically significant differences between the phases of the KMM.
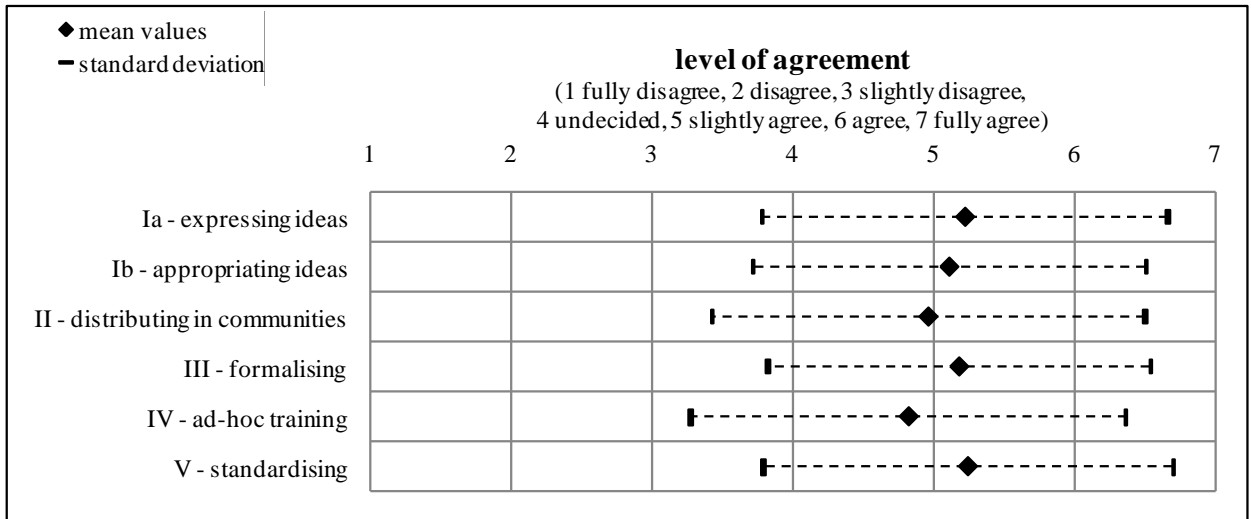
Figure 15: Successful performance of phases of KMM

Figure 16 to Figure 18 show answers of question 10 with regard to the stratification criteria.
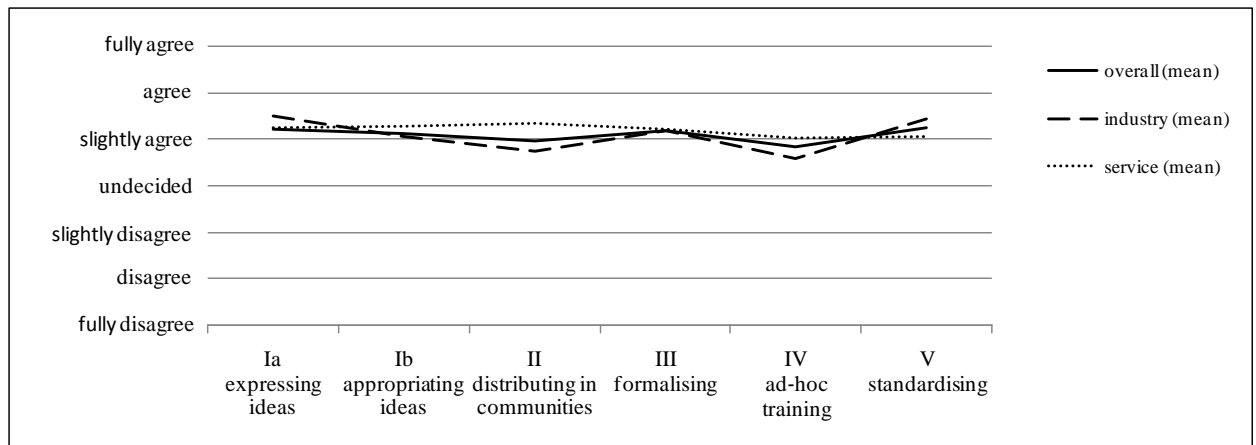
Figure 16: Perceived success of phases of KMM by sector

For testing, if differences between each strata were significant, Kolmogorov-Smirnov-test was chosen. For the stratification criterion size (see Figure 16 above and Table 50 in appendix 8.5.3.2), phase II (distribution in communities) scored a significant result with $p=.048$. The Mean value in the industry sector is with 4.74 smaller than the value of 5.34 in the service sector.
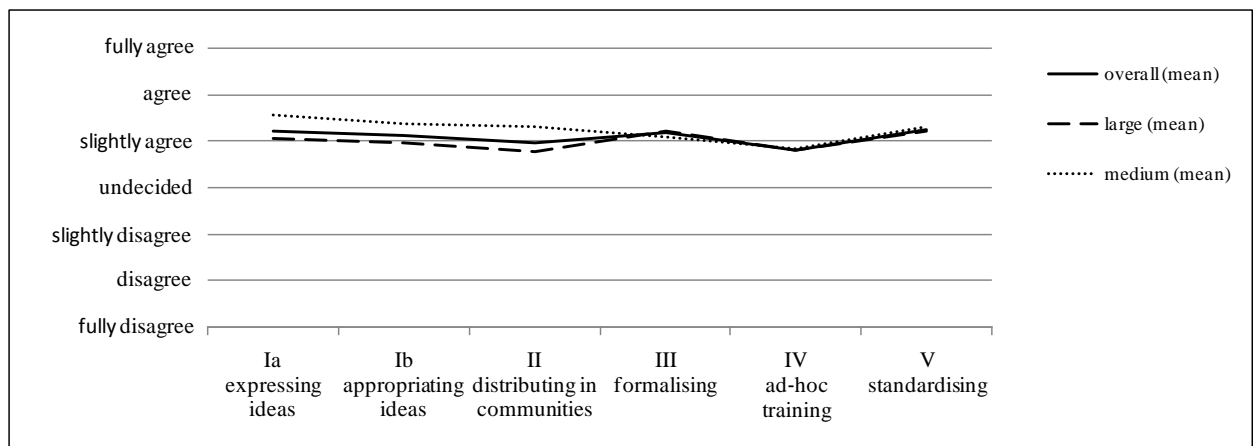
Figure 17: Perceived success of phases of KMM by size

This phase is also significantly different when choosing sector as stratification criterion. With p=.013, there is also a statistically significant difference in the perception of success of phase II (see Figure 17 above and Table 51 in appendix 8.5.3.2). Medium-sized organisations considered this phase more successful (mean 5.36) then large organisations (mean 4.79). This may partially be due to the fact, that communication in larger organisations is typically more formal and regulated than in medium-sized organisations.
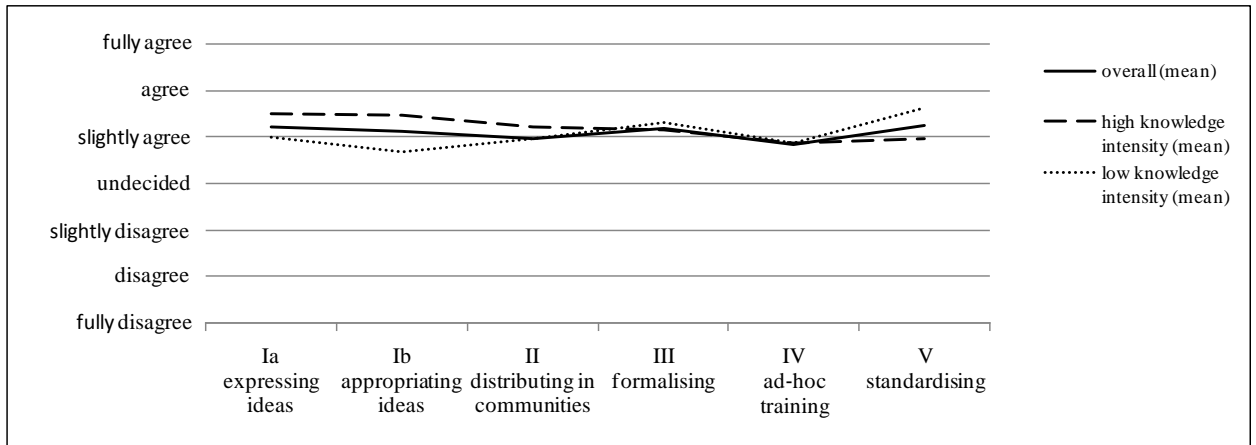
Figure 18: Perceived success of phases of KMM by knowledge/technology-intensity

In contrary, the only phase achieving a statistically significant result when focusing on knowledge/technology-intensity is phase Ib (appropriating ideas) with p=.024 (see Figure 18 above and Table 52 in appendix 8.5.3.2). Organisations deemed to be highly knowledge/technology-intensive perceive their success of this phase higher (mean 5.47) than organisations deemed to be less knowledge/technology-intensive (mean 4.69).

11. If you have agreed or fully agreed to the phases in question 10: Please could you explain why you think these phases are performed successfully in your organisation.

Responses to this question have mainly contributed to the narratives and could only be interpreted by taking a more holistic perspective. Thus, the responses were analysed as part of the knowledge maturing stories (see section 4.8).

Question 17 – overall successful performance: At the end of the interview, all participants were asked to reflect again on knowledge maturing and to assess its performance in their organizations. The statement they were asked about is: "I think that my organisation is successful in supporting knowledge maturing." In the following, the deemed overall successful performance of respondents is evaluated. The mean of this question lies at 5.34 with a standard deviation of 1.14.
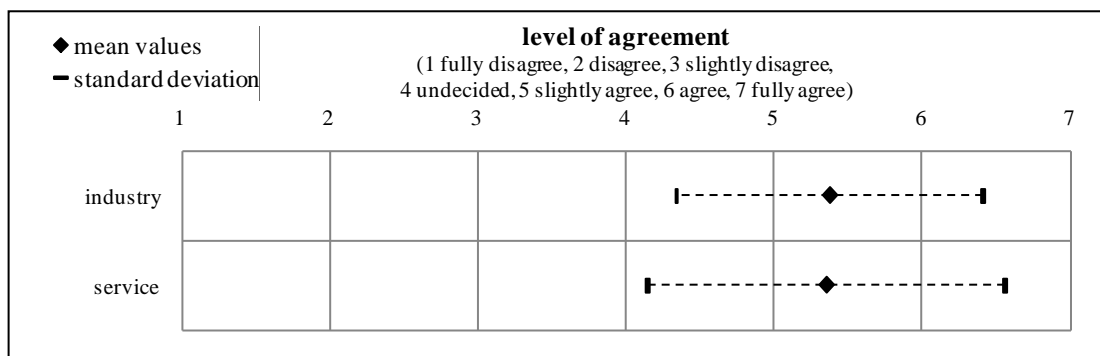
Figure 19: Perceived success by sector

As shown in Figure 19 suggests, there is no significant difference in the perception of success of knowledge maturing. The Kolmogorov-Smirnov test proves this assumption (p=.635, see Table 58 in appendix 8.5.3.5).
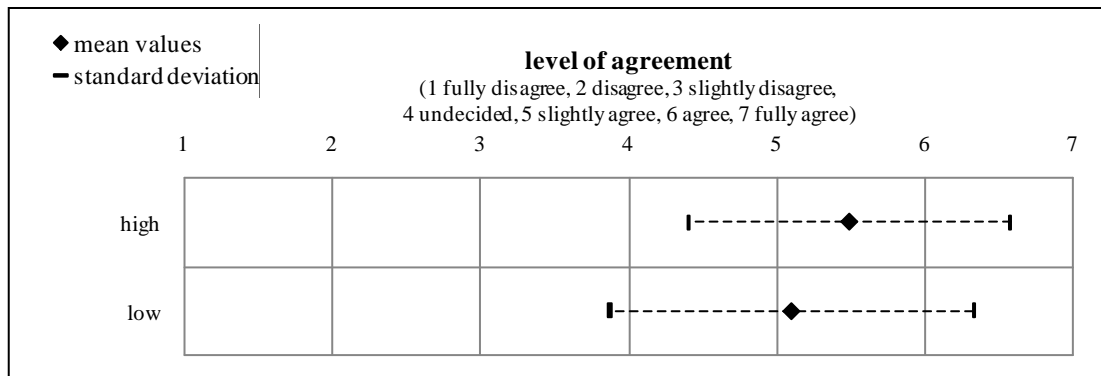
Figure 20: Perceived success by knowledge-intensity

Although the Figure 20 suggests, there seems to be no statistically significant difference between knowledge/technology-intensive and non-intensive organisations. The Kolmogorov-Smirnov test resulted in p=.208 (see Table 56 in appendix 8.5.3.5).
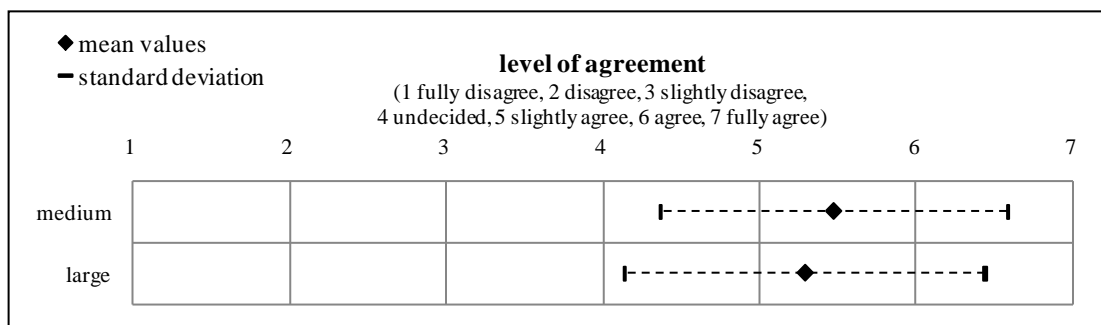
Figure 21: Perceived success by size

The Kolmogorov-Smirnov test for the perceived success resulted in no significant difference between medium and large organisations (p=.798, see Table 57 in appendix 8.5.3.5).

Summarizing for question 17, the perceived overall success of knowledge maturing, it can be stated, that there exist no statistically relevant differences with respect to our three stratification criteria size, sector and knowledge/technology-intensity.

18. *If you have agreed or fully agreed to question 17: Please could you explain why you think that your organisation is successful in supporting knowledge maturing?*

Responses to this question have mainly contributed to the narratives and could only be interpreted by taking a more holistic perspective. Thus, the responses were analysed as part of the knowledge maturing stories (see section 4.8).

4.5 Knowledge Maturing Activities

In the representative study, KM activities were investigated in three steps. The interviewees were asked to reflect (see section 3.3.4) with respect to how important they think that the KM activities were for increasing knowledge maturity (question 12), support of the KM activities in their organizations (question 13) and their perceptions on how successfully they perform these KM activities (question 14) in their organisation (section 4.5.1, see also interview guideline in the appendix, section 8.2). This detailed

information is then further analysed in section 4.5.2 that maps importance, support and success of KM activities to portfolios, section 4.5.3 that analyses these mappings statistically and section 4.5.4 which highlights some interesting facets of individual activities. Additionally, the respondents were asked to provide further KM activities performed in their organisation. These additionally mentioned KM activities are evaluated in section 4.5.5.

4.5.1 Importance, Support and Success of KM Activities

Perceived importance (question 12): A median of six on a seven-point Likert scale means that at least 50% of respondents agreed or fully agreed that all of the twelve KM activities are important for increasing KM in their organisation (see the boxplots in figure 74 in the appendix, section 8.5.4.2),. The agreement to the importance of KM activities *"find relevant digital resources"*, *"reflect on and refine work practices or processes"*, *"find people with particular knowledge or expertise"* and *"communicate with people"* was even higher as at least 50% of the respondents fully agreed. The KM activity with the highest standard deviation (2.150) is *"restrict access and protect digital resources"* (see table 60 in the appendix, section 8.5.4.1). One reason for that is that 26.0% of respondents fully disagreed or disagreed with the statement that this activity is important for knowledge maturing in their organisation. The histogram shown in section 8.5.4.3 indicates that two different interpretations of this KM activity might exist which is analysed in more detail in section 4.5.4. Nevertheless, overall, all KM activities identified during the first year of the MATURE project (see section 3.3.4) were deemed important for increasing knowledge maturity in organisations.

Perceived support (question 13): Agreement to the statement that the respective KM activity is supported in the respondents' organisations is not as high as the agreement to the importance of the respective KM activity asked for in question 12 (see the boxplots in figure 75 in the appendix, section 8.5.4.2). However, for ten out of twelve KM activities, according to the median at least 50% of interviewees agreed or fully agreed. With respect to the KM activity *"reorganise information at individual or organisational level"* 66.4% and with respect to *"assess, verify and rate information"* 69.9% of interviewees slightly agreed, agreed or fully agreed. Again, the most heterogeneous answers were given to the KM activity *"restrict access and protect digital resources"* (for a discussion, see section 4.5.4). The standard deviation of answers to this KM activity is 1.809 (see table 61 in the appendix, section 8.5.4.1).

Perceived success of performance (question 14): Compared to the agreement to question 13 about support of KM activities, the level of agreement to the statement that the respective KM activity is performed successfully in the organisation of the interviewee is lower (see the boxplots in figure 76 in the appendix, section 8.5.4.2). However, more than 50% of interviewees (exact values after each activity) agreed or fully agreed that the KM activities *"familiarise oneself with new information"* (54.4%), *"share and release digital resources"* (51.2%), *"restrict access and protect digital resources"* (61.0%), *"find people with particular knowledge or expertise"* (52.4%) and *"communicate with people"* (58.7%) are performed successfully in their organisation. With respect to the remaining seven out of twelve KM activities a median of four indicates that 50% of respondents slightly agreed, agreed or fully agreed. It is worth mentioning that the KM activity *"share and release digital resources"* has the highest standard deviation (1.673) closely followed by *"restrict access and protect digital resources"* which has again a high standard deviation (1.63) compared to the other KM activities (this is further investigated in section 4.5.4).

The descriptions above are also mirrored in figure 22 where the mean values of the level of agreement to the three questions for each KM activity are shown.
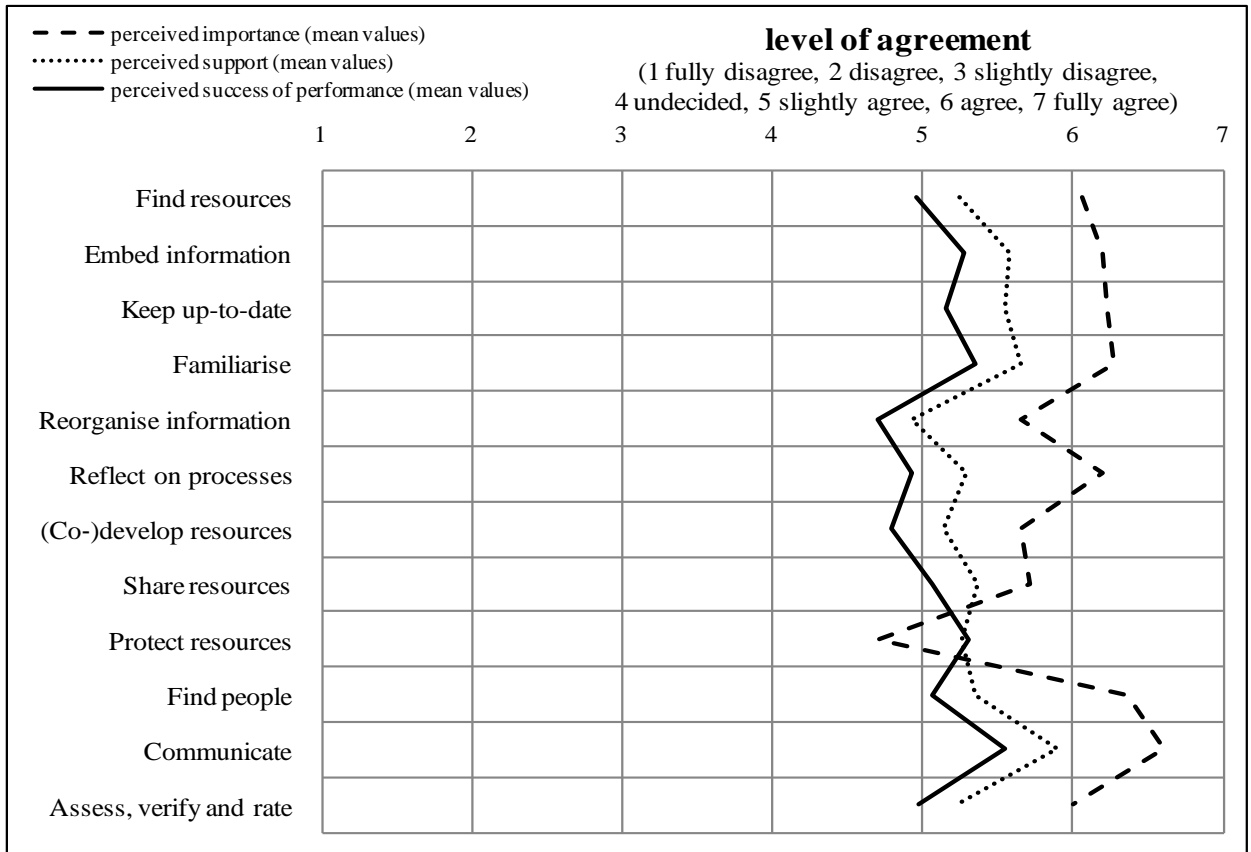
Figure 22: KM activities – level of agreement[11]

Except for the KM activity *"restrict access and protect digital resources"*, the mean values of given answers decrease from question 12 over 13 to 14 (numeric mean values can be found in table 59, see appendix). Hence, though KM activities are perceived to be important, they are actually less well supported and it might be a consequence that they are less successfully performed. In case of *"restrict access and protect digital resources"* it is actually the other way around: mean values increase from questions 12 over 13 to 14. For this KM activity, the perceived success of performance seems to be slightly higher than the perceived support and the perceived support seems to be higher than the perceived importance. This is probably related to the fact that in several interviews, interviewees considered the organisation to be too restrictive (so the organisation is successful in restricting access, but it is seen as counter-productive for knowledge maturing). We will investigate this further in section 4.5.4.

In order to investigate the differences between answers given to questions 12 (perceived importance of KM activity), 13 (perceived support of KM activity) and 14 (perceived success of performance) a statistical test can be performed. We chose the Wilcoxon matched-pairs signed-ranks test as it is applicable to the data which is conceptualized as an interval scale and as it has less stringent assumptions (e.g., according to the underlying distribution) than the t-test (for more information see Sheskin, 2007). In each of the following tests, missing values are excluded pairwise.

Perceived importance and support: For showing the difference between answers given to these two questions, we describe how we performed the Wilcoxon matched-pairs signed-ranks test exemplarily for the KM activity *"reflect on and refine work practices or processes"* in the following.

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[11] Please note that labels of activities are shortened. Complete names are: find relevant digital resources; embed information at individual or organisational level; keep up-to-date with organisation-related knowledge; familiarise oneself with new information; reorganise information at individual or organisational level; reflect on and refine work practices or processes; create and co-develop digital resources; share and release digital resources; restrict access and protect digital resources; find people with particular knowledge or expertise; communicate with people; assess, verify and rate information.

Null hypothesis: There is no difference between perceived importance and perceived support of KM activity *"reflect on and refine work practices or processes"*. With respect to the sample data, this is operationalised into the sum of ranks of the positive difference scores being equal to the sum of negative difference scores.

Alternative hypothesis: There is a difference between perceived importance and perceived support of the KM activity *"reflect on and refine work practices or processes"*. With respect to the sample data, this is operationalised into the sum of ranks of the positive difference scores not being equal to the sum of negative difference scores. Note: as this is a non-directional alternative hypothesis, it is evaluated with a two-tailed test.

When computing the test, a Z value of -5.728 is calculated based on positive ranks (see table 63 in the appendix, section 8.5.4.4). The negative sign means that the difference (i.e. perceived support minus perceived importance of KM activity *"reflect on and refine work practices or processes"*) calculated for each respondent is mostly negative. As the result is highly significant, the null hypothesis can be rejected and the alternative hypothesis is supported at a $p \leq 0.001$ level. With respect to our hypothesis, this means that the statement that the KM activity is important reached a significantly higher agreement than the statement that the KM activity is supported.

According to this exemplary procedure demonstrated for KM activity *"reflect on and refine work practices or processes"*, one test was executed for each of the remaining eleven KM activities. The outcomes of all tests performed are shown in table 63 (see appendix, section 8.5.4.4). Comparing the values of (1) perceived importance and (2) perceived support for each KM activity, it is shown that the perceived importance is higher (on an at least very significant level, $p \leq 0.01$) than the perceived support for all KM activities, except for KM activity *"restrict access and protect digital resources"*. In the case of this KM activity, importance is deemed lower than support on a highly significant level ($p \leq 0.001$).

Perceived importance and success of performance: For studying the difference between perceived importance and success of performance, a null hypothesis and alternative hypothesis is constructed for each KM activity. The wording of null hypotheses is constructed as follows: There is no difference between perceived importance and perceived success of performance of KM activity *"x"*. In contrast, the wording of alternative hypotheses is: There is a difference between perceived importance and perceived success of performance of the KM activity *"x"*. In both cases *"x"* stands for the KM activity that should be tested.

For *"restrict access and protect digital resources"* the null hypothesis can be rejected as a very significant result ($p \leq 0.01$) is calculated based on negative ranks (see Table 64 in the appendix, section 8.5.4.4). Thus, the alternative hypotheses is supported, consequently, success is deemed to be significantly higher than importance of this activity. For all other KM activities, the test produces highly significant ($p \leq 0.001$) results based on positive ranks. As the null hypothesis can also be rejected, this means that for eleven of twelve KM activities perceived importance is significantly higher than perceived performance.

Perceived support and success of performance: Also for investigating the difference between perceived support and success of performance, hypotheses are constructed. Similarly to the previous test, the wording of null hypotheses is constructed as follows: There is no difference between perceived support and perceived success of performance of KM activity *"x"*. The wording of alternative hypotheses is: There is a difference between perceived support and perceived success of performance of the KM activity *"x"*. Once again, in both cases *"x"* stands for the KM activity that should be tested.

The Wilcoxon matched-pairs signed-ranks test is not significant for KM activity *"restrict access and protect digital resources"* (see table 65 in the appendix, section 8.5.4.4). The test yields very significant results for four ($p \leq 0.01$) and highly significant results ($p \leq 0.001$) for seven of the eleven remaining KM activities. Perceived support is significantly higher than perceived success for eleven of twelve KM activities.

4.5.2 Portfolios

In order to support decisions in the MATURE project, it is of interest to identify KM activities that are, firstly, deemed important for increasing knowledge maturity, but perceived less supported and, secondly, deemed important, but perceived less successfully performed. In such cases, KM services (see D4.2) could be (further) developed to enhance the support of such activities aiming at a more successful performance in organisations. In order to avoid influences of the absolute values which are strongly imbalanced to the agreement side and thus the upper three values of the seven-point scale (i.e. absolute level of agreement over all KM activities), we decided to concentrate on the relative values (i.e. level of agreement to one KM activity relative to the other KM activities). Therefore, for each of the questions 12, 13 and 14, the upper quartile, the medium upper quartile, the medium lower quartile and the lower quartile of respondents for each of the KM activities were determined. These are then contrasted. Applying this approach makes explicit which KM activities are deemed to be more important and at the same time less supported or successfully performed than others and vice versa. For investigating and for presenting results of this area of interest, we decided to create and evaluate portfolios.

The portfolio technique, originally developed to balance potential risks and yields in the securities business, received a wide audience with the growth-share portfolio of the Boston Consulting Group (BCG) ranking business units based on relative marked shares and growth rates (David, 2001) The portfolio approach involves placing items with respect to dimensions and, thereby, developing an overall picture to support decisions with the help of norm strategies.

Each of the portfolios described in the following opposes two dimensions. According to the number of possible pairwise combinations of perceived importance, support and success of performance, three portfolios could be created. Based on the assumption that MATURE software or services can support KM activities and hence might have a positive influence on the success of performance, we concentrate on the deemed importance of KM activities and relate it to the perceived support and success of performance.
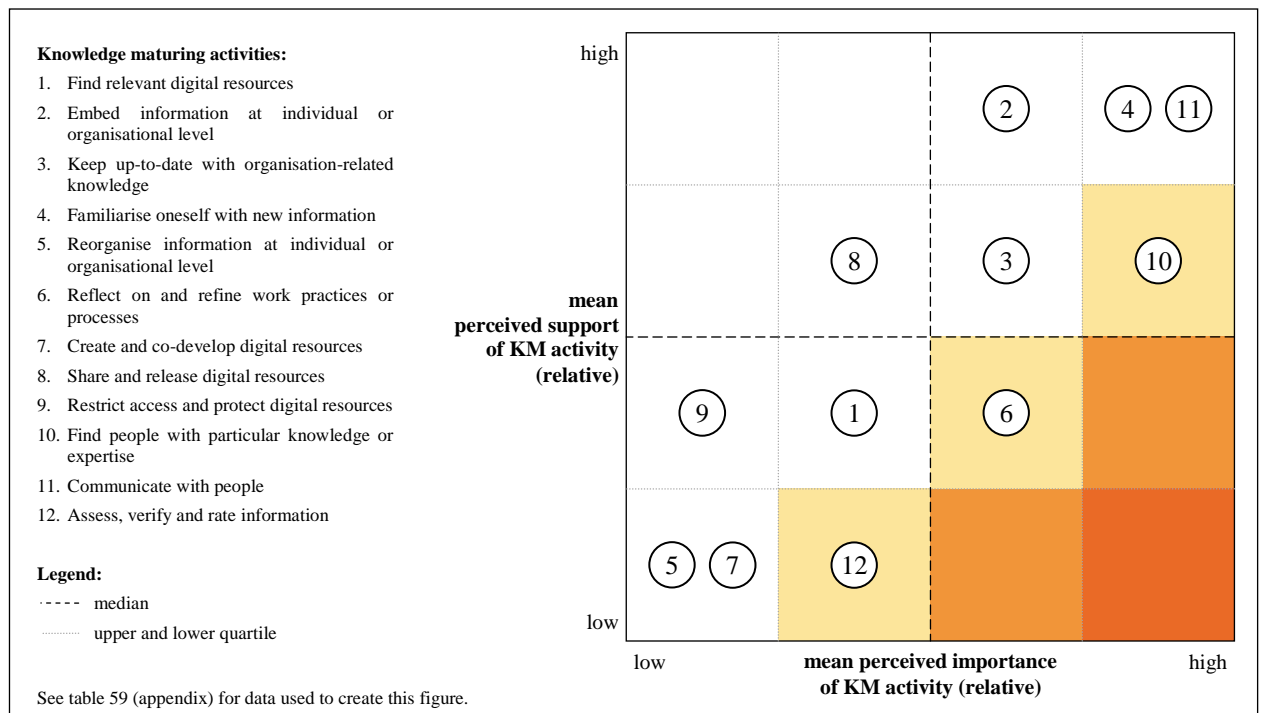
Figure 23: KM activities portfolio importance – support

The portfolio displayed in figure 23 depicts on its x-axis the mean values of answers given to question 12 (perceived importance of KM activity). The y-axis shows the mean values of answers given to question 13 (perceived support of KM activity). In order to show the ratings of KM activities in relation to each other, quartiles were used

for placing them within the portfolio. Hence, the mean values of both, perceived support and the perceived importance of each KM activity are arranged relatively to each other depending on their lower quartile, median and upper quartile.

The higher the perceived importance and the lower the perceived support, the worthier it is to focus on this activity. Following this, the background of the portfolio shown in figure 23 is coloured in different shades to show the norm strategy of investing into those activities that are in the lower right corner of the portfolio. The darker the background colour, the higher the assumed lack of software or services that provide functionalities to support the KM activity.

Relatively to others, the KM activities *"4-familiarise oneself with new information"*, *"11-communicate with people"* and *"10-find people with particular knowledge or expertise"* are deemed most important for increasing knowledge maturity in respondent's organisations. The latter out of this group is less supported and hence, would be most interesting for the MATURE project. The KM activities *"2-embed information at individual or organisational level"*, *"3-keep up-to-date with organisation-related knowledge"* and *"6-reflect on and refine work practices or processes"* are deemed of secondary importance. Again, the latter KM activity is deemed less supported. Additionally, this activity is the only one in this portfolio which belongs to both, the 50 percent of KM activities that are deemed more important and the 50 percent of KM activities that are deemed less supported than others. Hence, this KM activity would be of high interest to be further considered in the MATURE project. With respect to perceived importance, the KM activities "1-*find relevant digital resources"*, *"8-share and release digital resources"* and *"12-assess, verify and rate information"* would fall into the third group. The latter of this group is less supported and would be a candidate to be facilitated with the help of MATURE software or services. The group that is deemed least important in comparison to other KM activities contains *"5-reorganise information at individual or organisational level"*, *"7-create and co-develop digital resources"* and *"9-restrict access and protect digital resources"*.

The portfolio depicted in figure 24 also displays the mean values of perceived importance on its x-axis. The y-axis shows mean values of perceived success of performance. Those activities deemed important and at the same time perceived to be performed less successfully would be most interesting for further consideration in the MATURE project. Again, this area of interest is coloured in different shades to show the norm strategy of investing into those activities that are in the lower right corner of the portfolio and quartiles are used to determine the position of activities relatively to each other.
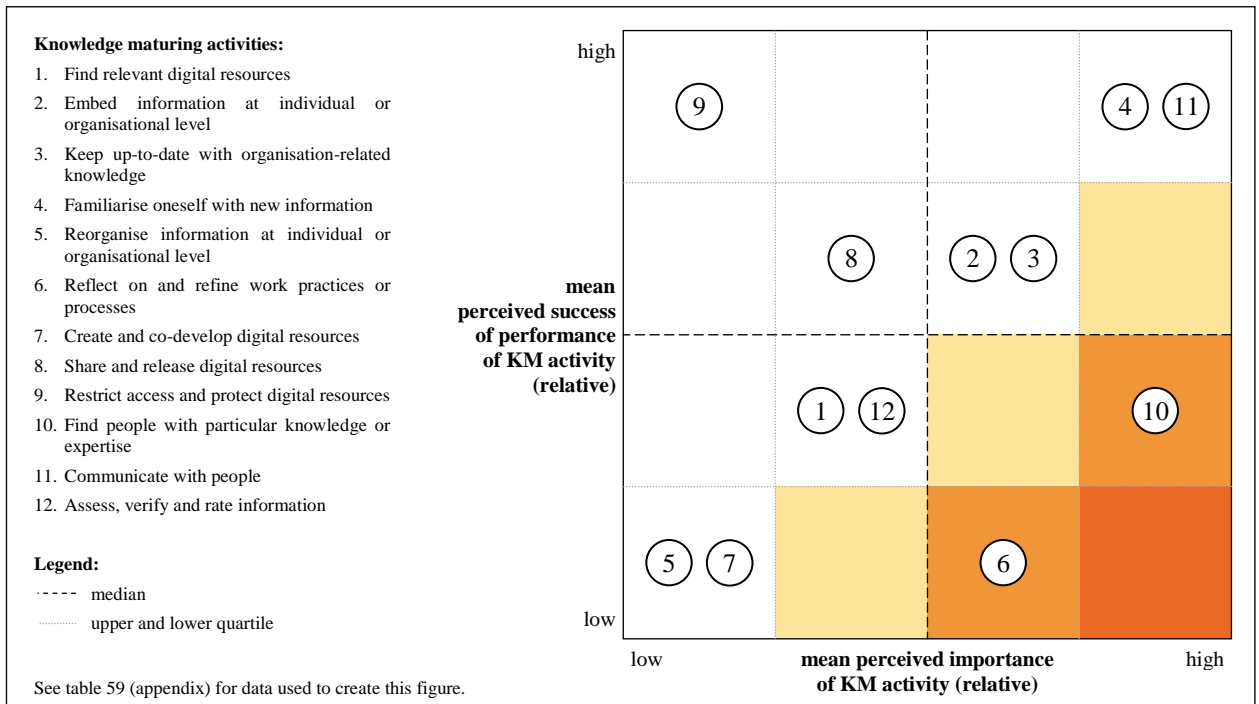
Figure 24: KM activities portfolio importance – success

According to this portfolio *"10-find people with particular knowledge or expertise"* and *"6-reflect on and refine work practices or processes"* would be most interesting KM activities for the MATURE project. The former falls into the group of most important KM activities and, at the same time, is part of the 50 percent of KM activities that are less successfully performed. The latter is deemed to be one of the 50 percent of more important and, at the same time, is perceived to be one of the three less successfully performed KM activities.

A comparison of the two portfolios depicted in figure 23 and figure 24 shows that for MATURE the KM activities *"6-reflect on and refine work practices or processes"* and *"10-find people with particular knowledge or expertise"* would be most interesting. *"12-Assess, verify and rate information"* could be considered as a third interesting KM activity, because it is one of the least supported and less successfully performed activities. Also *"1-find relevant digital resources"*, *"5-reorganise information at individual or organisational level"* and *"7-create and co-develop digital resources"* might be of interest to be supported with MATURE software or services. Although, in relation to others, these activities are deemed to be less important, their mean values calculated based on the Likert scale are still close to agree. Furthermore, compared to others, they fall into the group of less supported and less successfully performed KM activities.

The comparison of the two portfolios shows also that though the activity *"restrict access and protect digital resources"* is less supported than others, it is deemed to be one of the most successfully performed KM activities (for a more detailed analysis see section 4.5.4 and also Figure 73 in the appendix).

4.5.3 Correlation

In the following, the research model described in section 3.2 will be examined. According to the propositions 1 and 2, the relationships between, firstly, perceived importance and support and, secondly, between perceived support and successful performance are investigated. Therefore, for each KM activity, two correlation analyses are performed. The Spearman rank correlation coefficient (for more information see Keller and Warrack, 2000) was chosen as the collected data is conceptualized as an interval scale and

does not have to satisfy the normality requirement. Table 17 shows the statistical results of all performed correlation analyses.

	perceived importance and perceived support			perceived support and perceived success of performance		
	Correlation Coefficient	Sig. (2-tailed)	n	Correlation Coefficient	Sig. (2-tailed)	n
Find relevant digital resources	.366	.000	125	.772	.000	125
Embed information at individual or organisational level	.337	.000	126	.703	.000	126
Keep up-to-date with organisation related knowledge	.406	.000	126	.765	.000	126
Familiarise oneself with new information	.238	.008	125	.749	.000	125
Reorganise information at individual or organisational level	.444	.000	125	.777	.000	125
Reflect on and refine work practices or processes	.267	.003	125	.795	.000	125
Create and co-develop digital resources	.551	.000	124	.836	.000	123
Share and release digital resources	.458	.000	123	.843	.000	123
Restrict access and protect digital resources	.561	.000	123	.771	.000	123
Find people with particular knowledge or expertise	.336	.000	126	.645	.000	126
Communicate with people	.306	.000	126	.715	.000	126
Assess, verify and rate information	.388	.000	123	.798	.000	123

p <= 0.05 significant
p <= 0.01 very significant
p <= 0.001 highly significant

very low correlation (<=0.2)
low correlation (<=0.5)
medium correlation (<=0.7)
high correlation (<=0.9)
very high correlation (<=1.0)

Table 17: Correlations of KM activities

Proposition 1: The correlation between the perceived importance and support is highly significant (p<=0.001) for ten out of twelve KM activities. For the remaining two KM activities the correlations is very significant (p<=0.01). All correlation coefficients are positive whereas for ten activities a low correlation and for two activities a medium correlation is indicated. Hence, these findings support proposition 1 because they indicated that the more important a KM activity is perceived, the more it is supported.

Proposition 2: For all KM activities the correlation between perceived support and perceived success is highly significant (p<=0.001) and correlation coefficients are positive. Except for one activity, coefficients indicate a high correlation. For KM activity *"find people with particular knowledge or expertise"* the correlation coefficient still indicates a medium positive correlation. Consequently, for each activity this means that the more an organisation supports it, the more successful it is performed regarding knowledge maturing. Hence, proposition 2 is also supported.

Comparing the correlation coefficients of all 24 tests, the relationship between perceived support and perceived success of performance of each activity is apparently stronger than the relationship between perceived importance and perceived support. This could lead to the assumption that not everything organisations do to support a knowledge maturing activity (perceived support) is heading in the right direction (perceived importance) but the things they do to support it (perceived support), seem to result in a successful performance (perceived success of performance).

4.5.4 Qualitative analysis of knowledge maturing activities

Compared to the indicator analysis (see section 4.6.3), there were a lower number of comments that could be analysed. As a consequence, we focused on only those activities that were "controversial" in the sense that they had an above average variance in the quantitative analysis and for which there were a substantial number of comments for further analysis. This was the case for the two activities "restrict access and protect digital resources" and "reorganise information at individual or organisational level"

Restrict access and protect digital resources

The most controversial activity was "restrict access and protect digital resources", as shown in the quantitative analysis (see section 4.5.1). An analysis of the comments related to the activity (in total 42

comments) has revealed that we have to distinguish between two types of answers (depending on whether they are related to the importance of the activity or whether the company supports it): (a) statements whether and why the company restricts access and (b) statements about personal opinion whether restricting access is beneficial to knowledge maturing.

From an organizational perspective, a mixed picture emerged. For instance, there are minimum restrictions in some companies (related to an open organisational culture), whilst other organisations are characterized by giving high priority to restricting access. In some cases, this is due to the fact that organisations are required to protect the information (such as personal data and that related to their customers, e.g., the military), for others this is part of protecting their own competitive advantage.

On the personal side, three reasons why individuals considered restricting access as important emerged from the data:

On the personal side three reasons why individuals considered restricting access as important emerged from the data:

- **Trust as a prerequisite for knowledge sharing and collaboration.** Two interviewees mentioned that they consider restricting access as a measure to create a protected space in which you can more freely exchange knowledge because they trust each other. *"There are people who will share only in a limited way if they cannot trust that not everyone can see it."* The alternative they basically see is that knowledge is kept personally: *"But you have to restrict access, I think that restricting access as a functionality of a tool is an important prerequisite for exchanging knowledge. So if you restrict access, it is also good for knowledge exchange, not with those who don't have access, but for those who have access. Otherwise you wouldn't share anything if you couldn't restrict it to certain persons".* This is in line with the general comment that *"human nature of the individual is very important and needs to be taken into account".*

- **Information channelling and avoidance of information overload.** The underlying assumption of this line of argumentation is that shared knowledge and information leads to a counterproductive overload situation: *"Knowledge is not something that has to be always distributed. With this activity the knowledge is channelled to the right users."*

- **Data security and fear of competition.** While in many cases, data security and fear of losing competitive advantage was seen as a given necessity, in some cases the interviewees also shared the company's position that this is essential. In other cases, there were more critical statements that this obstructs knowledge maturing: *"It does not help knowledge maturing, I would clearly say. Has also reasons of data protection that not everyone has access to everything. Having to restrict it: would rather disagree".*

Furthermore, interviewees also gave reasons against restricted access to resources (from the perspective of knowledge maturing). The overall 14 comments all suggest that restriction means obstructing people's access to knowledge which they view as a prerequisite for knowledge maturing to happen. Answers range from *"nonsense"* to critical reflection on their own company's practice: *"The access rights are pretty strict, as extreme as personnel office not being able to see my drive, my drive cannot be seen by my colleagues, I find that unbelievable."* Or: *"We are destroying knowledge in this area".*

Finally, there were some much differentiated answers related to the tension around external collaboration. Already as part of the ethnographic studies, knowledge and information exchange with external contacts in an individual's social network was a very essential part of everyday work (even to an unanticipated degree). Also, external sources have been seen by interviewees as essential for triggering change in an organisation. Organisations tend to be very cautious towards external collaboration as they see the risk of losing competitive advantage, or need to ensure compliance to externally induced regulations for data protection. One balanced answer also indicated that you have to differentiate between different types of knowledge: *"Not all digital resources - I would here (and above) say all resources that influence the work process, the product, the organizational goals, here I would always say yes. If it is not influencing the work process, then it is stupid."*

Reorganise information at individual or organisational level

For the activity, "reorganise information at individual or organisational level", which also had a high degree of variance, there were 37 comments in total. As in the previous sections, these referred to both the personal opinion about the importance of organisational support.

One of the key problems with this activity was the interpretation of the activity by interviewees and the problems with understanding and mapping it to the practice in their company. Particularly, the activity name seemed to be too abstract and required a high degree of interviewer explanations so that interviewees could have responded more to the given examples than to the activity in general (e.g., "restructuring", "gardening"). Some misunderstandings could be observed that generalized the given example too much, such as equating it with organisational restructuring *"Leads to many distractions. Restructuring is a very hot topic. This brings a lot of turbulence. In case of doubt, I confuse people, here definitely. [...] Sometimes you have to do it, it is always difficult."* This could explain the high variance. However, it could also mean that reorganising information always or often goes together with organisational restructuring and this brings a lot of challenges with it. This could point towards extra care that would need to be taken when deploying IT support for a KM activity that targets reorganisation of information spaces.

From the remaining comments, you can distil arguments for the importance of this activity. It is mainly argued that reorganising is an activity which the person doing it is more actively involved than, e.g., in just finding. It involves "knowledge construction from their perspective" and changing perspectives: *"I think this is important because you have to view it in different contexts and that you can also present it in different contexts."* When this was seen as positive, however, there were also concerns whether it is actually done: *"no one is willing to do reorganisation"* and *"in the face of complexity it becomes hard to be satisfied".*

Additionally, there were also more critical answers which did not view the reorganisation of information as a knowledge maturing activity: "*Revision! By revising it as such? Don't agree. Only through revision, there is no knowledge maturing. Rather by the decision that revision is necessary."* This basically views reorganising not as a valuable activity as such. One interviewee went even further stating: "*A reorganisation is totally unimportant. You only have to offer information in the right context, then I don't have to reorganise it."*

4.5.5 *Suggested new knowledge maturing activities*

In total, we have received suggestions for additional activities from 28 interviewees. These suggested activities and their explanations were coded and classified into 17 different suggested activities (see Table 18). Those were related to the existing activities (see section 3.3.4).

Some suggested new activities (3 distinct activities, 4 in total) were refinements of existing activities like product testing (which is covered by "rate, assess, and verify artefact"), or organisational reflection. This also suggests that interviewees had some problem with the high level of abstraction of the activities and translating them to their work environments.

The majority of novel activities (6 distinct activities, 10 in total) were related to a **guidance perspective**, i.e., intervening into the environment (frequently from a management level) to influence not only an instance of a knowledge maturing process, but also the general capability to mature knowledge. This includes systematic human resource development and competence management (which was mentioned three times), give free time (*"you need free time to let things mature, but this is missing in many places."*), shape the culture ("*to what extent it is knowledge maturing is culturally fostered and whether an open climate is established"*), and involve the management (e.g., through an appropriate management system). Additionally, this also includes activities that improve the reflection process, e.g., by evaluating work practice through surveys. One important aspect is also the provision of enabling tools from a guidance perspective (mentioned three times) with examples like building a knowledge / people database,

providing context-based access to people and artefacts, and a forum-like platform that also links people together.

Most frequently mentioned were activities of **individual development**, which mainly aggregate participating in training activities (mentioned five times). This emphasizes the role and perceived importance of formal learning activities in company's practice, as opposed to the recent shift in research towards informal learning.

It was also surprising to see that importance was given to **external expertise and the interaction with externals** (mentioned four times). Company-internal developments need triggers from outside (*"For looking into new topics, new inputs out of my own division, I have to get a trigger from somewhere, or information about something unknown. For me, knowledge maturing happens through the confrontation with something new, which was not known before, therefore I would have said that the active examination outside the workplace as such leads to knowledge maturing in the organization for sure."*, or *"And when you invite someone external, from the same occupational group, who comes from practice and talks about such a topic how can you approach it, what was successful, what not, which things do not have to be done, then employees come and then they are very interested, and they need at the beginning two or three hours, but then they contribute, then they connect what they hear with their own operations, then good ideas and assessments emerge"*). This can also specifically happen as part of established relationships (e.g., in project consortia): *"The activities with external partners contribute to mature the internal knowledge."* This is in line with the controversial rating of the "restrict access" activity discussed above.

Other comments suggest to establish special forms of work practice as these are considered helpful as a maturing activity, e.g., working in projects (if the company is not organised along projects), but also building appropriate teams, which are considered especially important in phase II of the knowledge maturing process.

suggested new activity	number of comments
support individual development	5
interact with external contacts	4
provide enabling tool	3
develop human resources	3
involve management	2
meet people	2
evaluate practice	2
reflect on an organisational level	2
Archive	1
involve external expertise	1
guidance - give free time	1
guidance - shape culture	1
guidance - perform team building	1
create problem awareness	1
product - testing and evaluation	1
project work	1
update process roles	1
Sum	**32**

Table 18: Suggested additional knowledge maturing activities

Summing up the analysis of additional activities suggested by the interviewees, the set of KM activities as found in the ethnographic studies and subjected to validation in the representative study seems to be stable as there are only a few additions and nearly all questions regarding KM activities were answered. Apart from general management activities that are not specific for knowledge maturing, most comments elaborate more on the presented list of activities. Particularly, interaction, reflection, evaluation and providing support for the development of individuals and organisational units seem to be the most important activities when it comes to fostering knowledge maturing. This is well in line with the findings of the analysis of the set of closed questions on knowledge maturing presented in sections 4.5.1 to 4.5.4. For MATURE, the KM activities *"reflect on and refine work practices or processes"*, *"find people with particular knowledge or expertise"*, *"assess, verify and rate information"* are most interesting to be fostered by MATURE concepts and tools. Also *"find relevant digital resources"*, *"reorganise information at individual or organisational level"* and *"create and co-develop digital resources"* might be of interest to be supported with MATURE software or services.

4.6 Knowledge Maturing Indicators

Concerning KM indicators, interviewees were asked to consider the formulated statements as indicating that knowledge maturing had happened, more specifically, that organisational knowledge had matured. Indicators thus were operationalised as statements to which interviewees could agree or disagree depending on whether or not they thought that the statement would mean that knowledge had matured in their work environment (see section 3.3.5). The statements necessarily had to be formulated in an abstract, generic way to fit organisations of all sizes, sectors and in order to be comprehensible for interviewees with varying backgrounds. Thus, we had examples for the indicators which could be used by interviewers in the co-creation process together with interviewees aiming at making sense of indicators in the context of the interviewee's organisation. Section 4.6.1 presents and analyses the descriptive results on the indicators structured according to the four primary dimensions of knowledge maturing indicators, digital resources, persons, processes and combinations thereof. Section 4.6.2 then presents procedure and results of a factor analysis the aim of which is to aggregate indicators into factors of a certain type that

helps structuring the exhaustive list of indicators and also provides a basis for further analysis of correlations between factors and demographics of the organisations that our interviewees represent. Section 4.6.3 analyses the additional comments that were made by the interviewees on indicators, again structured according to the four primary dimensions of knowledge maturing indicators, digital resources, persons, processes and combinations thereof. Section 4.6.4 finally concludes the analysis of knowledge maturing indicators with a short summary of the most important findings and an analysis of the implications for the MATURE project.

4.6.1 Exploring indicators

KM indicators (question 15) related to digital resources: At least 50% of interviewees agreed or fully agreed that six of the twelve KM indicators of this group are good indicators for knowledge maturing in their organisation. For five indicators, at least 50% of interviewees slightly agreed, agreed or fully agreed. The remaining indicator has a median of 4 translates to undecided (see boxplots in figure 77, in the appendix). With respect to mean values (see figure 25), two KM indicators stand out against the others. The KM indicator that reaches the lowest mean level of agreement is *"a digital resource has not been changed for a long period after intensive editing"* (mean value 3.98, see table 66 in the appendix). The KM indicator *"has become part of a guideline or has become standard"* reaches the highest mean level of agreement (mean value 6.10). The former gained the most heterogeneous answers with respect to the level of agreement (standard deviation of 1.761). Based on this, one could assume that there might be different opinions or understandings of this indicator. This assumption is also supported by the histogram, see section 8.5.5.4 in the appendix. The latter of both KM indicators has the lowest standard deviation (1.052) within this group of KM indicators, which indicates that interviewees do not differ very much with respect to their high level of agreement.
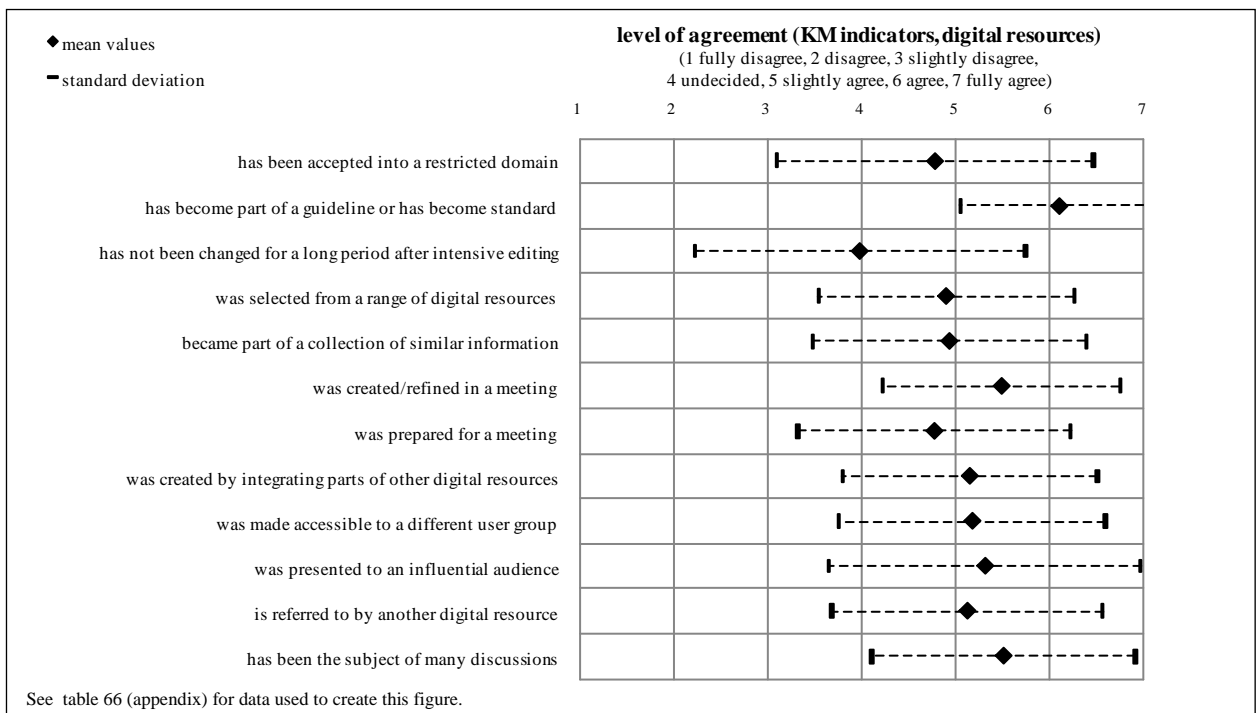
Figure 25: KM indicators: Mean values and standard deviation (digital resources)

KM indicators (question 15) related to persons: As depicted by the boxplots in figure 78 (section 8.5.5.2, see appendix) at least 50% of interviewees slightly agreed, agreed or fully agreed to five of nine KM indicators belonging to this group. With respect to the remaining four KM indicators the level of agreement was even higher as at least 50% of interviewees agreed or strongly agreed. This is also mirrored by the mean values (see figure 26), as the former five KM indicators reached lower mean values (ranging from 4.66 to 5.14) than the latter four KM indicators (ranging from 5.21 to 5.98). The KM indicator *"a person is approached by others for help and advice"* reaches the highest mean level of

agreement (5.98) whereas the KM indicator *"a person changed its role or responsibility"* reaches the lowest (4.66). Again, the KM indicator with the highest mean level of agreement (5.98) is also the one with the most homogeneous answers in this group (standard deviation is 1.098). The two KM indicators with the most heterogeneous answers, i.e. *"a person has been a member of the organisation for a significant period"* (standard deviation is 1.675) and *"a person changed its role or responsibility"* (standard deviation is 1.569) reached at the same time the lowest mean levels of agreement within this group of KM indicators (mean values are 4.81 and 4.66).
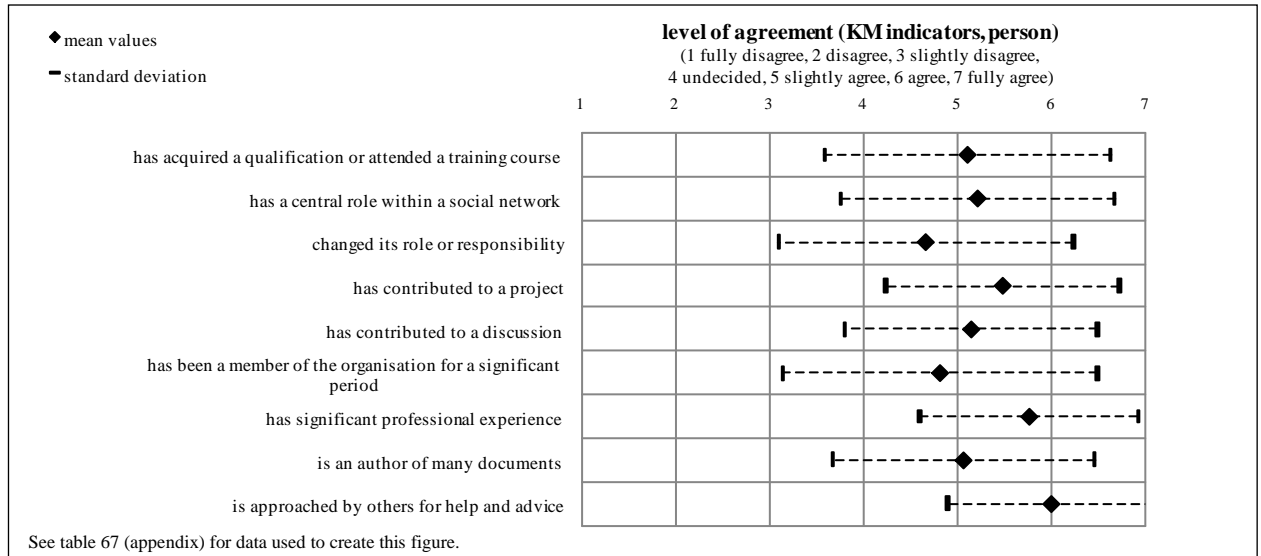
Figure 26: KM indicators: Mean values and standard deviation (person)

KM indicators (question 15) related to processes: More than 50% (exactly 60.7%) of interviewees slightly agreed, agreed or fully agreed that *"a process was changed according to the number of cycles (loops)"* would be a good indicator for knowledge maturing in their organisations (see boxplots in figure 79 in the appendix). This is the KM indicator having the lowest mean level of agreement (4.98) of this group (see figure 27). The relative high standard deviation of this indicator (1.364) might lead to the assumption that it was differently interpreted or understood. Again, this is also supported by the histogram (see section 8.5.5.6 in the appendix). For the remaining six of seven KM indicators of this group, at least 50% of interviewees agreed or strongly agreed. Thus, compared to the other groups of KM indicators, this group reached the highest level of agreement. With a mean value of 6.19, the KM indicator *"a process was improved with respect to time, cost or quality"* reaches the highest mean level of agreement. This is not only the highest mean level of agreement within this group but also the highest of all KM indicators. Furthermore, at the same time, this KM indicator has the lowest standard deviation (1.011) of all KM indicators being part of the interview. According to the standard deviation, the KM indicator *"a process was certified or standardised according to external standards"* received the most heterogeneous answers and stands out against the others of this group (standard deviation is 1.701).
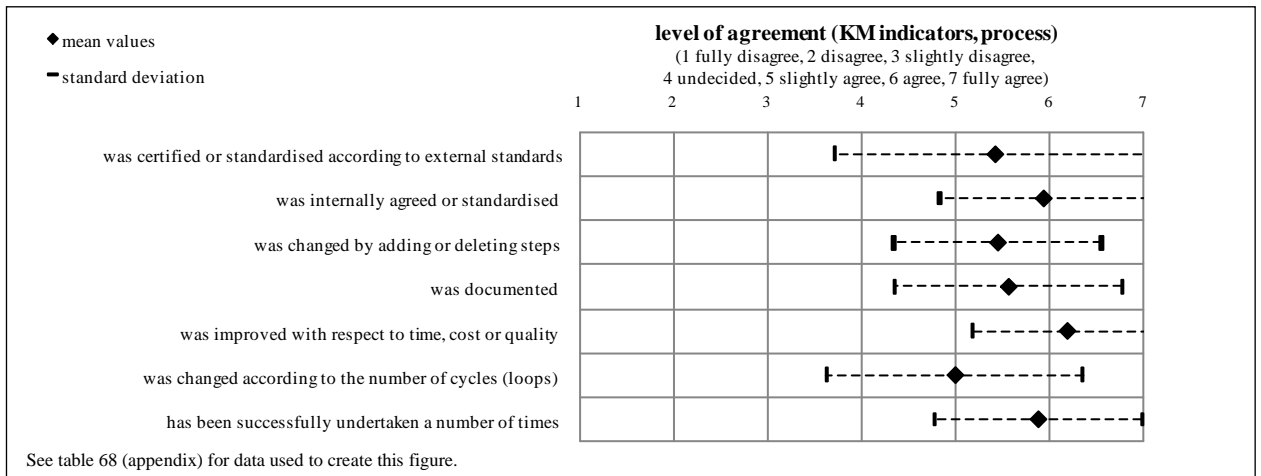
Figure 27: KM indicators: Mean values and standard deviation (process)

KM indicators (question 15) related to combinations: According to the boxplots (see figure 76 in the appendix), at least 50% of interviewees agreed or strongly agreed that five of the ten KM indicators of this group are good indicators for knowledge maturing in their organisation. With respect to four indicators the agreement was a little lower, as at least 50% of interviewees slightly agreed, agreed or strongly agreed. The remaining KM indicator *"a digital resource has been used by a person"* has a median of 4 which translates to undecided. Together with *"a digital resource has been assessed by a person"* this KM indicator gained the lowest mean level of agreement within this group (mean values are 4.23 and 4.58, see figure 28). The KM indicator with the highest mean (5.72) in this group is *"a digital resource has been changed after a person had learned something"*. According to the standard deviation, *"a person has been the owner of a process for a significant period"* received the most heterogeneous answers (standard deviation is 1.628).
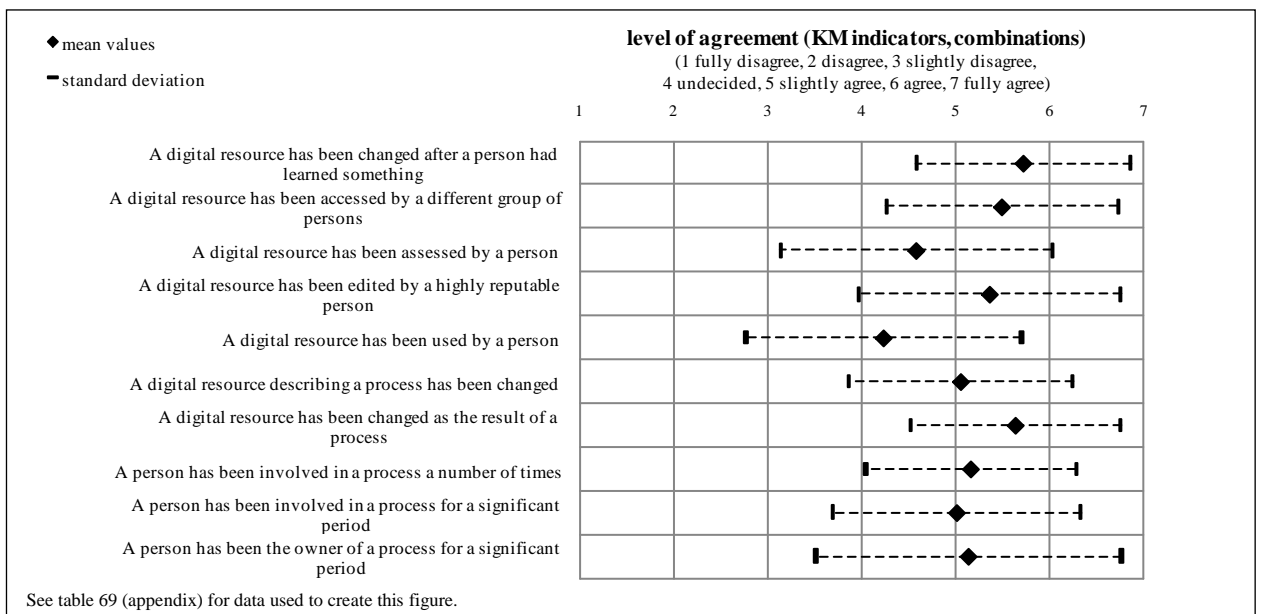
Figure 28: KM indicators: Mean values and standard deviation (combinations)

Figure 29 depicts the means per dimension of the KM indicators. The highest degree of average agreeing with the indicators is in the dimension *process* (5.63), the lowest is in the dimension *digital resources* (5.11).
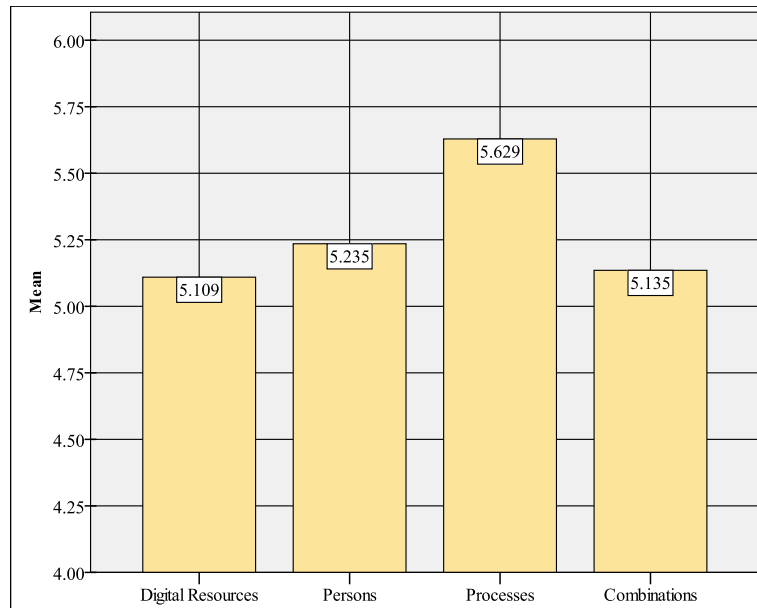
Figure 29: Mean values per dimension of KM indicators

Although the differences seem small, we decided to test them with regard to significance. A Kolmogorov-Smirnov-test of the mean values per dimension was conducted to test for normal distribution (see Table 70 in appendix 8.5.5.3). For all four variables, H0 could not be rejected. Therefore, a normal distribution is assumed.

The paired t-test was chosen in order to evaluate differences between the variable sets. As this test only works with a set of two variables per test, six tests comprising all variable combinations have been conducted. As Table 19 shows, only pair three, the difference between digital resources and combinations, is not significant (2-tailed) in terms of difference of means with $p \le 0.05$. Therefore, H0 was accepted for the difference between *digital resources* and *combinations*. All other differences accept the alternative hypothesis, so that it is assumed, that differences between these dimensions are significant.

Paired Samples Test

	Paired Differences					t	df	Sig. (2-tailed)
				95% Conf. Interv. of the Diff.				
	Mean	Std. Deviation	Std. Error Mean	Lower	Upper			
Pair 1: digital resources - persons	-.11705	.64171	.05834	-.23255	-.00154	-2.006	120	0.047
Pair 2: digital resources - processes	-.52416	.74951	.06814	-.65907	-.38925	-7.693	120	0.000
Pair 3: digital resources - combinations	-.02576	.65834	.06010	-.14476	.09324	-.429	119	.669
Pair 4: persons - processes	-.39610	.75005	.06791	-.53054	-.26166	-5.833	121	0.000
Pair 5: persons - combinations	.11193	.58794	.05345	.00611	.21776	2.094	120	0.038
Pair 6: processes - combinations	.49478	.67810	.06165	.37272	.61683	8.026	120	0.000

significance <= 0.05

Table 19: Paired t-tests for means of KM indicator dimensions

Thus, one can conclude that on the generic level of KMI dimensions, those KM indicators that target processes are considered significantly more important than the rest of the indicators. Next to process-oriented indicators, people-oriented indicators matter most in the eyes of our interviewees while those indicators that are oriented towards digital resources and combinations were considered significantly less important.

4.6.2 Aggregating indicators to factors

In order to investigate possible underlying factors of the knowledge maturing indicators the statistical method factor analysis was used. The extraction method used was principal components. Only factors

with Eigenvalue > 1 were considered. Each solution was rotated using the Varimax method of factor rotation. Missing values were excluded listwise.

The factor analysis was conducted in several steps. A first factor analysis using all indicators was conducted. However, as this resulted in only a few factors with rather low factor loadings, we decided to split the analysis with respect to the dimensions. Therefore, separate factor analyses were conducted according to the dimensions which were mapped to the indicators (digital resources, persons, processes and combinations). As a second step, factor analyses for the three main dimensions (digital resources, persons and processes) were conducted. In this second analysis, the indicators representing a combination of dimensions were included into the set of variables of the dimensions that they represent. For example, a combined indicator relating to digital resources and persons was included in both, the factor analysis of digital resources and the factor analysis of persons. We are well aware that the statistical method assumes independence of the factors. We have no reason to doubt this assumption. We conducted these two steps in order to perform a sensitivity analysis of the found solutions. The solutions we found for the independently conducted factor analyses and the combined factor analyses showed a high level of similarity. The procedure we then took in order to distil one joint and robust set of factors explaining the variables is described in more detail below.

Factor analysis: digital resource

The first analysis concentrated on all KMIs related to the dimension 'digital resource'. The analysis of the twelve indicators leads to a solution containing four factors (see Table 20). The Kaiser-Meyer-Olkin Measure of Sampling Adequacy for this case is 0.687. The seven factors found account for 64.4% of the total variance.

The first factor refers to a 'digital resource having been handled by persons' and consists of four indicators: 'A digital resource has been changed after a person had learned something', 'A digital resource has been accessed by a different group of persons', 'A digital resource has been assessed by a person' and 'A digital resource has been used by a person' which represent all combinations of the dimensions digital resource and person. The indicator 'A digital resource has been used by a person' maps nearly equally to factor 1 (.463) and factor 4 (.456). Also, 'A digital resource has been assessed by a person' has a relation to factor 4 (see below). It is a subset of factor one of the analysis of dimension persons (see below).

The second factor refers to a 'change in a digital resource's context of application'. It consists of the four indicators '(A digital resource) was made accessible to a different user group', '(A digital resource) became part of a collection of similar information', '(A digital resource) is referred to by another digital resource' and '(A digital resource) has been accepted into a restricted domain'.

The third factor describes a 'state change due to creation of a digital resource'. It consists of '(A digital resource) was created/refined in a meeting', '(A digital resource) was prepared for a meeting' and '(A digital resource) was created by integrating parts of other digital resources'.

The fourth factor can be characterized as a 'state change due to a digital resource being handled by influential persons'. It consists of two variables: 'A digital resource has been edited by a highly reputable person' and '(A digital resource) was presented to an influential audience'.

Factor five consists of the two indicators '(A digital resource) has become part of a guideline or has become standard' and '(A digital resource) was selected from a range of digital resources'. It can be described as a 'change due to the selection of a digital resource'.

The sixth factor consists of only one variable: '(A digital resource) has not been changed for a long period after intensive editing'. This concept may be described as the 'state of stability after editing a digital resource'.

Factor seven refers to 'a change in a digital resource referring to a process' consists of the two indicators 'A digital resource has been changed as the result of a process' and 'A digital resource describing a process has been changed'.

	Component						
	1	2	3	4	5	6	7
A digital resource has been changed after a person had learned something	.773	.052	-.020	.084	.107	.162	-.032
A digital resource has been accessed by a different group of persons	.747	.277	.031	-.010	.099	-.172	.016
A digital resource has been assessed by a person	.567	-.090	.390	.421	.068	-.155	-.013
A digital resource has been used by a person	.463	.140	.015	.456	-.149	-.007	.260
was made accessible to a different user group	-.086	.758	.124	-.031	.129	.031	.047
became part of a collection of similar information	.244	.671	.062	.091	-.108	.092	-.177
is referred to by another digital resource	.479	.586	-.010	.222	.135	-.013	.146
has been accepted into a restricted domain	.244	.469	-.170	.300	.334	-.243	-.015
was created/refined in a meeting	-.059	.100	.827	-.132	.076	-.004	-.062
was prepared for a meeting	.124	.021	.821	.179	-.030	.056	.092
was created by integrating parts of other digital resources	.109	.298	.453	.008	.380	.064	.340
A digital resource has been edited by a highly reputable person	.050	.070	-.008	.814	.035	.173	.181
was presented to an influential audience	.219	.382	.083	.525	.141	-.115	-.212
has been the subject of many discussions	-.076	-.277	.342	.353	.254	.301	.015
has become part of a guideline or has become standard	.000	.059	.061	.072	.768	-.180	.036
was selected from a range of digital resources	.240	.078	.060	-.009	.679	.320	-.096
has not been changed for a long period after intensive editing	-.061	.050	.031	.122	-.048	.860	-.044
A digital resource has been changed as the result of a process	-.026	-.077	.043	.181	-.062	-.075	.869
A digital resource describing a process has been changed	.374	-.010	.049	-.188	.194	.442	.467

Table 20: Rotated component matrix of variables describing digital resource-oriented KM indicators

The indicator '(A digital resource) has been the subject of many discussions' is not mapped to any factor within the analysis and relates nearly equally to factors two to six. It is therefore not considered as an factor in analyses based up on this factor analysis.[12]

Factor analysis: person

The indicators mapped to the dimension person and the five factors calculated are presented in Table 21. The Kaiser-Meyer-Olkin Measure of Sampling Adequacy for this case is 0.698. The five factors found account for 60.3% of the total variance.

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[12] it could be characterized as 'state of disputed digital resource'

	Component				
	1	2	3	4	5
A digital resource has been accessed by a different group of persons	.774	.014	.055	-.081	.032
A digital resource has been changed after a person had learned something	.685	.127	-.023	.399	-.086
has a central role within a social network	.666	.098	.049	.031	.013
has acquired a qualification or attended a training course	.641	-.237	.119	.316	-.100
A digital resource has been used by a person	.564	.337	-.069	-.035	.315
A digital resource has been assessed by a person	.507	.420	.191	.039	-.111
is an author of many documents	-.080	.739	.175	.222	-.068
A digital resource has been edited by a highly reputable person	.209	.715	.075	-.070	.153
is approached by others for help and advice	.084	.701	.073	.057	.092
has contributed to a project	-.074	.154	.802	-.047	.142
has contributed to a discussion	.191	.037	.682	-.178	.219
changed its role or responsibility	.081	.189	.661	.249	-.203
has significant professional experience	.008	.169	-.034	.760	.080
has been a member of the organisation for a significant period	.420	.022	-.062	.602	.320
A person has been the owner of a process for a significant period	-.087	.178	.011	.053	.840
A person has been involved in a process for a significant period	.008	.003	.350	.405	.600
A person has been involved in a process a number of times	.297	-.323	.326	.411	.445

Table 21: Rotated component matrix of variables describing person-oriented KM indicators

The first factor consists of the indicators: 'A digital resource has been accessed by a different group of persons', 'A digital resource has been changed after a person had learned something', 'A digital resource has been changed after a person had learned something', '(A person) has acquired a qualification or attended a training course', 'A digital resource has been used by a person' and 'A digital resource has been assessed by a person'. As this is a rather broad set of indicators, a fitting description of this factor may be 'state change due to individual learning, handling a digital resource or a state of network positioning'.

The second factor can be described as 'state of perceived expertise'. It consists of the indicators '(A person) is an author of many documents', 'A digital resource has been edited by a highly reputable person' and '(A person) is approached by others for help and advice'.

The third factor can be described as 'state change of a person's role'. It contains the indicators '(A person) has contributed to a project', '(A Person) has contributed to a discussion' and '(A Person) changed its role or responsibility'.

The fourth factor can be described as 'state of experience of a person'. It contains two indicators: '(A person) has significant professional experience' and '(A Person) has been a member of the organisation for a significant period'.

The fifth factor can be described as 'state of person involved in a process'. It contains the indicators 'A person has been the owner of a process for a significant period', 'A person has been involved in a process for a significant period' and 'A person has been involved in a process a number of times'. The last indicator, also loads equally highly onto the forth factor (.445 vs. .411).

Factor analysis: process

The indicators of the dimension process and their resulting four factors are presented in Table 22. The Kaiser-Meyer-Olkin Measure of Sampling Adequacy for this case is 0.630. The four factors found account for 58.0% of the total variance.

	Component			
	1	2	3	4
was improved with respect to time, cost or quality	.704	.117	-.128	.395
has been successfully undertaken a number of times	.692	-.095	.139	.210
was certified or standardised according to external standards	.619	.119	.181	-.188
was internally agreed or standardised	.540	.454	-.131	-.078
A digital resource describing a process has been changed	-.070	.757	.205	.171
was changed by adding or deleting steps	.023	.681	-.034	.394
was documented	.245	.657	.209	-.145
A person has been involved in a process for a significant period	.011	.191	.829	.074
A person has been involved in a process a number of times	-.053	.132	.666	.199
A person has been the owner of a process for a significant period	.386	-.065	.633	-.029
A digital resource has been changed as the result of a process	.336	.035	.048	.672
was changed according to the number of cycles (loops)	-.131	.175	.274	.657

Table 22: Rotated component matrix of variables describing process-oriented KM indicators

The first factor can be characterized as 'state change concerning success or standardization of a process'. It consists of the indicators '(A process) was improved with respect to time, cost or quality', '(A process) has been successfully undertaken a number of times', '(A process) was certified or standardised according to external standards' and '(A process) was internally agreed or standardised'.

The second factor can be characterized as 'state change of description of a process'. It consists of the indicators 'A digital resource describing a process has been changed', '(A process) was changed by adding or deleting steps' and '(A process) was documented'.

The third factor, consisting of the three indicators 'A person has been involved in a process for a significant period', 'A person has been involved in a process a number of times' and 'A person has been the owner of a process for a significant period' exactly equals factor 5 of the analysis of the persons dimension and thus can be referred to as 'state of person involved in a process'.

Factor four can be described like factor two as 'state change of description of a process'. It consists of the two factors 'A digital resource has been changed as the result of a process' and '(A process) was changed according to the number of cycles (loops)'.

As each of the combination-factors was included in two factor analyses, a selection had to be made, to which of the two resulting factors they would finally be mapped to if these differed from each other. However, for most of the indicators of this dimension this was not necessary: The three indicators mapped within factor three of the analysis for processes maps exactly to factor five of the factor analysis for persons. Furthermore, the four indicators within factor one of the analysis of digital resources poses a subset of factor one of the factor analysis of persons which adds another two indicators. This leaves three indicators to assign a final factor. For this decision, the factor in which the highest loading was achieved, was chosen. Therefore, 'A digital resource has been edited by a highly reputable person' is assigned to factor four of digital resources (.814) and excluded from factor two of persons (.715). The indicator 'A digital resource describing a process has been changed' is assigned to factor two of processes (.757) and excluded from factor seven of digital resources (.467). Finally, the indicator 'A digital resource has been changed as the result of a process' is assigned to factor seven of digital resources (.869) and excluded from factor four of processes (.657). The resulting factors are presented in Table 23.

no	type	factor	indicator
1	single occasion	change in a digital resource's context of application	A digital resource was made accessible to a different user group
			A digital resource became part of a collection of similar information
			A digital resource is referred to by another digital resource
			A digital resource has been accepted into a restricted domain
2	single occasion	state change due to creation of a digital resource	A digital resource was created/refined in a meeting
			A digital resource was prepared for a meeting
			A digital resource was created by integrating parts of other digital resources
3	single occasion	state change due to a digital resource being handled by influential person	A digital resource has been edited by a highly reputable person
			A digital resource was presented to an influential audience
4	single occasion	change due to the selection of a digital resource	A digital resource has become part of a guideline or has become standard
			A digital resource was selected from a range of digital resources
5	time period	state of stability after editing a digital resource	A digital resource has not been changed for a long period after intensive editing
6	single occasion; time period	state change due to individual learning, handling a digital resource or a state of network positioning	A digital resource has been accessed by a different group of persons
			A digital resource has been changed after a person had learned something
			A person has a central role within a social network
			A person has acquired a qualification or attended a training course
			A digital resource has been used by a person
			A digital resource has been assessed by a person
7	multiple occasions	state of perceived expertise	A person is an author of many documents
			A person is approached by others for help and advice
8	single occasion	state change of a person's role	A person has contributed to a project
			A person has contributed to a discussion
			A person changed its role or responsibility

9	time period	state of experience of a person	A person has significant professional experience
			A person has been a member of the organisation for a significant period
10	time period	state of person involved in a process	A person has been the owner of a process for a significant period
			A person has been involved in a process for a significant period
			A person has been involved in a process a number of times
11	single occasion	state change concerning success or standardization of a process	A process was improved with respect to time, cost or quality
			A process has been successfully undertaken a number of times
			A process was certified or standardised according to external standards
			A process was internally agreed or standardised
12	single occasion	state change of description of a process I	A digital resource describing a process has been changed
			A process was changed by adding or deleting steps
			A process was documented
13	single occasion	state change of description of a process II	A digital resource has been changed as the result of a process
			A process was changed according to the number of cycles (loops)

Table 23: Factors for KM indicators

All factors found were mapped to a specific type of occasion. A concept could either relate to a single occasion, multiple occasions or a time period. For nearly all factors it was possible to define a single type of occasion. The only factor for which we were not able to create a subsuming, precise description was factor seven. Altogether 13 factors were extracted that represent 38 individual indicators on a medium level of abstraction between knowledge maturing indicators and dimensions.

Eight factors clearly concern single instances and thus specify single occasions reflecting that knowledge maturing has happened. One factor comprises indicators that relate to multiple instances of happenings or states and thus specify multiple occasions that together reflect that knowledge maturing has happened. Three factors are about time periods which reflect that one can take progression of time in some cases as an indicator that knowledge maturing should have happened. Finally, factor six comprises indicators that mostly are about a single occasion, but the indicator 'A person has a central role within a social network' reflects a state that reflects a development that covers a certain period of time.

Eight out of 14 factors represent a change in a state, so that knowledge maturing can be assumed if a process, person or digital resource has changed in a certain way described by the respective indicators. Five factors represent a state that has been achieved which reflects that knowledge assumedly has matured, otherwise one could not achieve that state. Again, factor six reflects mostly state changes, but the indicator 'A person has a central role within a social network' reflects a state achieved. It is not surprising that those factors that represent single occasions also represent a change in a state while those factors that represent multiple occasions or periods of time also represent an on-going state.

The factors show no significant correlations (see appendix 8.5.5.8) with organisational demographics such as size, sector and knowledge intensity which confirms that the indicators are considered important independent of what type of organisations are using them.

4.6.3 Qualitative Analysis of Indicators

Interviewees made a comparably large number of comments on the indicators. The indicators were generally welcomed very much as they provide concrete measures that turn an abstract concept such as knowledge maturing into something that is perceived as much closer to being manageable. Many interviewees thought that it was a necessity for concepts in knowledge management in general to be measureable and that the lack of such indicators before MATURE was one of the largest barriers in adopting knowledge management instruments in organizations and, moreover, in keeping them on the agendas of executives and managers of organisational units.

In the following, we describe and analyse the comments made by the interviewees structured according to the four dimensions of knowledge maturing indicators, digital resources, persons, processes and combinations thereof. As a consequence, we focused only on those indicators for which there were a substantial number of comments for further analysis. As the high levels of positive agreement with the statements in general show, most interviewees were confident in the indicators and considered them useful. Thus, we focused in the following on critical comments. For each of those indicators that we analysed in more detail (see appendix 8.5.5.9 for the results of the coding process), we identified primary contextual factors that are considered important to assess an indicator's applicability for assessing that knowledge maturing has happened.

Digital resources

A digital resource has been accepted into a restricted domain

Interviewees struggled with understanding what a "restricted domain" means, even after examples were given by the interviewer. As a consequence, there was great variance in responses (see appendix 8.5.5.4) and the scope of examples used by the interviewees, some of them in line with the intended meaning of the question in the interview guideline, but some also outside of it. Therefore, there is no clear picture which suggests that the level of abstraction was too high, and the language used not close enough to their work environment.

Contextual factor	Additional example / narrative
Type of restricted domain	*depends on the type of the restricted domain (in case of portal I would agree)*
Area or unit in the company	*Can tell you areas where I am 100% sure that they are good, but I can also tell you areas (e.g., R&D) where this does not mean anything.*
Purpose of accepting	*maybe that type of documents must be improved in future discussions, but because it is stored to a restricted area it might also be important*

A digital resource has not been changed for a long period after intensive editing

This is the most controversial indicator as can be seen from the histogram/boxplot (see appendix 8.5.5.4) for this indicator.

One of the conclusions from the comments is that one can interpret the stability in two ways: (a) the resource is no longer relevant, or used, or considered useful, and (b) the content of the document has become stable, the knowledge has settled. In the answers, it emerged that there are different organisational cultures (see also section 5.2.2 on sedimentation of knowledge) with respect to the "stability" aspect. Most interviewees with comments to this question reflected on the stability more critically, e.g., *"Best practice in the description of real life doesn't last very long"* or *"They have their stuff for two years. Every two years there is a revision; time-limited validity. After two years, it has to be reapproved whether it is still up-to-date."* Even for stable knowledge, they expect changes to artefacts representing it, e.g., *"how to calculate a business case, this standard will not be changed in 100 years, but nonetheless, if such a standardized document does not change, and you don't put current projects or examples into it, then I would find that strange. Is a matter of attitude - you have to change things for making progress. Would be a bad sign for me."*

Contextual factor	Additional example / narrative
Type of digital resource	*e.g. a report that is not updated for a while is not mature where as a guideline that isn't changed but lived on could be*
Type of knowledge / content	*for Wikipedia I would say, yes, exactly when something was edited very intensively, many have contributed, and then it remains unchanged for a long time, then this is definitely an indicator for a good resource. That you can sufficiently trust*

	it.
Reason for not updating any longer - High quality - Stable knowledge - Obsolete or outdated - Non-acceptance	*You have to ask for the causes: was it really prepared so well, or does nobody follow it, is it not useful for anyone, whatever* *it could be standardized in the meantime* *could also be an unimportant document that wasn't agreed to in negotiations or is not up to date anymore* *Could also be the cases that somebody put effort in it, but afterwards it is completely ignored.* *either it is completely outdated and can be thrown away, or it is really the standard* *Because it fits perfectly, which I noticed after intensive editing? Or you just they can't be bothered with touching it anymore. If I change something because that wasn't good before and now it is good so that I don't have to change it anymore, then it is strong knowledge maturing. If I don't like looking at it, then I don't know if it is good or not.*
Length of period	*2 years, 3 years,*

A digital resource was selected from a collection of resources

A global analysis of the documents seems to suggest that the assessment of this indicator was mainly done with the quality of the document in mind, less with the contribution to knowledge maturing as such.

Contextual factor	Additional example / narrative
Person who selects	*The person that selected the ressource matters more*
Method/purpose of selection	*depends on the ranking that has been used* *Depends always on the selection process. If you just pick one randomly, then it could be of bad quality, but if I say I work on it, open a panel, get some consulting etc. and say, this is exactly what I want, then I would agree* *Was selected for deletion, or what? Selected for the start page, then I do agree that this is super mature, probably when selected for deletion, this is not so mature or obsolete*
Content	*depends individually on the resource*
Quality of the collection	*From rubbish I can select rubbish.*

A digital resource was prepared for a meeting

A key problem with this indicator is the fact that for a meeting, the maturity of knowledge only plays a minor role. Political aspects were mentioned frequently, also that presentation has priority over profound knowledge (*"the biggest idiot can make a PPT that looks nice"*).

Contextual factor	Additional example / narrative
Relevance of the meeting	*Some meetings are more carefully prepared than others. For a meeting with the executive board I would agree or strongly agree. A peer meeting or meeting with a lower level, you can prepare it in a more relaxed way.*

| Political aspects
  - power
  - interpersonal problems | *especially in meeting, there are completely other factors that play a role than arguments or the correctness of a date, or whatever, but there play completely other things a role. [...]In a meeting, there are so many political things, who can deal with whom, who has which relationship to whom, here I have become very sceptical.* |
| | *Sometimes member of a department wouldn't like to give a clear perspective on a subject to the other participants /members of other departments internal policy, people fear to give more information away than they will get back from others* |

A digital resource was created by integrating parts of other digital resources

This indicator was mainly related by interviewees to 'copy & paste' activities. Thus, it is no surprise that the integration of parts of resources does not create an advancement of the maturity, but inherits it from its sources. The vast majority of comments interpret the indicator, as an indicator for the state of maturity of the resultant artefact, not as an event signalling knowledge maturing.

Furthermore, due to the association with the copy & paste syndrome, it was seen even a bit more critical (*"Plagiarism without thinking on your own. Except if you can be sure that you have really just taken the best. You can also copy&paste out of laziness."*), also mixing as such was not seen as advantageous (*"Ah, that's mixing with other sources. That's mostly bad as you are losing information."*).

Contextual factor	Additional example / narrative
Quality (of the sources)	*Could be good literature or qualified resources, then I can easily agree. But you can make mistakes, that depends for me on the source.*

Persons

A general observation from analysing the comments in this area of indicators is that in many cases individual learning was interpreted as maturing of the individual's knowledge. This suggests that we have to interpret the assessments of the interviewees as whether individual learning has happened, or whether the person is experienced and competent.

A person has acquired a qualification or attended a training course

Comments on this indicator mainly reflect on the role of formal training in the respective company and the value assigned to formal qualifications. As to be expected, there can be different perspectives on formal training contributing directly to knowledge, or competence, and the significance of qualifications. For some, they don't matter at all (*"knowledge is gained from experience"*). Other respondents reflect on the difference between possibly inert knowledge that has been acquired as part of a course, and applied knowledge (*"Pure knowledge, the acquisition of information, is far from applied knowledge in a task, in practice, could be buried somewhere with the person.", "qualification matters only when used and performed")*. Others differentiated between activities that are active (acquiring a qualification) and passive (attending a course): *"You can sit in a training, but acquiring a qualification is active."*). For knowledge maturing, this suggests that an individual can be both active and passive in the process.

Contextual factor	Additional example / narrative
Quality of training	*depends on what training course*
	Depends on the training. You can sit in a training, and say the food was delicious. , e.g., pharmaceutical trainings. You can get 250 points in medicine.

A person changes its role or responsibility

The analysis of the comments shows that those who disagreed with this indicator found it to be unclear. It was not clear what kind of change is required (upgrade/downgrade), the relationship to the old position, and also the reason for the change (*"the new cabinet, where you wonder why the minister for economy suddenly becomes minster for defence. Wow, that's fast. Politics may be a bad example, because a*

minister does not have to have the detailed professional competence, but in companies, changes to the responsibility can be related to other things. This is no or no good indicator").

A person has contributed to a discussion

The comments suggest that "contribution" as such is too unspecific. It is not clear how significant, how good etc. the contribution was (*"This has always a content component, just contributing   - if only rubbish comes out of it...?"*).

Interestingly, one respondent made explicit his understanding of the indicators for this section as indicators for the advancement of knowledge of the individual (as outlined in the beginning): *"The knowledge maturing process of others would be supported if I contribute to a discussion. Only when someone else comments on my contribution, it can lead to knowledge maturing within me."*.

Contextual factor	Additional example / narrative
Quality of contribution	*depends on the contribution*
	If that leads to knowledge maturing... you can also contribute garbage to a discussion.

A person has been member of the organisation for a significant period

Clearly, this indicator suggests the measurement of experience and competence of the individual. This is mostly confirmed in the responses. However, several respondents differentiated between the accumulation of knowledge and experience and the contribution to knowledge maturing, this was mostly seen ambivalent: *"Clearly, special know-how, routine knowledge, but... maturing only under certain conditions. At some point, it stops."* Or: *"it depends on what the employee does, if he wants   to acquire knowledge - he can just sit on his place forever"*. As seen in the context of activities with the importance of interactions with externals, getting new employees from outside was seen as an important alternative: *"a new member of staff may bring different ideas and new methods of working and if accepted would be a good indicator of knowledge maturing, someone who has been in the organisation for a significant period may need to refresh her ideas."*

One respondent made an explicit link to the sociofact dimension of this indicator: *"If only you would write 'is member of the organization for a significant period of time and knows a lot of contact persons', then I would see it much more positive."* This indicator, however, is also part of the list of indicators: 'A person has a central role within a social network'.

A person has been author of many documents

Here mainly the issue of respondents was related to the quality of the documents:

Contextual factor	Additional example / narrative
Quality	*relevance unknown*
	Just means that he can write well
	Quality of the documents matters.
	quality before quantity

Processes

A   process   was   certified   or   standardised   according   to   external   standards
While the majority of respondents rated the indicator on certification quite high (see appendix 8.5.5.4), those who disagree have given their reasons for disagreement in the comments. These mainly follow two lines of argumentation:

- **Certification as paper production.** It is not uncommon that certification is mainly about documenting, and formalizing, less about actually doing something in better way: *"If you have*

not generated it exclusively for ISO, then I agree". Or: *"That's the question how far the processes live or if it is just on the shelves."*

- **Significance of certification.** The other objection is that you actually get certified for describing things appropriately, but not for doing something that makes sense, as the example shows: *"If you describe a process properly, you get ISO approval. But the result does not make sense. We are relatively certification-free in the company. Simply because if you only describe a process without looking at the result, you have a good process description, but a bad result. Like the lifesaver made out of concrete, technically possible, you get ISO certification if you tell how to produce concrete and everything, but it does not make sense."*

Contextual factor	Additional example / narrative
Institutionalisation	*A crucial factor is whether the standardised or certified processes actually are rolled out and people adhere to them.*
Business value of process	*Standardisation and certification says a lot about how well a process is documented and not, whether it makes sense from a business point of view.*

A process has been documented

The same line of argumentation (to a lesser degree) also applies to the indicator on documenting a process: *"documenting a process can be just for the drawer. But when you don't live it, you can forget it".*

Interestingly, documenting a process was seen by one respondent as "counter-productive"; one respondent even elaborated more on the tension between formalized and optimized processes and the human dimension which was seen as more important for knowledge maturing: *"The process and what comes out of it is a good thing, but it does not respect the satisfaction of employees, the environment, whatever. That has also to do with values, and there I think about things like creating a document where you need to get a number, and then this, and then that, and this is cumbersome, but ensures that something good comes out of it, but for the people behind it, this is inconvenient. [...]for me maturing is associated with humans, who grow".*

Additionally, one respondent even saw the documentation as a sign for low maturity of the process knowledge: *"if you have to document a process, it is not simple, then it has also not yet matured".* The assumption behind this statement is that a mature process is internalized by the involved persons so that no documentation is needed.

Contextual factor	Additional example / narrative
Institutionalisation	*A crucial factor is whether the documented processes actually are rolled out and people adhere to them.*
Agency	*It makes a difference whether a process is performed primarily or even exclusively by people or by machine agents (e.g., straight-through processes). In the latter case, documentation is a prerequisite for automation. In many cases, there will be some combination of the two, though.*
Internalisation	*If a process is carried out exclusively or primarily by people, then one might have to assess to what extent process participants have internalised a process.*

Combinations

A digital resources was assessed by a person

From the quantitative analysis, the responses are quite controversial, and there is no clear tendency (see 8.5.5.4). While the number of comments, in general are significantly lower for the combinations dimension than for the previous three dimensions, they suggest that the indicator misses out important aspects of that assessment: the result, and the assessing person.

One additional aspect mentioned is that the assessment as such does not contribute to maturing, but it depends on the effect: *"Assessment also matters, but it depends how it evolves from there, whether the assessment is taken seriously - only then it contributes to knowledge maturing. Sometimes people don't care if it is assessed negatively, or how good the effect of critical statements is."*

Contextual factor	Additional example / narrative
Result of assessment	*That's the question: positively or negatively?*
Person who assesses	*Depends on the person, I mean, if rated by an incompetent person, the document does not get a higher value* *depends on the person; quality assessment often done by at least two persons*

A digital resource has been used by a person

Similar to the previous indicator discussed, it is also rated controversial (see appendix 8.5.5.4), and the reason for that seems to be that important details are left out: how the document is used, and which person uses it.

Contextual factor	Additional example / narrative
Type of usage	*What does "use" mean? Somebody accesses a document? I.e., tracking how many hits a topics has, then it would be more important. Is that knowledge maturing? Rather not, that must be more detailed. The digital menu card is accessed by 50 users a day, then it is extremely mature, while the detailed description of how to build your business in another country is only used every five years. That means totally unimportant [according to the usage criterion], but it is possibly better and more important than the others. Pure usage is difficult.*
Person who uses	*depends on the person* *depends on motivation of the person and her education*

A person has been the owner of a process for a significant period of time

While in general, this seems to be an acceptable indicator (see appendix 8.5.5.4), comments to this question show that this indicator is difficult to generalise and seems to be organisation-specific in certain respects. This particularly centers around the meaning of process owner: "Owner who has written the process? Or owner who just has the position?" Or: *"Simply being owner does not tell anything what she did with this process."* Whether this contributes to maturing seems to be subjective and probably based on organisation-specific experiences: *"a person may have significant experience of a process, but unless the process is reflected upon and reviewed, it is not necessarily a good indicator"* vs. *"He has collected experiences, here I like the question more: he also collects the trade-offs, the problems, the potentials for improvement, he knows then how it runs the right way."*

Contextual factor	Additional example / narrative
Level of reflection on process	*A crucial factor is whether process owner is just a formal role or whether that person reflects on an improves the process.*

4.6.4 Suggested new knowledge maturing indicators

Similar to the knowledge maturing activities, we have also analysed the suggested new indicators with 89 responses from interviewees. These were grouped into 41 indicators. This was the basis for a new structure of the indicators (which is already displayed in table 23). These will be discussed in more detail in section 5.5.1.

Code	count	high level	mid level
resource-evaluation	4	artefact-related	rating/assessment
referral	1	artefact-related	rating/assessment
resource-usage	8	artefact-related	usage
resource-adoption	7	artefact-related	usage
resource – number	1	artefact-related	usage
resource-repeated usage	1	artefact-related	usage
usage interdependency	1	artefact-related	usage
resource-external	1	artefact-related	usage > scope of users
resource-scope of users	1	artefact-related	usage > scope of users
resource-usefulness	1	artefact-related	usefulness
organisation-performance acquisition	2	impact/results	company success
organisation-performance customer satisfaction	1	impact/results	customer satisfaction
organisation-patents	2	impact/results	patents
organisation-performance	9	impact/results	performance
process performance	1	impact/results	process performance
organisation-performance errors	1	impact/results	quality of products/services
Products	1	impact/results	quality of products/services
produt identification	1	impact/results	quality of products/services
organisation-publications	1	impact/results	quality of products/services
person-collaboration	1	individual-related	competence
person-invitation	1	individual-related	competence
person-involvement	1	individual-related	experience
person-position change	1	individual-related	experience
person-scope of experiences	1	individual-related	experience
person-assessment	1	individual-related	individual performance
person-HRD	2	individual-related	participation in HRD measures
person-mentoring	2	individual-related	role in social network
process – scope of contributors	1	sociofact-related	agreement > scope of contributors
organisational culture	2	sociofact-related	collective capability
organisational environment	1	sociofact-related	collective capability
organisation-values	1	sociofact-related	collective capability
organization – employee autonomy	1	sociofact-related	collective capability
organisation-fluctuation	3	sociofact-related	HRD
organisation-HRD	3	sociofact-related	HRD
organisation-investment	1	sociofact-related	mid level
organisational change	3	sociofact-related	organisational development
process change	3	sociofact-related	organisational development
collaboration	10	sociofact-related	quality of collaboration
organisation – external collaboration	1	sociofact-related	quality of collaboration
organisation-reflection	3	sociofact-related	reflection processes
organisational structure	1	sociofact-related	
Total	89		

Table 24: Suggested new indicators

4.6.5 Resumée

Summing up, on the generic level of KMI dimensions, process-oriented and person-oriented indicators were rated higher and significantly more than those oriented towards digital resources and combinations. 14 factors were extracted that represent 38 individual indicators on a medium level of abstraction.

Eight factors clearly concern a single instance each and thus specify a change in a state due to a single occasion reflecting that knowledge maturing has happened. Two factors comprise indicators that relate to multiple instances of happenings or states and thus specify multiple occasions accumulating into a state that reflects that knowledge maturing has happened. Three factors are about time periods passed by to achieve a state which reflects that knowledge assumedly has matured, otherwise one could not achieve that state. One factor comprises indicators that mostly are about a single occasion and thus a change in a state, but one indicator reflects a state covering a certain period of time.

Interviewees took the indicators seriously and let the interviewers participate in their reflections on what such an indicator could mean in their work environments. Often, the indicator could be interpreted as "good" or "bad" with respect to knowledge maturing, depending on some additional context factors. Therefore, MATURE needs to be well aware of the fact that maturing services that rely on indicators will need to consider as much context as possible so that chances are maximised that the indicator actually points toward something beneficial happening with respect to knowledge maturing in that organisation in order to be as useful as possible.

The feedback we have got in the interviews and in talks with practitioners has been very promising. Practitioners are really excited about the fact that here are some concrete indicators that they might look at when assessing knowledge maturing with the intention of designing a targeted intervention into improving knowledge maturing. The indicators are just that, though, indicating that knowledge maturing might have happened, yet they are strongly dependent on the context and, thus, as with all indicators that assess success, performance or quality of facets of socio-technical systems, they need to be interpreted with care.

4.7 Types of Organisations with Respect to Knowledge Maturing

One could assume that organisations differ from each other with respect to their success in performing knowledge maturing. In order to investigate this assumption, we concentrated on the perceived performance of knowledge maturing activities. Alternatives would have been to look at performance of phases or overall performance, however, activities are more fine granular than both, the phases and the overall success thus allowing us to interpret clusters with richer detail. Also, the interviewees turned out to be very interested in the activities. This is for example manifested in a large number of additional statements that we have analysed (see section 4.5). Furthermore, we chose activities because these are most closely related to what support potential tools, developed in the MATURE project, could offer. This is in line with our plan on investigating those data in more detail that are interesting from a theoretical point of view, that were well received by the practitioners asked in the interviews and that are likely to impact our design and development activities most. Section 4.7.1 discusses how we proceeded in developing the clusters using the statistical method of cluster analysis. Section 4.7.2 describes the clusters with the help of demographics such as size, industry sector and level of knowledge intensity. Finally, section 4.7.3 analysis the clusters in more detail with respect to importance, support and success of KM activities and gives a rich description condensed in one label for each cluster.

4.7.1 Procedure of cluster analysis

Goals of this approach are (1) to analyse differences between clusters of organisations in more detail and explore organisations' characteristics that explain differences between perceived success of KM activities and (2) to pave the ground for selecting organisations to be investigated in more detail as part of the subsequent in-depth study (year 3).

We applied a hierarchical cluster analysis to support categorization of organisations regarding the perceived success of performing KM activities. In the following, the steps of the conducted analysis are described in more detail.

Select attributes for evaluation: Selecting attributes for assessing similarity of organisations with respect to success of knowledge maturing is a critical step, as the resulting clusters are highly dependent on these attributes (Aldenderfer and Blashfield, 1996). Aldenderfer and Blashfield (1996) recommend to select a set of attributes that best represents the concepts of similarity under which the analysis operates and at best can be related to a theory supporting the classification, in our case the knowledge maturing model v2 and corresponding concepts that have been explored in more detail, i.e. knowledge maturing activities.

As we focus on the way organisations perform knowledge maturing, the respondents' evaluations of successful performance of KM activities are selected as clustering variables. The KM activities are grounded in qualitative data gained from the ethnographically informed study of year one of the project (see also section 3.3.4) and can be related to theory, i.e. the phases of the knowledge maturing model v.2 described in D1.1 and briefly summarised in section 5.1.1. Each of the twelve KM activities are evaluated by interviewees with respect to (1) importance for increasing knowledge maturity, (2) support in their organisation and (3) successful performance in their organisation. As we concentrate on the latter, 12 assessments measured using a seven-point Likert scale feed as attributes into the cluster analysis.

Perform cluster analysis: Cluster analysis (Aldenderfer and Blashfield, 1996) maximises similarity of objects in the same cluster while similarity to objects in other clusters is minimized. The data set has to be described as a matrix X_D consisting of n cases (the rows) and a attributes (the columns). Each variable $x_{i,j}$ represents the assessment of interviewee i $(i = 1, 2, ..., n)$ with regard to attribute j $(j = 1, 2, ..., a)$.

$$X_D = \begin{pmatrix} x_{1,1} & \cdots & x_{1,a} \\ \vdots & \ddots & \vdots \\ x_{n,1} & \cdots & x_{n,a} \end{pmatrix}$$

In our case, all attributes are measured on the same seven-point Likert scale. Any case with missing data in one of the twelve variables is excluded from the cluster analysis. As this is true for nine cases, 117 out of 126 cases will be part of the following cluster analysis.

There are several methods that can be used to conduct cluster analysis (Aldenderfer and Blashfield, 1996). It might be helpful to compare the results of different clustering methods performed on the same set of data. We relied on a cluster solution gained by a hierarchical agglomerative cluster analysis performing Ward's method using squared Euclidean distance. This method was chosen because it is applicable to the sample data, it creates clusters of relatively equal sizes and it is widely used in social sciences (Punj and Stewart, 1983, Aldenderfer and Blashfield, 1996). The results are depicted by a dendrogram shown in figure 30.

There are several approaches supporting the determination of the number of clusters. Heuristic procedures are by far the most commonly used methods (Aldenderfer and Blashfield, 1996, Hair et al., 2006). Unfortunately, no standard objective selection procedure exists. We decided to rely on a more formal, but still heuristic method that maps the number of clusters implied by the dendrogram against the agglomeration coefficient (Backhaus et al., 2008, Aldenderfer and Blashfield, 1996). The created diagram (see figure 81, appendix, section 8.5.6) shows the growth of the agglomeration coefficient dependent on the number of clusters. If the curve progression shows a so called "elbow", this can be used as a decision criterion to determine the number of clusters (Backhaus et al., 2008). In figure 81 (see appendix, section 8.5.6), the "elbow" suggests that a three cluster solution should be chosen.[13] The three cluster solution is also supported by the structure of the dendrogram (figure 30) in which the numbers of identified clusters are shown.

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[13] Please note: the two cluster solution is not taken into account, as this solution is indicated by an elbow generally in most cases (Backhaus et al., 2008).
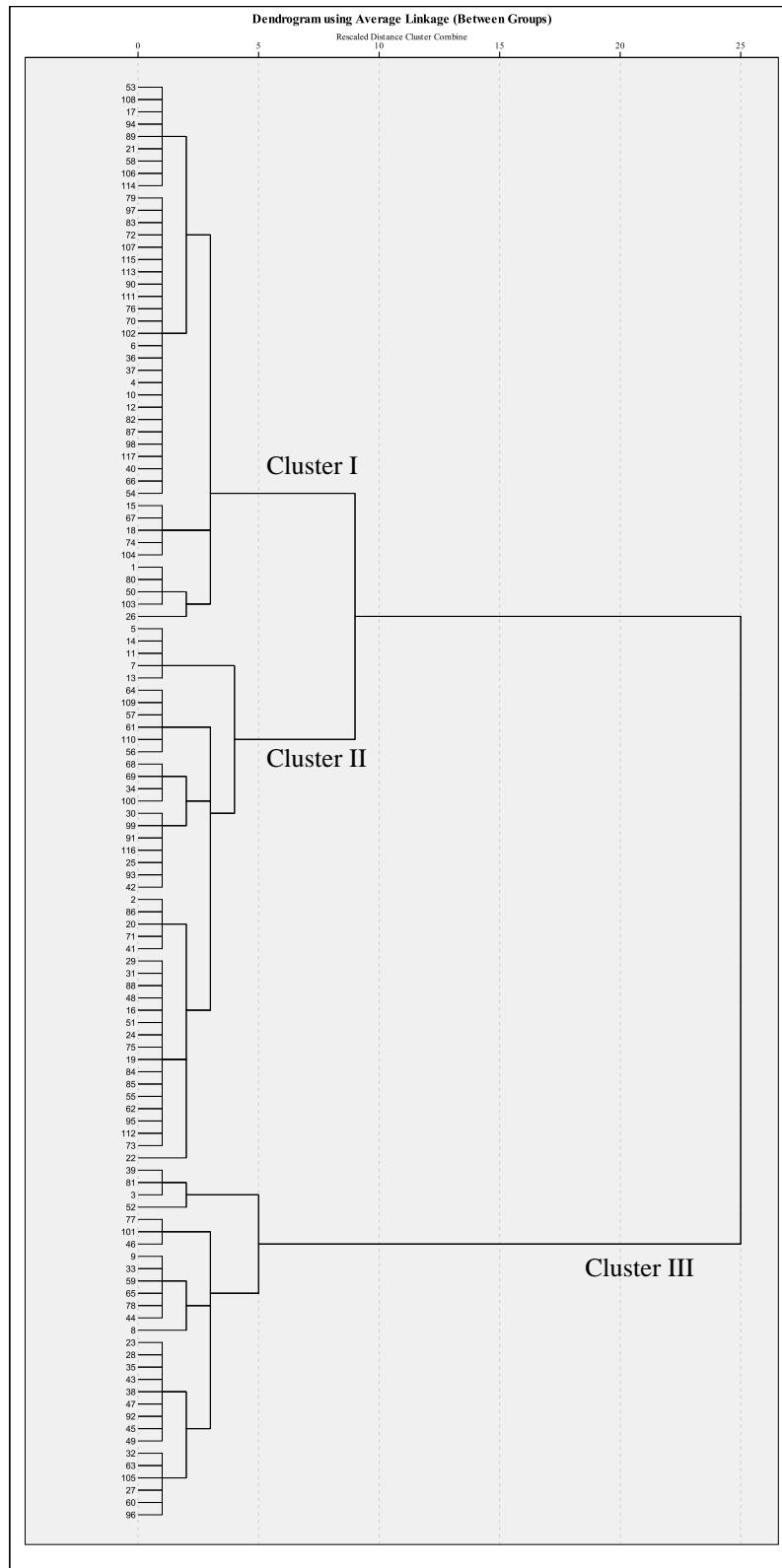
Figure 30: Clustering by KM activities using Ward's method and squared Euclidean distance

4.7.2 Cluster demographics

Clusters I and II of the three cluster solution are of equal size containing 44 cases each. In comparison to them, Cluster III which comprises 29 cases is smaller. This can be seen as a well-balanced cluster solution concerning the number of cases per cluster. Figure 31 shows the clusters in relation to our three strata variables. For each of the clusters, the cases belonging to different strata are depicted in relation to each other. Additionally, absolute values are displayed representing the numbers of cases per strata for each cluster.
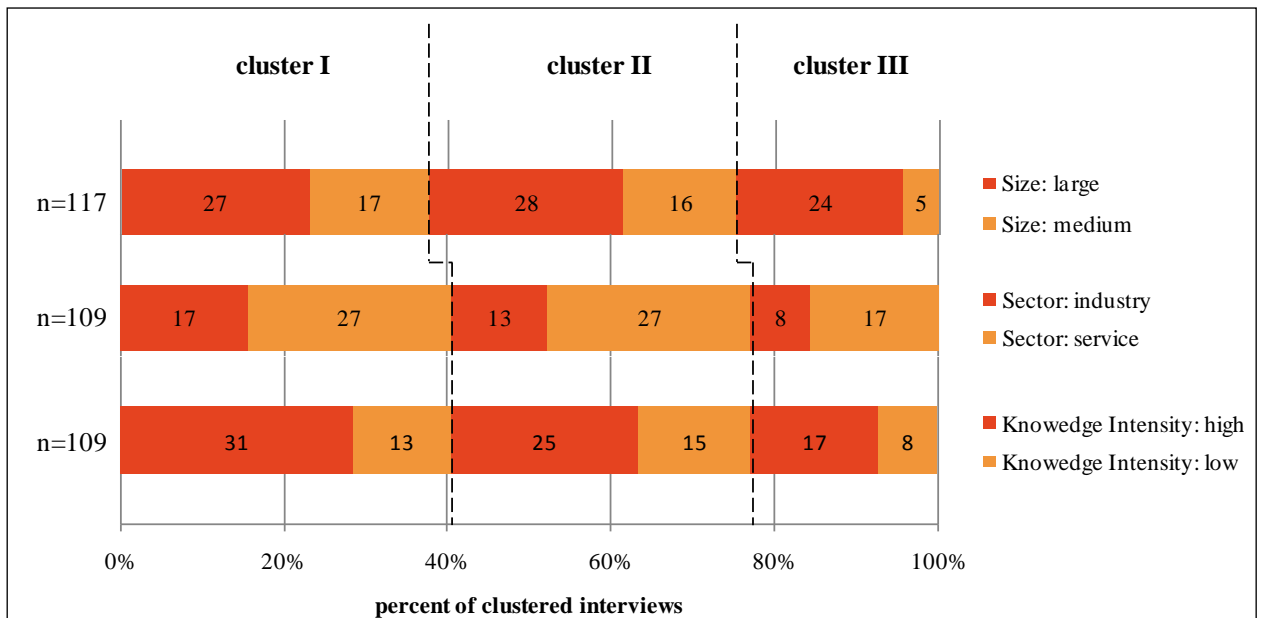
Figure 31: Clusters in relation to strata[14]

In order to study whether the clusters contain a well balanced set of organisations, i.e. whether the distribution of organisations in the clusters corresponds to the distribution in the entire sample with respect to size, sector and knowledge intensity, we employed chi-square tests for comparing the distributions of organisations in clusters in relation to the three variables representing our strata, i.e. size, sector and knowledge intensity. Concretely, we tested whether the observed frequencies shown in figure 31 differ significantly from the expected values based on the overall sample. The results of the tests are shown in the appendix (see table 71 to table 75).

The cross-tabulation of clusters and size shows that the actual distribution is very much in line with the distribution in the sample for clusters one and two with the exception of large organisations which are overrepresented in cluster three[15]. This deviation is not significant, however.

Concerning sector and knowledge intensity, the cross-tabulations of clusters and sector as well as knowledge intensity show that the actual distribution is very much in line with the overall distribution in the sample for all clusters[16]. As all results are not significant, the alternative hypotheses (observed values differ from expected values) are not supported. Thus, the clusters were built independently from sector, size or knowledge intensity of an organisation and the clusters are composed of sets of organisations that are representative of the sample.

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[14] Please note that n is lower in the cases of sector and knowledge intensity because not all organisations could be assigned to these (see section 4.3 for details).

[15] 24 out of 29 organisations are large compared to 19.6 expected organisations. These 24 organisations account for 82.8% of organisations in cluster three compared to shares of 61.4% and 63.6% for clusters one and two)

[16] Differences between expected and actual value are 1.8 at most.

4.7.3 Cluster labelling

The three charts visualised in Figure 32, figure 33 and figure 34 show the mean values of perceived importance, support and success of the twelve knowledge maturing activities for our three clusters.
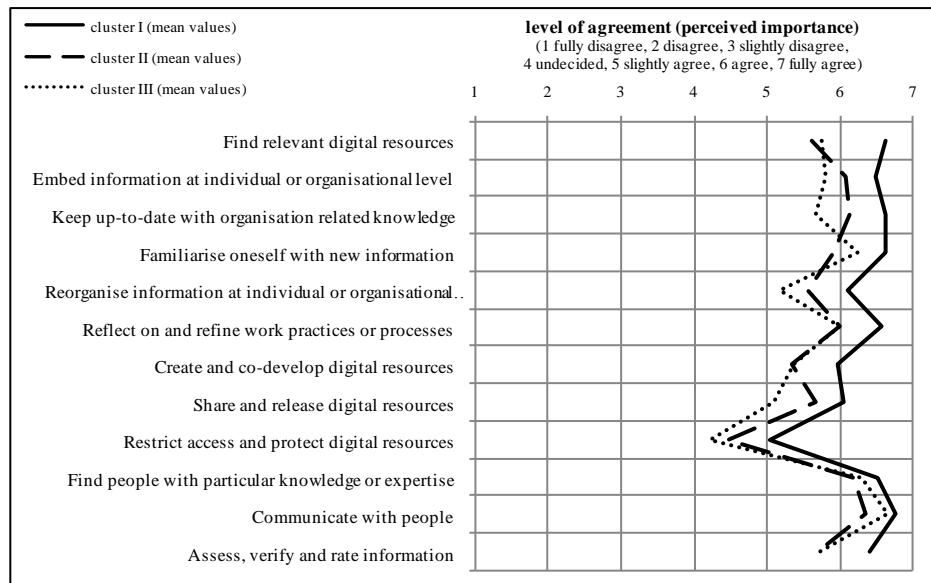
Figure 32: Perceived importance of KM activities (question 12) grouped by clusters

Clearly, clusters have been separated from each other with respect to perceived success of knowledge maturing activities. With the exception of the two activities "keep up-to-date with organisation-related knowledge" and "restrict access and protect digital resources", both, success and support are perceived as quite different between all three clusters. Cluster one receives the highest perceptions of success and support for all KM activities. Cluster three receives the lowest perceptions of success and support for all KM activities. The mean values for organisations allocated to cluster two all lie in the middle between the values for cluster one and cluster three with a fair distance to either one of them. Exceptions are the two activities "keep up-to-date with organisation-related knowledge" for which cluster two and one have similar mean values and "restrict access and protect digital resources" for which cluster two and three show similar mean values.
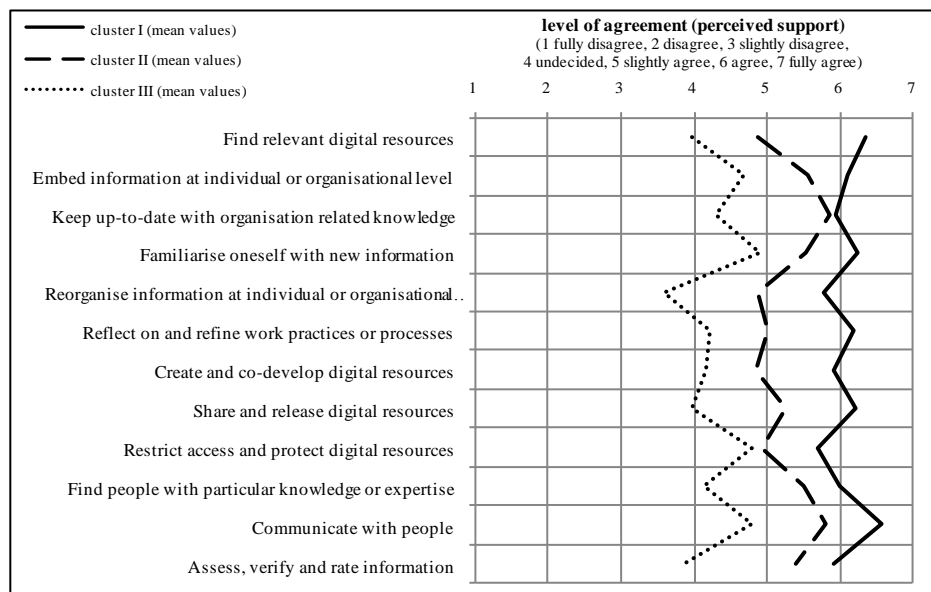
Figure 33: Perceived support of KM activities (question 13) grouped by clusters

- This pattern – cluster one having the highest values, cluster three showing the lowest values and cluster two lying in between the former two also holds for the two sets of questions on perceived support and perceived success concerning knowledge maturing phases (see figure 82 figure 83, appendix, section 8.5.6) as well as the estimated overall success of knowledge maturing (see figure 35). Cluster one thus comprises the "best performers", cluster two selective organisations and cluster three comprises the laggards:
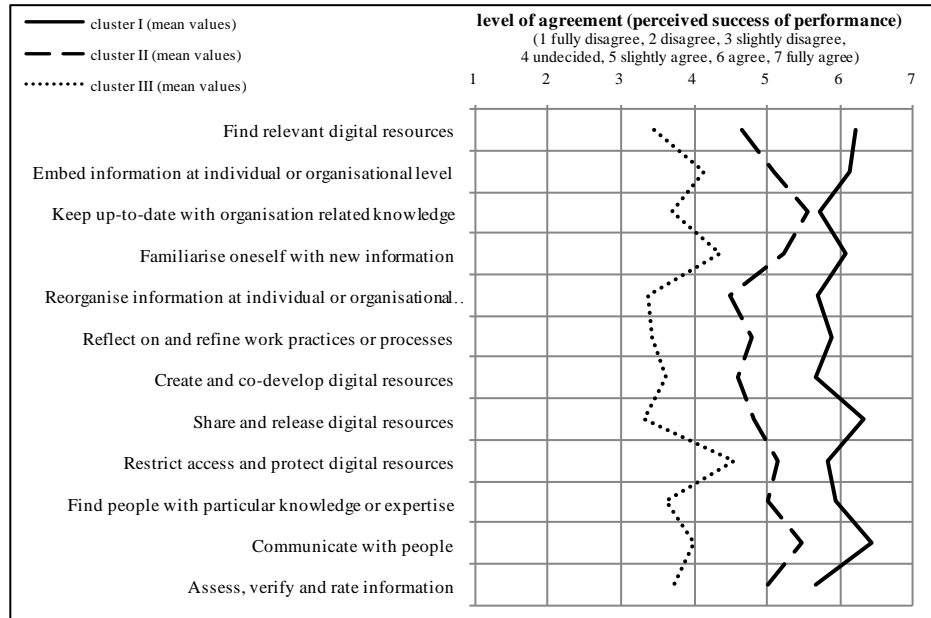
Figure 34: Perceived success of performance of KM activities (question 14) grouped by clusters

Cluster 1: "best performing maturers": These organisations can be characterised as perceiving themselves as highly successful with respect to support and success of knowledge maturing. This holds true for all phases and all activities and both the fostering and support they give as well as how successful they perceive themselves. Compared to organisations in the other two clusters, they seem to be particularly successful with respect to the phases "distributing in communities"[17] and "formalising"[18] as well as the activities "find relevant digital resources"[19], "reorganise information at individual and organisational level"[20] and "share and release digital resources"[21].

Cluster two: "people- and awareness-oriented maturers": These organisations lie in the middle between best performers and laggards. With respect to the individual-oriented maturing phases "expressing ideas"[22], "individuation"[23] and "ad-hoc training"[24] as well as with respect to awareness-oriented activities such as "keep-up-to-date with organisation-related knowledge"[25] and "assess, verify and rate information"[26] and people-oriented activities such as "find people with particular knowledge or

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[17] Mean difference cluster one – cluster two: 1.16.

[18] Mean difference cluster one – cluster two: 1.00.

[19] Mean difference cluster one – cluster two: 1.55.

[20] Mean difference cluster one – cluster two: 1.20.

[21] Mean difference cluster one – cluster two: 1.50.

[22] Mean difference cluster one – cluster two: 0.66; cluster two – cluster three: 0.81.

[23] Mean difference cluster one – cluster two: 0.75; cluster two – cluster three: 1.08.

[24] Mean difference cluster one – cluster two: 0.82; cluster two – cluster three: 1.25.

[25] Mean difference cluster one – cluster two: 0.18; cluster two – cluster three: 1.86.

[26] Mean difference cluster one – cluster two: 0.66; cluster two – cluster three: 1.30.

expertise"[27] and "communicate with people"[28], they are closer to the best performers. With respect to the phases "distributing in communities"[29], and "formalising"[30] as well as with respect to the activity "find relevant digital resources"[31] oriented towards the handling of digital resources they are closer to the laggards.

Cluster three: "the hesitant formalists": These organisations perform worst with respect to all activities and phases of knowledge maturing and also with respect to the perceived overall success, although this group also has the largest variance. They perceive themselves as comparably supportive and successful with respect to the phase "formalising"[32] and the activity "restrict access and protect digital resources"[33]. With respect to the phases "ad-hoc-training"[34] and "distributing in communities"[35] as well as the activities "find relevant digital resources"[36], "share and release digital resources"[37] and "reflect on and refine work practices and processes"[38], they perceive themselves as particularly badly performing compared to interviewees' perceptions in the other two clusters.
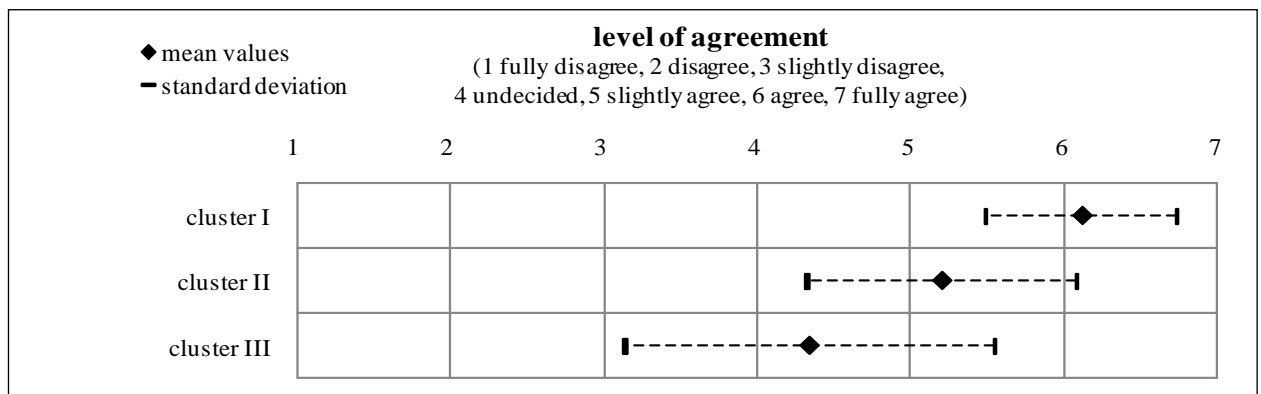
Figure 35: Overall success of KM (question 17) grouped by clusters

In clear opposition to the comparably large differences between the clusters with respect to perceived support and success of most knowledge maturing activities and phases, the clusters score fairly similar concerning the perceived importance of knowledge maturing (see figure 32). Somewhat pronounced differences can only be seen with respect to the activity "find relevant digital resources". Also in clear opposition to the pronounced differences, the interviewees agreed very strongly with respect to the perceived suitability of the knowledge maturing indicators no matter whether the indicators were attributed to persons, processes, digital resources or combinations thereof (see appendix 8.5.6, figure 84 to figure 87). Somewhat pronounced differences can only be seen with respect to the indicators "was created by integrating parts of digital resources" (digital resource) and "has acquired a qualification or attended a training course" (person). Thus, assumedly the general importance of indicators is not dependent on success of knowledge maturing and those indicators that are deemed important can therefore be useful for organisations in all clusters. Thus, knowledge maturing indicators assumedly can be applied no matter what an organisation's level of maturity with respect to knowledge maturing is.

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[27] Mean difference cluster one – cluster two: 0.91; cluster two – cluster three: 1.40.

[28] Mean difference cluster one – cluster two: 0.95; cluster two – cluster three: 1.48.

[29] Mean difference cluster one – cluster two: 1.16; cluster two – cluster three: 0.89.

[30] Mean difference cluster one – cluster two: 1.00; cluster two – cluster three: 0.41.

[31] Mean difference cluster one – cluster two: 1.55; cluster two – cluster three: 1.21.

[32] Mean value of 4.52.

[33] Mean value of 4.55.

[34] Mean value of 3.59.

[35] Mean value of 3.86

[36] Mean value of 3.45.

[37] Mean value of 3.31.

[38] Mean value of 3.41.

These results of generally very close perceptions of importance both of activities and indicators underlines the differences between the clusters with respect to support and success as particularly pronounced. These results thus strengthen our general impression that the interviewees reflected very well about the organisational units they represented.

Thus, the cluster solution allows us to separate organisations with respect to their perceived support and success of knowledge maturing. It is particularly interesting in this respect to remember that the distribution of organisations with respect to size, sector and knowledge intensity is fairly balanced between the clusters (see section 4.7.2), so that we have high performers as well as laggards in every industry and every size of organisations, no matter whether the industry is considered knowledge-intensive or not.

4.8 Knowledge Maturing Stories and their analysis

In addition to the interview guideline, interviewers were asked to amalgamate interesting facets that they had come across in their interviews in the form of knowledge maturing stories. This was considered as an important additional source of information for the MATURE project as some interviewees would be willing to move beyond what was asked for in the interview guideline and thus provide additional input about interesting happenings surrounding knowledge maturing in their organisations. Section 4.8.1 briefly explains why we used stories and how this approach is justified in the literature. Section 4.8.2 describes how we proceeded and finally section 4.8.3 presents the results in the form of stories structured according to how enthusiastic interviewees were about our ideas on knowledge maturing.

4.8.1 Rationale for using narratives

A key problem of communicating the knowledge maturing model to outsiders is that due to its theoretical nature on a high level of abstraction, it is usually presented in a strictly scientific format which makes it a little difficult at times for others to develop shared understandings about the knowledge maturing process. Hence in the second year, we consciously sought to generate some narratives which could help everyone share some contextualised stories about knowledge maturing.

The rationale for this way of seeking to understand learning and development could be linked to the way Jerome Bruner contrasted two ways of knowing: the narrative and the scientific. The former seeks to find a **good story** (which resonates with readers as life-like) while the latter seeks to draw out key concepts and ideas by abstraction and the application of logic. As one would expect of a research and development project much of the time, we operate within a formal scientific paradigm. However, in order to complement this approach, we also intend to use narrative in order to examine actions, intentions, consequences and context (see Brown, 2001 for more on this approach).

A good story should be emotionally engaging, capable of application in different contexts and provide a broader framework for understanding generalities, partly because there is a certain looseness of ideas. Generalities in this sense are different from knowledge derived from abstraction: in this case learning and knowledge are the result of multiple intertwining forces: content, context, and community (and the set of expectations with which the reader approaches the material).

Following Brown (op cit) in purposeful storytelling people should get the central ideas quickly and stories should communicate ideas holistically, naturally, clearly and facilitate intuitive and interactive communication. Our intention therefore is to supplement analysis through storytelling to enable us to imagine perspectives and share meanings about different knowledge ecologies by conjuring up pictures more conducive to a culture of learning and development than a formal analytical presentation which is more in the form of knowledge transmission.

The MATURE project itself is focused upon an abstraction: knowledge maturing processes. Further it fits within the enlightenment tradition of knowledge and learning being forces for good and the path to an improved future, as in the defining statement of our project description: "the agility of organizations has become the critical success factor for competitiveness in a world characterized by an accelerating rate of change. Agility requires that companies and their employees together and mutually dependently learn and develop their competencies efficiently in order to improve productivity of knowledge work."

Now in order to do this we focus on "an **analysis of real-world maturing practices**, resulting in a sound general conceptual model of the knowledge maturing process and ways to overcome barriers to it (particularly including motivational and social)." This approach has considerable value but when we have ventured to look at organisations and talk to individuals involved in them many do not share our vision, perhaps because they see the world from a different perspective or view it in more complex ways, which makes it difficult for them to accord a high priority to a collaborative and open approach to the improvement of knowledge maturing processes.

For reasons associated with our project goals our focus is mainly upon those organisations who are interested in improvement of their knowledge maturing processes. However, perhaps it will be helpful to start with a few stories about organisations where our ideas find little purchase.

4.8.2 Procedure

As expected after the pre-study, many respondents were eager to explain their answers to the questionnaire by telling stories of their own company as long as interviewers allowed them to do so or encouraged them to elaborate. This was particularly true for questions 7 to 11, but some elements were further explained when it came to related activities or indicators. Due to the fact that reproducing those stories involves combining pieces together, interviewers were asked to select interesting stories from their subjective view and provide summaries of those in the MATURE wiki. A total of 19 stories were collected from United Kingdom, Spain, Germany, Austria, Switzerland, and Greece. These stories were subsequently analyzed and reflected upon which resulted in the summaries below.

The organisations for which we had broad descriptive stories were organised into three categories: those organisations inclined to, not inclined to and ambivalent towards improving knowledge maturation processes in a collaborative way. The level of description was reduced in most cases in order to create a single narrative about these three types of organisation. For our compelling lead cases we gave fairly full descriptions, in some cases we added a few organisational details in order to enrich the analysis and in a few cases where information about an organisation did not 'add value' to the existing narrative we did not include any detail at all. The data was therefore processed in order to communicate ideas holistically and clearly and facilitate interactive communication with the review team by focusing on some 'big ideas' rather than reproducing too much detail.

4.8.3 Results

There are three major stories assembled below reflecting how some organisations inclined to improving knowledge maturation processes in a collaborative way, while others were not so inclined and a third group are ambivalent. The stories are outlined in ascending order of commitment to collaborative knowledge maturation and we are particularly interested in those organisations which were making use of collaborative knowledge maturation processes. We identified cases where the drivers of these processes were explicit policies and practices for innovation management, while in other cases organisations used collaborative knowledge maturation processes to support particular innovations which were seen as (a series of) one-off events. An alternative, or possibly linked, approach to organisational innovation used performance improvement as the driver of collaborative knowledge maturation processes and performance improvement itself could be linked to 'lean' approaches to manufacturing processes or service delivery. In some of these cases the organisation could be embedded in a wider series of relationships because staff regularly engaged in multi-institutional working or as part of a supply chain or other knowledge sharing network.

4.8.3.1   Organisations not inclined to knowledge maturing

This section presents stories about organisations where people are not inclined to improve (some) knowledge maturing processes in a collaborative way. Where organisations are in a state of conflict or some other basic preconditions for trust and openness are absent due to large-scale redundancies, late payment for services etc. then there may be no appetite for improving knowledge maturation processes in a collaborative way.

We came across a case of organisational restructuring, where people had to reapply for their jobs in a competitive process and the focus of interest for some managers was upon image management and presentation of organisational knowledge in a form which did not reflect what was actually happening. Even in otherwise fairly transparent organisations, individuals and groups may have areas where the official data does not accurately reflect reality: for example, in relation to budget forecasting, target setting, focus on performance indicators etc. Indeed in any number of organisations aspects of the formal institutional knowledge system have become so 'sedimented' (see section 5.2.2.1) that a parallel informal system exists: one manager reported that you do not even put something into the formal system until you have already gained the necessary support and approval through the informal system. He went further with a 'story' of how it was actually impossible to survive in the organisation unless you had a network of contacts at the company headquarters whereby you could get your ideas approved. The 'story' may have been partly apocryphal, but the key point is that he told it to new recruits so that they would pay attention to developing their personal networks, which would undoubtedly help them progress in their organisational careers.

The clearest example we had of an organisation which was completely disinclined to improve their knowledge maturation processes in a collaborative way was a large construction company. The processes of formalising and standardising ideas are only carried out by a small number of people for whom these are designated work tasks as part of their roles within the company. However, new technologies are heavily blocked and even censored. Electronic mails are printed and filed as hardcopies. There is a hostile attitude towards new ideas and their distribution in communities. Communication only takes place as a top-down action whereas proactive communication across departments or in a bottom-up manner is neither desired by the management nor part of the company's culture. It is questionable if such an attitude is conducive to long-term success, particularly in the case of a change in management where people who are familiar with new technologies could open up a wider set of opportunities. However, at present the company flourishes, senior managers feel they are in control and there is no urge for a change as the formalising and standardising of knowledge is well supported – it is just that it is tightly controlled by management using an explicit 'command and control' strategy.

Additionally, organisational cultures may vary widely on where they fall on a spectrum of individualist or collaborative behaviour. One human resources director of an investment bank told the following story: Investment banks can have two diametrically opposite cultures – one is completely individualist, where everyone competes with everyone else in the firm, and if you are successful you are made a partner and this reinforces the culture. The other is collaborative with the focus being upon the performance of the team or unit. We have a collaborative culture here, our chief executive says our policy is 'no jerks here': no matter how good an individual if he, and it is nearly always a 'he', is not a team player we will not employ them. Whereas in the organisations in the other camp it is 'survival of the fittest' and some individualists flourish there. The two cultures are so different that we have now set up a 'trek' for our under-graduate interns where they spend time in both types of bank and they can then self-select the culture they prefer.

Now the point of this story from a knowledge maturation perspective is that in the 'collaborative culture' bank they do indeed have collaborative knowledge maturation processes where a great deal of time is spent exchanging ideas about what are the most effective strategies to employ in different contexts. The knowledge maturing model is applied almost in full with several iterations between different stages: collaboration is maximised. Whereas in the 'individualist' banks sharing and networking do occur but they are individually driven and the goal is an individualised end-product rather than a standardised one.

Lessons for the project: organisations have political and socio-cultural dimensions which may mean that the extent to which people are open to ideas for improvement in knowledge maturation processes may be circumscribed. Some of these organisations are highly political in the sense that knowledge is used as tool for power and control and those in control do not necessarily want to change. In other cases, however, organisational culture and the 'sedimentation' of knowledge may have created barriers to change without there being active opposition to ideas for improvement in knowledge maturation processes as such. In these types of organisation the focus is often upon completion of tasks, with 'defensive' relationships between individuals and departments at best and in some cases explicit power-centred competition –

Argyris argued that in such circumstances you would seldom be able to move beyond single-loop learning (Argyris, 1990).

Let us examine in the following section some stories where the challenge of the 'management of change' comes up against organisational inertia or where there are other constraints on engagement with knowledge maturation, learning and development, but there is at least the possibility of more expansive learning.

4.8.3.2 *Organisations ambivalent to knowledge maturing*

This section presents stories about organisations largely ambivalent to ideas for improving knowledge maturing processes in a collaborative way (due, for example, to organisational inertia). Some organisations may be operating with a division of labour and organisation of work where a few individuals have the major (or sole) responsibility for knowledge maturation processes. Alternatively, as in the following example, key expertise may be sub-contracted or reside in individuals.

The company manufactures pre-cast concrete products for the agricultural and civil engineering industries, including bridge beams, box culverts and agricultural slurry tanks, and produces a range of standard and bespoke products. Several years ago the business diversified into manufacture of pre-cast units, which required changes to work processes and the development of new knowledge. Apart from the directors, most other strategic expertise is generally subcontracted: marketing consultants are employed to analyse and report on specific market data; civil engineering consultants perform structural calculations, stress analysis and theoretical modelling as required. In other areas of the company, technical expertise is used largely on an individual basis. Individual products and projects are divided among the project engineers who are expected and encouraged to deepen their own specialist expertise and who were recruited for their knowledge or experience. Individual engineers are encouraged and given a lot of freedom to keep abreast of and explore new technology via the Internet and relevant technical journals. They also tend to have their own personal and professional networks. The engineers tend to work in parallel rather than collaboratively: most activities are performed by each project engineer in isolation. The directors hold ad-hoc discussions with each engineer to review specific projects, but there are no formal reviews or exchange of ideas among personnel, and communication is restricted to verbal exchanges and conversations. Project engineers and designers will record information and knowledge acquired but there is no formal process or central database for this. Individuals store their records and information on their own PCs and this is generally not shared.

With regard to idea generation at shop floor level, there is no mechanism to encourage or develop new initiatives. The manufacturing operations are largely labour intensive. There are no formal procedures or work instructions unless individual project managers explicitly request a specific methodology be adopted. This is always passed on by word of mouth and training is "on the job" and involves learning from colleagues. Some operators are very knowledgeable and skilled at their specific tasks but in many cases there are tasks which only one or a few operators perform and even then there are no standard operating procedures. The only company manufacturing related database which exists and is used regularly is the mixing control software. Overall then, in terms of applying the knowledge maturation process within the organisation, there are certain aspects where this is encouraged and is successful, but there are a number of aspects of the process where it is either not performed at all or it is not being operated successfully. Nevertheless, this is a very successful and growing business. Because it is a family run business it is evident that much of the control and decision making is retained within a very small group. What does not appear to be occurring successfully is the sharing and dissemination of the knowledge gained throughout the business. No formal documentation and very little training are provided for staff. Expertise is either recruited or subcontracted. However, as the business expands and engages with larger and more professional civil engineering construction industry clients, there is some pressure from their clients for a much higher degree of control to be exercised and demonstrated in the manufacture of their products. So, while there has been ambivalence towards collaborative knowledge maturation processes until now, the business may have to engage in quality improvement activities, including making greater use of documentation, standardisation, training and knowledge retention and development.

Many of the other organisations contacted had similar ambivalence towards collaborative knowledge maturation, where it was taking place in particular parts of the organisation. For example, one large energy provider had a continuous improvement programme, where some benefits were generated but participation was now individualised without any wider community involvement. In another case, a rubber and plastics products manufacturer, initial idea generation and appropriation could be team-based, but then the process was taken over by specialists.

Some organisations' ambivalence towards collaborative knowledge maturation stemmed from the perception of senior staff in the organisation that there were parts of the organisation where this could be applied and other parts where it was not considered appropriate. For example, one organisation was engaged in the design, distribution and retail of clothing, with design now being the critical function and the company depending upon knowledge-intensive processes, whereby of the 116 staff 30 were in Purchasing and Design and 20 in Information Technology Support, with most of the remainder working in warehouse and distribution operations, with manufacturing being sub-contracted overseas. Garments are designed and developed by the Purchasing and Design staff. The warehouse is a new "state of the art" facility and lean approaches to stock control and inventory management and the use of IT-supported stock control systems have already delivered major efficiency savings. Staff, in areas other than design and IT, are now expected to carry out routinised tasks and any training tends to be informal and ad-hoc, with perceptions that "the Company Directors are mainly focussed on cost cutting and performance rather than on training issues." There has recently been a major focus on cost cutting for which "forums" have been established in response to an initiative from the directors and cascaded down through senior and middle management. There is no real culture to encourage idea generation and development at lower staff levels within the business. The cost cutting forums have been recently established in response to the recession. The supply chain in fashion retail is now very knowledge-intensive and the company has one of the most modern warehouse facilities in Europe, so the company focuses upon the design team as being the group where expertise has to be continuously developed. Staff are encouraged to research for new ideas using both the Internet and also attending fashion shows and taking trips abroad to stay abreast of developments and new trends. Personal and professional networks are important and individual and collective knowledge develops as whole ranges rather than just individual styles will be developed. Male fashion is also not as dynamic as female fashion, with new ranges launched approximately every 6 months rather than every 8 or 9 weeks. Expertise is generally gained through a recruitment programme rather than from growing and training staff. Designers are generally recruited from the local colleges and universities, using work experience placements to identify bright students who can then be enticed to work for the business. This is a conveyor as they develop experience and may then move on to larger organisations. In terms of knowledge maturing, this company is not a particularly good example of a business which attempts to encourage idea generation or develop systems whereby knowledge is retained. This only occurs on an ad-hoc basis depending upon the individual department managers. The perception given from the interviewee is that the business directors do hold training and staff development in high regard and thus the barriers to knowledge maturing are centred at board level. If there is not encouragement or culture from the top down it then follows that individual employees will lack motivation to generate and develop ideas for the benefit of the organisation. The buying in of young creative talent, particularly after they have shown what they can do on work experience, seems a viable alternative strategy to developing your own talent. However, if the product market changes in some respect or competition increases still further it may be that the company will switch to making more collaborative use of its current knowledge resources.

Lessons for the project: organisations' product market strategies, human resources utilisation strategies (including use of consultants, contractors, sub-contractors and off-shore labour), regulatory environments (for example, medical product developers could not change production processes and quality assurance regimes used to produce products) may produce an environment in which people are open to ideas for improvement in knowledge maturing processes to a limited degree. This contingent approach to knowledge maturing is similar to how these companies may react to high performance working, seeing these as a 'bundle' of practices some of which they may adopt. Additionally, some companies may simply be so bound up with doing their current activities well that they display what Argyris (2004) called 'skilled incompetence', where the focus on doing current activities well can result in neglect of professional growth and longer-term development (Argyris, 2004).

4.8.3.3   Organisations inclined to knowledge maturing

This section presents stories about organisations broadly sharing our ideas about the importance of improving collaborative knowledge maturing processes as a tool for progress, learning and development. Some organisations may be engaged with other related improvement practices associated with high performance working and/or the implementation of 'lean' performance improvement practices which also make use of collaborative learning, development and knowledge maturing. Notwithstanding this it is of interest to look at some stories which individuals working in organisations that broadly share our ideas about the importance of improving collaborative knowledge maturing processes shared with us. It may also be helpful to distinguish between organisations which see innovation as a continuing process and those which view it as an event (or series of events).

4.8.3.3.1   Innovation management as the driver of collaborative knowledge maturing processes

A large highly successful, but still relatively new, IT company is considered by many to be one of the most innovative IT companies of its size. Employees who are willing to elaborate on one of their ideas need to convince their peers that this idea is worth pursuing. Thus, appropriation means self-commitment in this field but can only be maintained if others are willing to join them in their endeavours. After a determined period of time, e.g., a quarter of a year, the results are revisited and it is decided whether efforts are continued or discontinued. Corporate culture and management policies request over-communication, i.e. employees are encouraged to communicate whatever feedback on ideas they have received to more than fewer peers. This system brings a dynamic with it, as employees constantly need to be engaged in cycles of appropriation, convincing and revisiting ideas, some of which are naturally turned into projects that attract as many resources as people are convinced.

A SME manufacturing metal fittings for sliding doors uses an approach to support innovation through management attention. If a new idea is born it is illustrated on a piece of paper (in handwriting and hand painting), which is pinned on a board within the team room. These ideas are discussed within the team and the three best rated ones are introduced to a member of the management during her monthly visit. If an idea is approved by the management it is directly put in place (e.g., a part of a process is optimized or a machine is put to another place or is enhanced with a specific supply). This 'innovation process' is handled equally for all ideas no matter whether it is a completely new idea or an enhancement of an already existing solution, and no matter whether it is something complex or something simple. None of these innovations is captured electronically and the only reward for innovation is management attention: a manager visits the team on a regular basis and takes her time to discuss problems, solution and ideas. The team with the most ideas put in place is mentioned at the Christmas party.

The company is a large and traditional manufacturer that follows a quality leader strategy which was highly successful in the past although the current recession is creating problems. The company boasts longstanding experiences with personnel development and specific knowledge management programs tailored on the one hand to white-collar workers and on the other hand to blue-collar workers. One specific highly successful measure is the way in which process innovations are committed on by all affected parties. The production as well as the maintenance teams are shift workers which means that they can never all meet synchronously. In order to commit on a suggestion for improvement made by one shift, the idea is laid out and documented on a physical blackboard and feedback as well as voting is requested and provided by the other three shifts. If all of the shifts agree and therefore mark it on the blackboard, the initiating shift is authorized to start implementing it. Ideas are never considered as individual with blue-collar workers but are always associated with teams. This is in sharp contrast to white-collar workers in the very same company where a highly individualized culture prevails so that ideas can always be traced back to individuals.

Innovation management is the most important economic factor of this enterprise which is itself involved in knowledge management and consequently the emphasis is on the first three maturing phases. The organisation takes care of appropriate conditions suggested by creativity research to facilitate and encourage the expression and communication of ideas. Much attention is paid to the dialogue and thus processes involved in appropriating and distributing ideas cannot be separated from each other. Since – in this organization – knowledge maturing means collectively developing methods for the emergence of new ideas, phases III to V mainly concern the documentation and dissemination of schemes conducive to

creativity. One example of a learning process resulting in standardization is based on the participation of the enterprise in a project aiming at analyzing and developing creativity-methods for knowledge workers. An essential and final result was the implementation of insights in the form of software supporting innovation by guiding a user through a creativity process. The software has proved to be a useful creativity tool and is both the outcome of a maturing process and an established instrument of the enterprise for expressing new ideas.

4.8.3.3.2 A major innovation process being implemented through use of collaborative knowledge maturing processes

All the above examples are organisations which have explicit policies and practices for innovation management, but innovations may also be treated as (a series of) one-off events. A hardware and software company, which had grown partly through acquisitions, with 500 employees identified they had a problem in trying to ensure that their 40 technical support agents knew enough about newly acquired technology to provide quick and accurate answers to customers on the phone. The company wanted to supplement the website, which had frequently asked questions and text documents, with a more comprehensive knowledge management system. At the same time, they wanted to streamline its customer service organization by making more of its product and systems information available directly to customers and shortening the length of customer calls. "We wanted to leverage the Web for customer self-service versus increasing the number of agents. We also wanted to provide our frontline engineers [who interact directly with customers] with more information more quickly so that they could resolve more calls faster." When they began evaluating knowledge management technologies a few years back, they found the concept of sharing knowledge among agents was nothing new. Agents were already accustomed to working in teams of three or four people, gathering in meeting rooms to solve customers' technical issues. In order to institutionalise such practices, the company actually provided a percentage of agents' quarterly bonuses on the amount of knowledge they submitted to the online system as well as their involvement with mentoring and training other agents. "Each agent was expected to teach two training classes and write at least 10 FAQs to earn their full bonus."

4.8.3.3.3 Performance improvement as driver of knowledge maturing

All the above examples are organisations which have explicit policies and practices for innovation management, but performance improvement activities may also be approached from a collaborative knowledge maturation perspective. The executives of a snack producer company wanted to capture and share best practice but information was scattered around the company in disparate systems, and there was no easy way for the geographically dispersed sales force to get at it: if the 15-member sales team could only access the same information, it would solve many ongoing problems with information sharing and communication. The answer was to build a knowledge management portal on the corporate intranet: a single point of access to multiple sources of information which also provides personalized access.

A well-established food manufacturing company already had clearly defined processes and operation techniques, with significant improvements in work processes and technology in order to remain competitive. The company is constantly involved in the technical development of new products. Most of the processes in the factory are now automated. Hence, a major factor within the organisation was maintaining control over all operations at all stages. Much of this is achieved through automation, but some operations and interactions with technology still require operator intervention and despite established procedures and instructions, problems still arise. The need for consistency of operations is critical and there is little room for error or waste within the manufacturing process, so great attention is given to making sure workers are aware of their duties and responsibilities and how they "know" what they are required to do. For each product, there are written formulae and methodologies which have been developed by a technical department, whose role it is to develop new products; to improve existing products; and finally to support production when problems arise on current product manufacture. These documents are used to form part of operator training and most factory floor operator training is given "on-the-job". This is documented by means of a 'training matrix' which lists all tasks and equipment for which each person has demonstrated their capability. A daily "quality meeting" is held at the start of each day to discuss the previous days' production and to review any non-conformance and waste, in order to decide what happened and any corrective and preventive measures that need to be taken. The meetings

are attended by all production supervisors and the process is designed as a continuous improvement activity where lessons were learned from mistakes made. The company is adopting a classic performance improvement strategy, but as so often it was difficult to get all supervisors to change to more fully collaborative styles of working. [Some companies faced with this problem have removed the 'old' supervisor role and replaced them with 'team leaders'.]

In terms of the knowledge maturing model, the methodology in which ideas are expressed or generated through appropriation, development to eventual standardisation, the organisation adopts a structured approach. A New Product Development team exists for the purpose of not only generating and developing new product ideas, but also, refining and improving existing processes and products currently being manufactured. Idea expression and generation are not confined to this department, as examples were given of the major project carried out over the past year to introduce new business software to replace the previous obsolete system. The company has formal systems in place, both electronic and documented, to record and disseminate knowledge within the organisation.

Other organisations, especially those involved in manufacturing, had fully committed to using performance improvement processes and procedures. One such company manufactured plastic products using thermoplastic forming and extrusion or blow moulding followed by either printing, attachment of pre-printed adhesive labels or sleeving where a printed plastic sleeve is placed over the product. The manufacturing operations are highly automated and a team of process engineers typically develop the tooling and equipment required. They also provide the methodology and operating instructions. Technicians will develop the processes and procedures through a 'trial and error' or 'iterative method' until the optimum solution is achieved. They will then provide training for all operators and issue work instructions or Standard Operating Procedures, which are documented and stored electronically. Staff training is formalised and records maintained within a training matrix format. The company follows a path of Continuous Improvement through a Lean Manufacturing approach. The wider organisational philosophy is very much people and communication focused, not only with customers but also within the business. They believe in exchange of good ideas and working practices between each of their 21 businesses located throughout Europe and encourage idea generation and training of their workforce. The organisational CEO reported that: "A leading position is generated through know how. Know how is generated through training… …communication actions within the enterprise are significantly defined by nine properties; creativity; innovative mindset; seriousness; reliability; open-mindedness; customer orientation; partnership orientation; responsibility and environmental awareness."

This permeates through the group, but with this particular company having been taken over in the past the main barrier to knowledge maturing stemmed from the longer term employees who are reluctant to change because they are suspicious of what this will mean for them and consequently they were wary of change in case it had negative consequences.

The business is very reliant on IT and there is an internal bespoke designed business management system for controlling all aspects of the business from stock control, production control through to financial accounting and human resources management. The business prides itself on being innovative and successful in knowledge growth. The interviewee firmly believed the organisation is very successful with regard to the process of knowledge maturing and cited business growth of over 80% in 4 years as concrete evidence of this. Examples of innovation and idea generation are visible in both large and small projects, all of which have either reached a successful conclusion or are currently ongoing and reported as being "on target". The business operates a KPI system to monitor performance at all levels and uses these to monitor and report within a culture of Continuous Improvement, again evidenced by the business growth and contribution to the group profitability. His only comment with regard to barriers to this is the difficulty in achieving cultural change with more established workers and he finished with the remark: "That's my job to manage the change of culture with the people."

4.8.3.3.4 Lean engineering performance improvement processes being expressly linked to collaborative knowledge maturing processes as a driver of innovation

A construction services company supports maintenance in running and modifying production plants: effectively it sells its expertise in construction engineering and project management in the modification and maintenance of plants throughout their life-cycle. This industry is intensely competitive and the

industry reward mechanisms have changed from being based on 'person-hours sold' to being more directly linked to the output produced by the plant and plant availability. This shift has significantly changed the risk/reward relationship and, in turn, fostered an incentive for this company to ensure remedial work, for example, is not repeated, as well as to provide engineering solutions and support services more rapidly than before. To remain competitive they realized they need to re-use or adapt prior solutions, as well as reducing the time it takes to execute such solutions. This approach also links with a parallel drive to adopt a more standardised 'Lean Engineering' approach which is complementary to the collaborative working of the knowledge management programme used in the organisation and is driven by the same challenges of the business environment.

Some sectors of the organization initially reacted defensively to these changes in the operating environment. But the management decided to treat the changes as a business opportunity and implemented an awareness-raising campaign. Their vision was to become smarter at transferring know-how across the organisation, particularly as the company was expanding on a global scale to maximise the use of their intellectual capital for the benefit of their clients. The anticipated outcomes included changing the work and behavioural patterns of staff and employing suitable techniques and technologies to realise that vision and gain a competitive advantage. This vision is clearly articulated by senior management and strenuous efforts are made to align all activity to support it. The personnel evaluation system is, in turn, linked to achievement of strategic goals aligned to this vision. It was quite a straightforward matter for personnel to include aligned activities related to the knowledge management programme in their own, personal goals.

The knowledge management strategy had also to be seen in the context of an ageing workforce, with a major challenge being to retain the mainly tacit knowledge in the heads of people - their 'know-how'. To address this problem, they recruited in a period of about 5 years around 40 new graduates annually – about four times their previous intake rate. But they still needed a system to ensure that the knowledge of retirees, for example, built-up during a life time of working in the industry was not lost entirely with their departure. Furthermore, they also needed to ensure that personnel had access to all the knowledge tools they need from wherever they were. Frequently, that will be in client offices and on client systems. Any team sent from the headquarters of the company will be relatively small and will need to be able to tap into the rest of the organisation back at base for some skill sets, including accessing web-based communities.

They also recognised that to introduce, and more importantly, to embed knowledge management within the organisation would depend in large measure upon connecting people seeking solutions with those who originally developed them. This formed the basis of the initial strategy of finding skills using a social-networking-like approach, which was basically helping staff to find and talk with other people in the organisation who shared a common interest. They developed a software application to help users find others with similar interests or particular skill sets. The application was available from the web portal, but went beyond the conventional directory as each employee controlled their own profile, rather than having their entry written for them by human resources or their department leader. Also they developed a system that helped staff find information about prior work within their context. In other words, it is about helping staff to dig out and use an existing solution or method, if one exists, instead of spending time and re-inventing it. This helped also to increase the trust levels between staff who may not have worked together before. Indeed, it helped put the two together and overcome the widespread 'not invented here' syndrome, which seems to afflict so many organisations. Such developments were designed to help them move on from the process of simply relying upon the memory of someone involved, or of somebody remembering who was involved, especially given the medium to high rate of staff turnover in the construction industry. The problem of staff turnover is increasingly being compounded by demographic changes as older, highly experienced staff retire to give way to younger staff with much shorter 'organizational memories'.

4.8.3.3.5   *Organisations dependent upon collaborative knowledge maturing processes as a driver of innovation and/or improvement because they are involved in multi-institutional working*

Some organisations are dependent upon their staff using collaborative knowledge maturing processes which span organisational boundaries because their staff routinely work delivering services to and in other organisations. In the latter case the distributed nature of expertise between their own and other

people may pose challenges as to where certain types of knowledge are held and what are the core competences for the company. For example, an electrical repair, installation and maintenance company specialises in the industrial and petrochemical field and mainly works in the installation, repair and maintenance of electrical equipment for industrial organisations. The company has a clear management structure and staff have clearly defined roles and responsibilities, with a director overseeing all work and tendering. Four senior managers are responsible for the different elements of work undertaken by the company and they oversee the day-to-day management of contracted staff. The office based staff are responsible for day-to-day running of the organisation – such as financial records, managing tenders and contracts, website maintenance, plus maintenance of vehicles and equipment. The company has achieved ISO quality status so many of their procedures and policies are well documented.

Work is gained through a tendering process, but much of the company's business has been built up by word-of-mouth and reputation. The organisation has specialist skills and expertise, and there is very little direct competition in their area for the work. As part of the tendering process, a feasibility consultation is provided to the client to produce a range of engineering design options to meet their requirements. When the work has been commissioned the most effective design solution that meets the client's needs is agreed in consultation. At this stage of the commissioning process, the director and senior manager(s) will set out the work schedule and work plan with agreed deadlines, identify appropriate staff, review contractors, and delegate work through team meetings. Therefore, skill and competency requirements for each project are assessed and matched to available resources. Much of the organisation's work is offsite so staff undergo site inductions before work is started. Staff use the project method statement and risk assessments throughout the project. If it is a large project involving several organisations completing different aspects of the job, over-runs and delays in the project are normally the result of other organisations failing to complete work. Design changes and non-conformance reports are recorded, reported and resolved according to the company's quality assurance procedure. When a project has been completed the director will go through the work with the client, ensuring that all aspects have been completed to their satisfaction before the final hand-over. Clients are provided with document maintenance schedules and procedures upon completion of the work, which can lead to further work.

The company had clear management and communication structures, together with well documented processes and procedures which fit well with the knowledge maturing model. However, pressures of other commitments, work deadlines, and sometimes lack of understanding that some information should be shared prevented as full knowledge sharing as desirable. Updating knowledge and skills was considered essential to maintaining the track record and reputation of the company, with IT being used as a tool to support work processes recording and documenting information. The company has considerable project management expertise, but when dealing with other contractors it is interesting that extended collaboration and trust may mean that key aspects of expertise do not reside within the organisation itself but are embedded in the broader network.

4.8.3.3.6 *Organisations dependent upon collaborative knowledge maturing processes as a driver of innovation and/or improvement because of their position in a supply chain*

This issue of where expertise resides could also be seen within supply chain networks. The key aspect in those cases was the extent to which collaborative knowledge sharing was able to take place across organisational boundaries. For example, an aerospace supply chain learning network was set up to provide opportunities for collaborative learning and knowledge development across organisations and to facilitate improved performance within and between companies involved in the supply chain. The intention was to train 'change agents' in each of the companies who would then be responsible for learning, development and process improvement in their own organisations. The initial training and continuing technical support was provided by specialist tutors (Master Engineers) and learning support tutors who were experienced at supporting distance learners in a distributed network.

The training was designed to generate organisational and inter-organisational learning as well as individual learning and development. In particular, the focus was upon supporting SMEs in adapting to demands for increasing knowledge as a foundation for supply chain relationships, and in extending their adaptive and innovative capabilities. The intention therefore was to stimulate economic innovation in SMEs through innovative learning. The learning network was process-oriented, comprising workplace

teams of operators, specialists and managers, which linked eight suppliers to the lead company (a Tier One supplier of complete aerospace systems). They functioned through learning about the core tools and skills needed to improve performance. Teams undertook 'hands-on' learning by doing, which involved problem identification and the development and testing of solutions. The companies were expected to use measurement and improvement tools designed to meet the increasingly demanding quality, cost and delivery standards of customers. It was recognised that this could also involve cultural change as the companies sought to adapt to an increasingly competitive environment.

In the network, the lead company persuaded their suppliers to identify key individuals with central responsibility for shop-floor innovation in supply management. These people, nominated as 'change agents', participated in a series of one week, intensive workshops at the lead company, led by the engineering tutor together with help from the learning support tutor. In the four week intervals between workshops, the change agents applied what they had learned in a practical context in their own companies. They kept in touch with other students via a computer conferencing system and undertook assignments designed to encourage them to reflect on their learning and the implications of applying what they had learned.

As the programme progressed, the focus shifted from work in individual companies to collaborative learning across the network of participating companies. There are obvious advantages of such a programme for the tier one company that sees rapid benefits in terms of the cost, quality and delivery performance of suppliers. There are also competitive advantages for all the companies in the network. Participants also gained as individual learners. The expectation was that the future competitiveness of the companies will be enhanced, whether they are working with this particular customer or not.

The whole rationale of the programme was to support the development of 'change agents' who initially would be involved in collaborative knowledge maturing processes which went across institutional boundaries. The 'change agents' were then expected to drive improvement in their own organisations, while also being able to draw upon the support and expertise of people working for other organisations in the supply chain. It was interesting to see how the 'change agents' fared in two different organisations – the performance improvement techniques were sufficiently powerful to deliver substantive improvement in all cases, but the key issue was whether the organisations embraced the idea of a continuing commitment to collective knowledge maturing processes.

The first organisation, a relatively small specialist engineering company, used as their 'change agent' the chief inspector of the company who had also previously worked as an inspector at the lead company in the supply chain network for 10 years. The application of performance improvement techniques, built upon a collaborative approach to problem solving, generated major improvements in overall equipment efficiency and value stream mapping had proved useful, particularly in being able to concentrate efforts upon loss-making jobs and find out in which areas there were problems and why. Problems were encountered, however: 'The main problem was to get management to accept that these approaches were valuable....... I was a bit of a one man band - I kept getting knocked down, but I kept coming back. There have been no problems with the shop floor. Balancing the two roles (inspection and improvement) has been a challenge as I tend to spend one or two days a week on 'problem jobs'.'

The technical workers quickly appreciated the value of the new techniques and were willing to learn new ways of working. One reason for the positive response from the workers was their work was less pressured, instead of always having to respond to immediate pressures and apparent crises, the flow of work was much better planned: 'we have continuous roll-out plans, whereas previously we were responding much more day to day. There is now a more regular flow to the work: with fewer large batches.' Sustaining long-term continuous improvement was seen as difficult, precisely because management saw this almost exclusively as the role of the 'change agent' – to work collaboratively with workers to produce improvements through sharing and developing knowledge and understanding together.

The second company was a precision engineering company that makes specialist parts that are used in aircraft sub-assemblies and in other industrial settings. The person most directly involved in the 'change agent' training had managerial responsibility for personnel and business development, but he had worked for the company for 20 years since leaving school, as an apprentice, machine operator and production

planner. After involvement in training at the lead company he was charged with cascading the training to employees involved in production and/or technical activities in his company. He considered the main benefits and highlights from the 'change agent' training and subsequent application of what had been learned to include 'success in developing people: so far, 54 people have been involved in business development. We have had greater management involvement at directorial level and we can now measure business performance at shop floor level. The [employees on the] shop floor are pleased, too, because they had become frustrated that their ideas had not been taken up previously. We are also working more closely with a major customer (the lead company in the supply chain network), and we have more idea of the problems and solutions of other companies. We have been swapping development ideas and personally this has given me a new lease of life and a new learning focus. It has also led to recognition in my own company.'

However, introducing major changes in manufacturing processes and practices also generated problems: 'mainly negativity from some people: some with good reasons and some without. The latter 'well poisoners' can be very disruptive, so all you can do is concentrate upon the positive people. There is also the issue of time constraints: change takes time and the fact that there are no 'quick fixes' often leads to frustration.' Sustaining long-term continuous improvement was likely to be harder: 'this becomes more difficult. We do have director support and direction, not least because the company needs the financial benefits. We do though need to give greater emphasis to training and development and we should form a dedicated performance improvement unit. We could use more people in the business improvement teams. We are looking at our own suppliers, too - they are at the crux of some of our own non-delivery problems.'

4.8.3.3.7   *Lessons for the project*

On the one hand, where organisations had top management support for explicit policies and practices for one or all of the following: innovation management, performance improvement and knowledge management, then conditions for support of collaborative knowledge maturing processes were favourable. On the other hand, where innovation and improvement practices either did not have full top management support or were treated as (a series of) one-off events, then collaborative knowledge maturing processes were also likely to be viewed in a similar fashion. The issue of how to cope with cases where expertise is distributed across organisations is an interesting challenge, as treating knowledge as something to be matured separately in single organisations could itself be problematic. Many organisations also saw movement towards more collaborative knowledge maturing processes as part of a 'bundle' of practices inevitably bound up with the 'management of change' and significant shifts in the organisational culture.

Overall, it is clear that the stories told to us from a wide variety of organisations align with the view that the knowledge maturing model is one of a number of possible perspectives for engaging people in discussions about organisational change, learning and development. Further, that some participants could see how collaborative knowledge maturing processes could be a key part of achieving a more fundamental transformation where the quality of choice, information and commitment are improved in a move towards double-loop learning where broader questions about organisational goals are also addressed. Inter-organisational learning and knowledge development can be a particular challenge in this respect.

It is also clear that innovation, learning and knowledge development within organisations are essentially social processes. Hence, within the organisations and networks particular attention was given to building relationships to support innovation and this applied to the MATURE project itself. It proved almost impossible (and is perhaps not desirable in any case) to get agreement from application partners to make a simple decision to test project tools in isolation from their broader concerns about where they stood in relation to organisational change and development. Where application partners fully embraced the idea, they were looking to support process innovations within their organisations. This meant that participation in the project could be viewed not only as a possible mechanism for technology and process transfer but also as a means of generating an exchange of ideas about practice, development and innovation. As with the networks mentioned above, where participation in the project was positively welcomed, it was valued because it gave people not only access to innovative ideas, but also opportunities to shape these ideas in ways that were directly useful to them in their practice.

These stories have also been a comfort in that struggles within our own project (prospectively at least) to support substantive change within partner organisations have been mirrored in many other organisations and contexts. Whenever attention is focused upon problems and dilemmas (at least some of which) are central to practice, then these problems and dilemmas will have significance both for individual and organisational performance. Furthermore, these problems are likely to contain combinations of practical concerns, organisational issues and socio-cultural challenges. More positively, what is also of interest is the way that the focus on collaborative knowledge maturing processes, as in our project, can in turn generate significant learning experiences for those involved.

One further interesting finding from these stories is how many organisations keep a very tight focus on what is contributing to their current success in a particular market and their human resources development strategy is geared towards bounded improvements in how they operate. While Argyris (1990) calls this approach 'skilled incompetence', because the almost exclusive focus on doing current activities well can result in neglect of professional growth and development to the long-term detriment of the organisation, these organisations believe that their current preoccupations do mean that they will at least be in a position where they are able to think about their long-term future at some unspecified time in that future (Argyris, 1990). However, the occurrence of significant reshaping of technological activities due to breakthrough events, or even to the effects of incremental innovation in the field, might cause unforeseen problems in an organisation which does not systematically reflect on its ways of interacting externally, its community practices, and its approach to applying technological solutions.

From this perspective, it is interesting that some companies are explicitly using a developmental view of expertise that goes well beyond expecting technical proficiency and a commitment to continuing improvement. Thus, some companies, working in technologically advanced sectors, build up competence inventories of their staff which differentiate between:

- Those who are technically able to perform a task but have very limited practical experience of actually doing so (e.g., could use in an emergency or, if necessary, for a one-off activity);

- Those who have successfully performed the task on a small number of occasions (e.g., could use if wish to develop their expertise further; in a support role or if time is not necessarily a key criterion);

- Those who have performed the task many times and under a variety of conditions (i.e. experienced worker standard – completely reliable);

- Those who have substantial experience but are also able to support the learning of others (i.e. they can perform a coaching or mentoring role);

- Those who are world class, that is they are able to think through and, if necessary, bring about changes in the ways that tasks are tackled (e.g., could be chosen as a team leader for performance improvement activities).

The interesting thing here is that this approach to professional development recognises the importance of having a capacity to support the learning of others as well a capacity to change the way things are done. That is, our exhortation to greater use of collaborative knowledge maturing processes has already been operationalised in some companies working in knowledge-intensive sectors. Engagement in collaborative knowledge maturing processes could also be seen as compatible with learning through networking. The latter could be seen as an example of an active model of learning whereby learners are engaged in processes of self and peer assessment and reflection leading to the creation of 'new contextualised' knowledge, not recipients of a largely passive process of knowledge transmission (compare the processes of organisational knowledge creation outlined by Nonaka and Takeuchi (1995)).

It is also clear that innovation and learning within and across organisations are essentially social processes and both personal networks and cross-company networks need to pay attention to building relationships to support development as well as focusing upon substantive issues. There is also a need to consider the interaction between formal and informal approaches to learning, skill development and knowledge

creation as a particularly effective way forward not only for enhancing personal professional development but also as a means to improve organisational effectiveness. We hope that our stories have reinforced these points in compelling ways.

4.8.4 Summary

These stories have driven our awareness well beyond the topics that were focused in the interview guideline which were geared towards evaluating and detailing findings on the knowledge maturing model, phases, activities and indicators as well as software tools to support and barriers that prevent individuals from participating in collaborative knowledge maturing processes. This perspective beyond knowledge maturing revealed important contextual factors and parallel activities that one has to keep in mind when preparing the tools for being deployed in particular organisations.

In line with the empirical results, organisations more or less inclined to knowledge maturing can be found across sizes, industry sectors and the level of the organisation's knowledge intensity. The examples for reasons that leave organisations reluctant to knowledge maturing enrich our analysis of barriers on individual knowledge maturing phases to a general level of barriers that prevent organisations from buying into collaborative knowledge maturing at all. Consequently, when considering an intervention into an organisation's way of handling knowledge, these contextual factors need to be taken seriously as measures aiming at boosting collaborative knowledge maturing would otherwise contradict established management practices and organisational culture in an unwanted way.

The large number of cases that discussed knowledge maturing in the context of innovation management shows the close interaction between the two, so the innovation management "regime" in place in an organisation needs to be carefully studied before introducing an organisational and software solution supporting knowledge maturing. Several stories also point beyond the innovation system of one organisation and include suppliers, customers or other partners in the business or, more concretely, the innovation ecosystem surrounding an organisation which enhances the need for MATURE concepts and tools to be open to interact with solutions being adopted in business partner organisations of a focal organisation that intends to adopt these tools.

Last, but not least, the stories reinforced that knowledge maturing takes place as complex social processes that have profound effects on an organisation's and the participating individuals' ways of handling knowledge and learning, on organisational effectiveness and on the relationships beyond the organisational boundaries. MATURE concepts and tools therefore will initiate processes that are effectively out of management's control and thus it does not come as a surprise that organisations are only taking the risks of changing their existing knowledge maturing practices, roles, rules and tools, if assumed benefits are both, substantial and likely to be achieved.

4.9 Limitations

Limitations of the study generally are in line with limitations of comparable empirical studies using stratified and purposeful sampling, interviews for data collection, statistical methods for quantitative data analysis and storytelling for qualitative data analysis. In the following, we concentrate on specific limitations of our study which are structured according to limitations concerning the sample, concerning the topic being investigated, concerning the interviewee and concerning data analysis.

Limitations concerning the sample. Overall, almost 1,000 organisations were contacted throughout Europe. These contacts resulted in 139 interviews. Due to the method of organising interviews (making appointments) consecutively, it was not possible to collect data on possible late respondents. Therefore, the non-response bias could not be estimated further testing for differences between early and late respondents as suggested for questionnaires (e.g., Churchill, 1991, Hartman et al., 1985). Some contact persons gave us their reasons for rejecting to participate in an interview, basically because of no time and to a minor degree because of company guidelines preventing them, which are in line with experiences we had in previous empirical studies while no interest was stated in only three cases (see section 8.5.1 in the appendix).

Organisations in the knowledge-intensive service sector are over-represented whereas other strata like medium sized organisations within the technology-intensive industry are only sparsely populated. Especially for evaluating results on a qualitative basis, these may be underrepresented. This is due to the fact that we combined a stratification sample with a purposeful sample in our study. Also, most interviews within the stratified sample were conducted in Spain and Germany. Another point on the sample is that companies selected via purposeful sampling usually have strong relationships with universities or research organizations and thus generally seem to be more interested and agree do take part in empirical studies than others. Thus, one can assume that there is a certain bias instilled by purposeful sampling. However, we are confident that the advantages of having a broader set of organisations with respect to nations[39] as well as potentially more interested organisations concerning knowledge maturing outweigh the disadvantages of a potentially biased sample.

4.9.1 Limitations concerning the topic

The topic of knowledge maturing is quite complex in general. The fact that knowledge maturing is a complex topic might have affected the phases and the indicators while activities seemed to be comparably well understood. On the one hand, an interviewee might not fully have been aware of the meaning of a certain phase (e.g., appropriating ideas) or only was guided by certain aspects or subtopics of a phase due to examples given by interviewers. On the other hand, the part asking about opinions on indicators may not always have been understood fully by the interviewees. Especially for the indicators relating to persons, it seemed quite difficult to differentiate between the development of the person and the maturing of the organisational knowledge, collective learning as is at the heart of our definition of knowledge maturing.

This has been known in advance as knowledge maturing is a distinct and new lens to look at phenomena surrounding knowledge handling in organisations and thus the concept certainly was new to all interviewees. This also was a primary reason why we decided to do interviews in the first place and thus the interviewer-interviewee relationship and the interviewers' competence in appropriating an understanding of knowledge maturing in the context of the organisation represented by the interviewee was crucial. We spent substantial effort in preparing precisely defined concepts well explained with further explanations, examples and example stories to ease the task for the interviewer. Moreover, the study coordinators offered intensive interviewer trainings and kept in close contact with interviewers in order to transfer lessons learned and help overcome barriers of understanding. The overall impression that all interviewers did an excellent job in this was also confirmed by the fact that there are no significant differences between cases with respect to what interviewer had performed them.

Question 8[40] in the interview guideline asked for the interviewer's opinion on two items at once. It may not have been possible for interviewees to differentiate whether an organisation does not want to support a phase or is not able to do so. The second part "is open to quickly take up results" maybe blends the phase asked about too much into the following phase. This may have led to a higher variance and therefore may influence findings on possible correlations. Furthermore, the order of concepts and questions asked might have had an influence on answers to the following questions, e.g., we asked for importance, support and success of KM activities.

4.9.2 Limitations concerning the interviewee

Although the interview aimed at (parts of) organisations, the personal scope (responsibility, interests) of the interviewee may have had an influence on the interviewees' perceptions. Although we excluded the personal background, e.g., technical background versus business or HR background, as a factor influencing answers, different interviewees within one organisation might have given different answers on the organisation, nevertheless. However, as we made sure that we carefully selected interviewees who had a good command of the knowledge and learning management in their organisation, this problem

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[39]Consortium members in some nations, such as the UK, could otherwise not have participated in the study.

[40] My organisation encourages this phase and is open to quickly take up its results.

could at least be alleviated. Another impression which arose during the conduction of interviews was, though, that CEOs of companies tended to provide an optimistic vision of the company, rather than pointing out shortcomings.

4.9.3 Limitations concerning methods of data analysis

The coding procedures used for evaluation of questions 1, 2, 4 and 9 may introduce information loss, especially since there are several ambiguous topics, e.g., job descriptions or concrete software products in use in the organisations represented by our interviewees. The count of codes only allows for limited conclusions on how many software functionalities were used, as this number is dependent on the level of granularity the interviewees provided us with. Thus, it indicates the interviewee's awareness of the software used for supporting the respective phase. E.g, if an interviewee stated that they use MS Excel and MS Word, we used the codes 'office.spreadsheet' and 'office.word_processing' rather than 'office.generic'. Hence, this would result in a number of two codes instead of one. However, this challenge has not negatively affected the reflection process that we carried out on the software used to support KM phases.

Another set of limitations is standard with respect to the statistical methods that we employed. For example, factor analysis and cluster analysis may produce different results based on the specific methods chosen (Hair et al., 2006). In addition to that, there have not been any specific limitations encountered in this in our study.

4.10 Conclusion and Parallel Take-up in other Work Packages

This section reported the findings of the second in a series of three MATURE empirical studies building on the results of Year 1 activities in MATURE. This study investigated **knowledge maturing phases, activities and indicators** which were agreed in the consortium as being the most relevant concepts for broadening the scope of studied organisations in order to get a more varied picture of perceptions held in companies compared to the ethnographically-informed study and to further explore corresponding assumptions underlying the knowledge maturing model. Moreover, WPs 2 and 3, specifically the **demonstrator teams**, have been particularly interested in learning more about the current software support and barriers for fostering knowledge maturing phases in order to get a clear picture about on the one hand which software tools MATURE tools need to extend, replace or with which they need to interact. Also, knowledge maturing **activities and indicators** have been used as prime boundary concepts between engineering-oriented design activities in WPs 2, 3 and 4 and the interpretive empirical activities in this WP. Contrasting perceived importance with perceived support and success of knowledge maturing activities helps explore in more detail patterns in which knowledge maturing is perceived as important, but not yet sufficiently supported in order to be successfully carried out and as a consequence **prioritise prototype development** for Year 3. Exploring perceived importance of knowledge maturing indicators provides a primary source for **reflecting** on the main contributions of **MATURE demonstrators** on knowledge maturing (WPs 2 and 3) as well as for selecting indicators that are automatically analysed and offered as **maturing services** (WP4). Last, but not least, the results of the study, particularly the ones about activities and indicators, build a much more detailed **conceptual basis for evaluation**, described in WP6.

Due to the fact that the timeline of the representative study overlapped with the development of the demonstrators (see D2.2/3.2) and the planning of their evaluation (see D6.2), it was decided to **feed preliminary results of the representative study into demonstrator development** as early as possible as the final results of the study would have become available too late for Year 2 developments, but will provide a detailed foundation for Year 3 developments. Similarly, the **Evaluation Plan** in D6.1 had to be completed in advance of this deliverable, so this considered the work in progress on this deliverable as much as possible, accepting that refinements to the Evaluation Plan in consideration of this document are reflected in D6.2.

In addition to the interesting and encouraging results that have found their way into MATURE conceptual, design, development and evaluation activities in numerous ways, the interviews with representatives of organisations that had no previous exposure to MATURE or MATURE partners can

also be considered as a good instrument for dissemination of the project's concepts and activities. A large number of flyers were provided for interested organisations. There have been numerous organisations that have substantial interest in the project's activities and results, 4of which have even been acquired as associate partners for MATURE (and other still in the process of internal decision making).

Altogether, **139 interviews** have been conducted from which 126 meet the criteria with regard to organisation's size (medium-sized and large), location (European Union) and data completeness (less than 10% of missing data). Although there is a concentration of organisations within the knowledge-intensive service sector, the sample is characterized by a **broad spectrum of organisations** with respect to size, sector and knowledge intensity.

From a **methodological perspective**, our study employed a mixed-method approach that used a complementary set of quantitative, statistical methods and qualitative, interpretive methods. Figure 36 gives an overview of the primary categories explored in this study and shows how qualitative and quantitative parts of the study interacted with each other.

Category	Subcategory	Quantitative	Qualitative		
KM phases	software	used in different phases		interpretation, development of propositions for in-depth study, evaluation of comments	
	fostering	identify (less) fostered KM phases			
	barriers	pre-defined barriers	additionally mentioned barriers		
	success of performance	descriptive statistics	provided reasons		
KM activities	importance	validation, portfolios, correlations	comments describing/ elaborating KM activities; additionally mentioned KM activities		
	support				
	success of performance				
KM indicators	suitability	validation (descriptive statistics), factor analysis	comments describing/ elaborating KM indicators; additionally mentioned KM indicators		
	factors				
KM overall	types of organizations	cluster analysis			
	perception of success	validation (descriptive statistics)			
	stories	comprehensive overview and complementary initiatives providing deep insights			

legend: quantitative / qualitative

Figure 36: Overview of mixed-method approach to data analysis

Next to background data about the organisations and the interviewees, interviews primarily focused the phases of the knowledge maturing model, knowledge maturing activities and indicators. The evaluation aimed at **phases of the KMM** explored software support, barriers and perception of success. Especially office software, personal information management software and intranet-related software was used across all phases, whereas specialised software like suggestion systems or idea management tools were used rather seldom. The **fostering of KM phases** was evaluated to be equal across all organisations regardless of size, sector or knowledge-intensity.

The **barriers** which may hinder the maturing of knowledge were very much in line with those expected, e.g., lack of time, lack of usability and low awareness of the value and benefit. Additionally, interviewees reflected on organisational culture as barrier, specifically lack of individual autonomy, lack of formalization and guidance, lack of collaboration and personal interdependencies. Some barriers, such as fear of disgrace affect earlier phases of the KMM more than later phases.

Although **perception of success** is very similar between sectors, the phase 'distribution in communities' is perceived more successful in service-based and in medium-sized organisations than others. The phase 'appropriating ideas' is perceived more successful in knowledge/technology-intensive organisations.

Besides KM phases, activities of KM were focuses of the study. On average, all **KM activities** were deemed important for increasing knowledge maturity in interviewees' organizations. For eleven out of twelve KM activities, perceived importance is significantly higher than perceived support and perceived support is significantly higher than perceived success of performance. Based on these results, **portfolios contrasting importance/success and support/success** were created. For the MATURE project, the KM activities *"reflect on and refine work practices or processes"* and *"find people with particular knowledge or expertise"* are most interesting. Both are deemed to be important, whereas less supported and less successfully performed activities.

The more important a KM activity is perceived, the more it is supported. The more an organization supports a KM activity, the more successful it is performed regarding knowledge maturing. **Correlations** between perceived support and perceived importance are stronger than correlations between perceived importance and perceived support. Thus, one could assume that not everything organizations do to support a knowledge maturing activity (perceived support) is heading in the right direction (perceived importance), but what they do to support KM activities (perceived support), seems to aid performance (perceived success). In general, the activities seemed understandable, although were some discussions, as indicated in the comments. Several interviewees suggested **additional activities** to support individual development, to provide an enabling tool or human resource development measures, to meet people, specifically to interact with external contacts and to reflect on practice and the organisation in general as supportive for knowledge maturing.

The evaluation of the **KM indicators** revealed that process-related indicators had a higher rate of agreement than indicators of the dimensions digital resources or persons. The KM indicators "a digital resource has become part of a guideline or has become standard", "a person is approached by others for help and advice", "a process was improved with respect to time, cost or quality" and "a digital resource has been changed after a person had learned something" reach the highest mean level of agreement within their respective dimensions. Furthermore, some indicators seemed to be more debatable, context-related or maybe also simply "understandable" than others (indicated by a higher variance in the answers), e.g., "a digital resource has not been changed for a long period after intensive editing", "a person has been a member of the organisation for a significant period" or "a process was certified or standardised according to external standards", so that it seems necessary to further refine them. As one method for paving the path to such refinement, a factor analysis was done. This led to **13 factors** which could be related to three types of occasions, i.e. a single occasion, multiple occasions or a period of time, and to either an ongoing state or a change in a state which they described. In addition to indicators having been fed continuously into parallel activities in demonstrator and evaluation teams these factors aid in restructuring indicators for further take-up in Year 3 developments of the KMM and Demonstrators.

Three types of organizations were identified by clustering organization according to their success of performing knowledge maturing. The **three clusters** are **well balanced** with respect to number of cases per cluster and stratification of organizations in the cluster and also score fairly similar concerning perceptions of KM indicators and of importance of KM activities. In contrast to that, clusters clearly **separate organisations** from each other **with respect to perceived support and success of knowledge maturing** activities as well as with respect to overall success of KM. Based on the differences to each other, it is possible to further characterize the three clusters as "*best performing maturers*", "*people- and awareness-oriented maturers*" and "*hesitant formalists*". Based on the evaluation of the cluster analysis, three propositions could be developed that are considered to be part of further investigations in Year 3.

The analysis of the data has not yielded any significant difference between different countries, and although there were some tendencies that professional culture has an impact on the answers of the interviewees, they were not statistically significant. This indicates that at least national **culture** has no major impact.

Besides the evaluation of answers related to the interview guideline, further contextual factors and complementary initiatives in organisations that affect knowledge maturing were analysed utilising

knowledge maturing stories as a tool for their description. Next to additional barriers that leave organisations reluctant about accepting collaborative knowledge maturing at all, the stories revealed factors, e.g., the innovation management "regime" of an organisation or even beyond the organisation, involving business partners in an organisation's innovation "ecosystem", that also need to be taken seriously when further developing tools and concepts in the MATURE project.

5 Knowledge Maturing Model

5.1 Knowledge Maturing Model Development

The notion of "knowledge maturing" is the central concept of the MATURE project, denoting goal-oriented knowledge development on a collective level. It represents the shared conceptual understanding that glues together the different strands of activities. The empirical strand focuses on gaining a sound and deep understanding of the nature and challenges of knowledge maturing. The conceptual strand develops approaches to support and guide knowledge maturing. The technical strand implements those approaches by means of advanced technology. The evaluation strands investigates in which way and to which degree the goal of supporting knowledge maturing was actually met in real-world application settings. Furthermore, besides this internal function of the model, it is also one of the key results of the project, contributing to the scientific discourse in technology-enhanced learning and the more and more related community of knowledge management, but also having an impact on practice in enterprises. From these multiple functions, it becomes clear that we have to reconcile several requirements at once: (1) usefulness for team collaboration and solution development within the project, (2) advancement of the scientific state of the art, (3) relevance to practice and ease of comprehension for non-researchers.

For convenience, we present in this chapter first a concise summary of the knowledge maturing model as of end of year 1 (Knowledge Maturing Model v2, slightly reworked and summarized from D1.1) which was the starting point for our year 2 activities. Then, we proceed by explaining which activities were undertaken in order to develop this further, before we present the key results of this further development, the Knowledge Maturing Model v3.

5.1.1 Knowledge Maturing Model v2

Development of the model started several years ago by the joint interpretation of empirical evidence gained in several practical cases in applied research projects; the first version of the knowledge maturing process model was first published in (Schmidt, 2005) and got later on refined in (based on Maier and Schmidt, 2007) by incorporating results from a large empirical study conducted in 2000 (Maier, 2007b). This model got further refined in the proposal preparation of the MATURE project by incorporating additional perspectives. Thus, the process of developing the knowledge maturing model is also a knowledge maturing process in itself. In the following, we will first briefly touch on our conceptualization of knowledge, repeat our definition of knowledge maturing before we move on to review the phases and most important characteristics of the knowledge maturing model v2.

5.1.1.1 Dimensions

Building on the differentiation in *cognifacts*, i.e. individual knowledge, expertise, and competencies, sociofacts, i.e. collective knowledge phenomena (including collective rules, norms, structures of social interaction, but particularly also collective knowledge in the narrower sense, and artefacts, i.e. codified representations of knowledge (described in detail in D1.1 and D2.1), Figure 37 gives an overview of the types of knowledge that we focus.
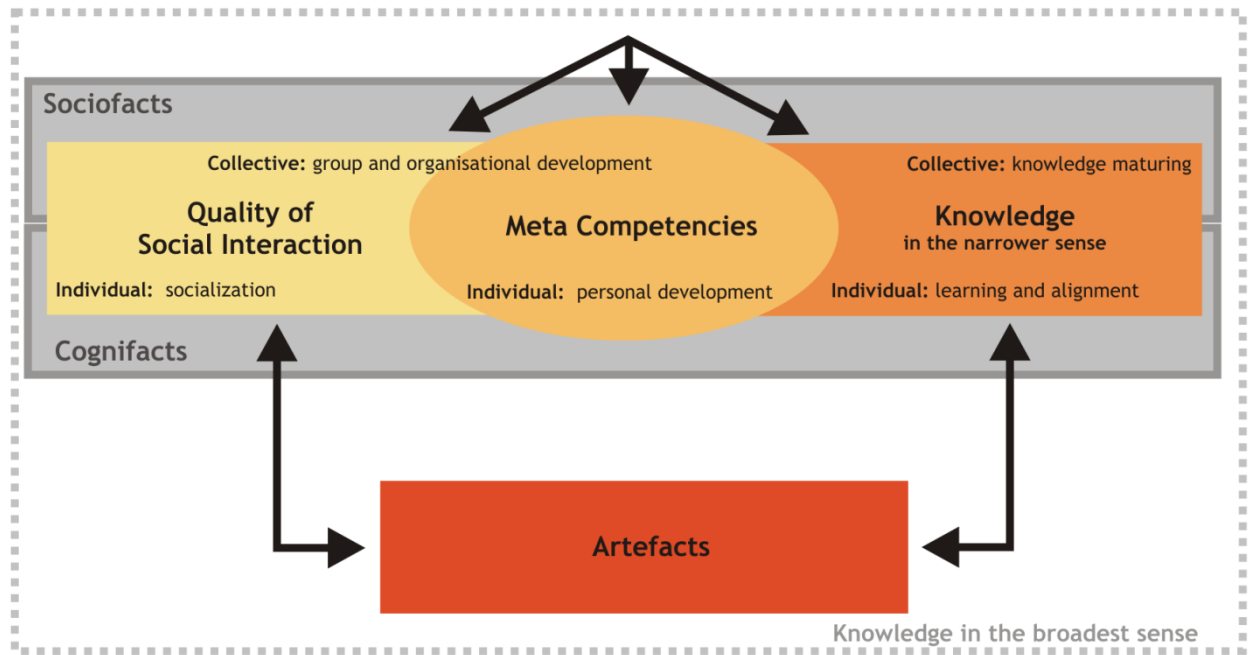
Figure 37: Dimensions of knowledge maturing

- The **knowledge** dimension refers to knowledge in a narrow sense, i.e., domain knowledge in a non-tangible form, including "know-what" and "know-how" which is always bound to people's minds while everything beyond that is an *abstraction*. That means that we have to distinguish:

  o **Individual** level. Knowledge is bound to individuals' minds and their structures. The process of augmenting and changing that knowledge is what is usually called (individual) **learning** processes.

  o **Collective** level. This level is an abstraction if we "zoom out" from an individual to a (larger) group of people. Collective knowledge is an aggregation of individual pieces of knowledge. From this meso- or macro-level[41], we can see if an individual learning process contributes to an advancement of the collective knowledge level in line with organisational goals which is what we call **knowledge maturing**. While learning at an individual level is always the prerequisite for any advancement on the collective level, there is a fundamental difference if an individual just learns what others have learnt before or if this learning is an active construction process that advances knowledge on a higher level. We call this "higher level" the collective level. This has a quality of its own while still acknowledging that it is an abstraction from the sum of individual knowledge.

- **Artefacts** are manifestations, touchable or visible items, either in physical or electronic form (e.g., models, documents, videos, notes), that have been directly or indirectly created by humans. While those artefacts do not "contain knowledge" in the proper sense, they are instruments to communicate about knowledge and mediate its development, are involved in learning processes and thus reflect some aspect of maturity of knowledge. The maturity of artefacts depends on the maturity of the underlying knowledge, but not vice versa. Very mature knowledge does not need to have corresponding artefacts. A **maturing process for artefacts** needs to be clearly distinguished from knowledge maturing, but is dependent on the knowledge maturing process and might even influence the latter.

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41   Depending on the size of the organisational unit (macro stands for the entire organisation, e.g., a company, whereas meso denotes any organisational level within, e.g., a work group, a project or a department.

- Not only artefacts facilitate learning and knowledge maturing, but also **"meta-competencies"** of the individual or the organisation.

  - **Individual level.** As knowledge maturing rarely is an individual activity, but rather a collaborative activity where individual activities become interconnected, the individuals in that process need collaboration competencies that enable them to participate in knowledge maturing. This comprises a general willingness and competencies to interact with others, communicate, negotiate, compromise and accept rules, learning and coping strategies. These determine the capability and affect the motivation to engage in maturing activities. Evolution of these competencies is what we call **personal development**.

  - **Collective level.** An organisation's capability to make knowledge maturing happen within its social system refers to organisational competencies like innovation and change to external stimuli, communicative culture, dealing with errors, work organisation etc. Evolution of these competencies is part of **team** and **organisational development**.

- **Quality of social interaction** refers to more stable areas like the value system, non-explicit rules and norms. On the **collective level**, an evolution of this is part **of team and organisation development** processes, while on the **individual level** we call this process **socialization**.

As knowledge maturing is an inherently social phenomenon, it has turned out to be useful to describe it from a symbolic interactionism (Blumer, 1969) point of view. The result is a categorization of knowledge (in its broadest sense): **Artefacts** refer to codified representations of knowledge, **cognifacts** refer to individual knowledge, expertise, and competencies, and **sociofacts** describe collective knowledge (including collective rules, norms, but also collective knowledge in the narrower sense).

5.1.1.2 Defining Knowledge Maturing

We define knowledge maturing as the goal-oriented development of collective knowledge, or better **as goal-oriented learning on a collective level** where

- *goal-oriented* describes knowledge maturing as a process with a direction. The goal can be an individual goal (e.g., deepen understanding in an area out of curiosity), a team goal (e.g., grasp known errors with respect to a product that the team works on), or an organisational goal (e.g., refine an organisation's core competency). Goals typically change over time and get aligned in social processes, resulting in a direction as a (mostly a posteriori) interpretation.

- *collective level* can refer to different levels of granularity, e.g., a team, an organisation or a community. Knowledge maturing is not the result of an individual's activity, but of an interconnected series of activities of interacting individuals, frequently also within different collectives.

- *knowledge* is understood as both cognitive structures bound to individuals' minds (becoming manifest in their behaviour) and as an *abstraction* of the knowledge of individuals in a collective.

The primary goal of MATURE is to improve the knowledge maturing process as a goal-oriented learning process on a collective level. However, there are hardly any means to influence this directly (in a repeatable way) so that we need to intervene on individual learning processes, artefact creation and usage processes, developing personal meta-competencies and developing the quality of social interaction by team and organisational development as **secondary goals.**

5.1.1.3 Phases of knowledge maturing

For describing in more detail how maturing takes place or what maturing is, **related maturity concepts** from, e.g., biology, economy, psychology or sociology have frequently relied on identifying characteristic phases with well identifiable transitions in between. In this spirit, the **process of development of this model** has focused on identifying maturing phases. Based on a much more detailed literature review, the analysis of knowledge maturing statements brought into the project by the members of the consortium, the results of the ethnographic study, the views created and feedback collected in the design studies and a

number of face-to-face, Flashmeeting and telephone discussions in the consortium, the project developed the **knowledge maturing model, version 2** (see Figure 38), structuring the development process of knowledge on a collective level.
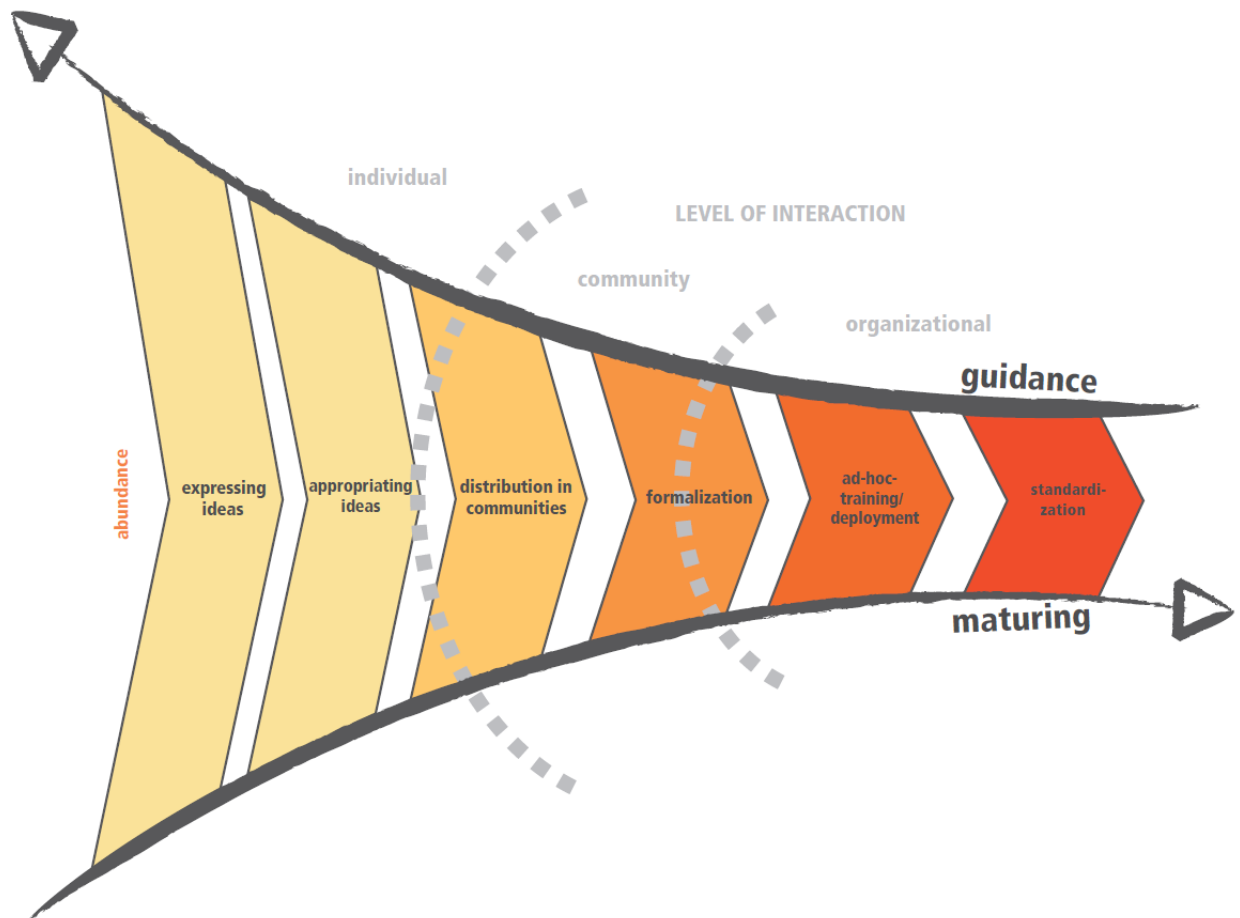
Figure 38: Knowledge maturing model v2 (based on Maier and Schmidt, 2007)

- **Ia. Expressing ideas (investigation):** New ideas are developed by individuals either in highly informal discussions or by browsing the knowledge spaces available inside the organisation and beyond. Extensive search and retrieval activities often result in loads of material influencing idea generation. Knowledge is entirely subjective, deeply embedded in the originator's context and the vocabulary used for communication might be vague and restricted to the originator.

- **Ib. Appropriating ideas (individuation):** New ideas or results found in the investigation phase that have been enriched, refined or otherwise contextualized with respect to their use are now appropriated by the individual, i.e. personalised and contributions are marked so that an individual can benefit from its future (re-)use. While many initiatives for knowledge management have focused on sharing knowledge or even detaching knowledge from humans as "media", at least in a more individualistic culture, individuals also require support for appropriation.

- **II. Distributing in communities (community interaction):** This step is driven by social motives and the benefits that individuals typically attribute to sharing knowledge. These are, among others, belonging to a preferred social group, thus increasing the probability of getting back knowledge from the community when one needs it. From the perspective of semantics, a common terminology is developed and shared among community members.

- **III. Formalising (in-form-ation):** Artefacts created in the preceding phases are often inherently unstructured and still highly subjective and embedded in the community context. In this phase, e.g., purpose-driven structured documents are created in which knowledge is de-subjectified and context is made explicit.

- **IV. Ad-hoc training (instruction):** Documents produced in the preceding phase are typically not well suited as learning materials because no didactical considerations were taken into account. Now the topic is refined to improve comprehensibility in order to ease its consumption or re-use. Individual learning objects are arranged to cover a broader subject area. Tests allow to determine the knowledge level and to select learning objects or learning paths.

- **V. Standardising (institutionalisation):** Finally, formalized documents that have been learned by knowledge workers are solidified and implemented into the organisational infrastructure in the form of processes, business rules and/or standard operating procedures. From a learning perspective, the subject area becomes teachable to novices. Certificates confirm that participants of formal training achieved a certain degree of proficiency. On an organisational level, certificates allow organisations to prove compliance with a set of rules that they have agreed to fulfil, e.g., with service level agreements or with respect to regulations such as Basel II or SOX.

This model describes characteristic phases of knowledge maturing, but does not imply a linear development that is the same in each and every case. Rather, the phases are used as an analytical tool to distill commonalities from context-specific knowledge maturing. Therefore, *this model should not be misunderstood as a process model in the business process modeling sense*.

Rather we can observe complex patterns, as shown in Figure 39 like the combination of knowledge assets, backward steps and cycles as well as improvement patterns.
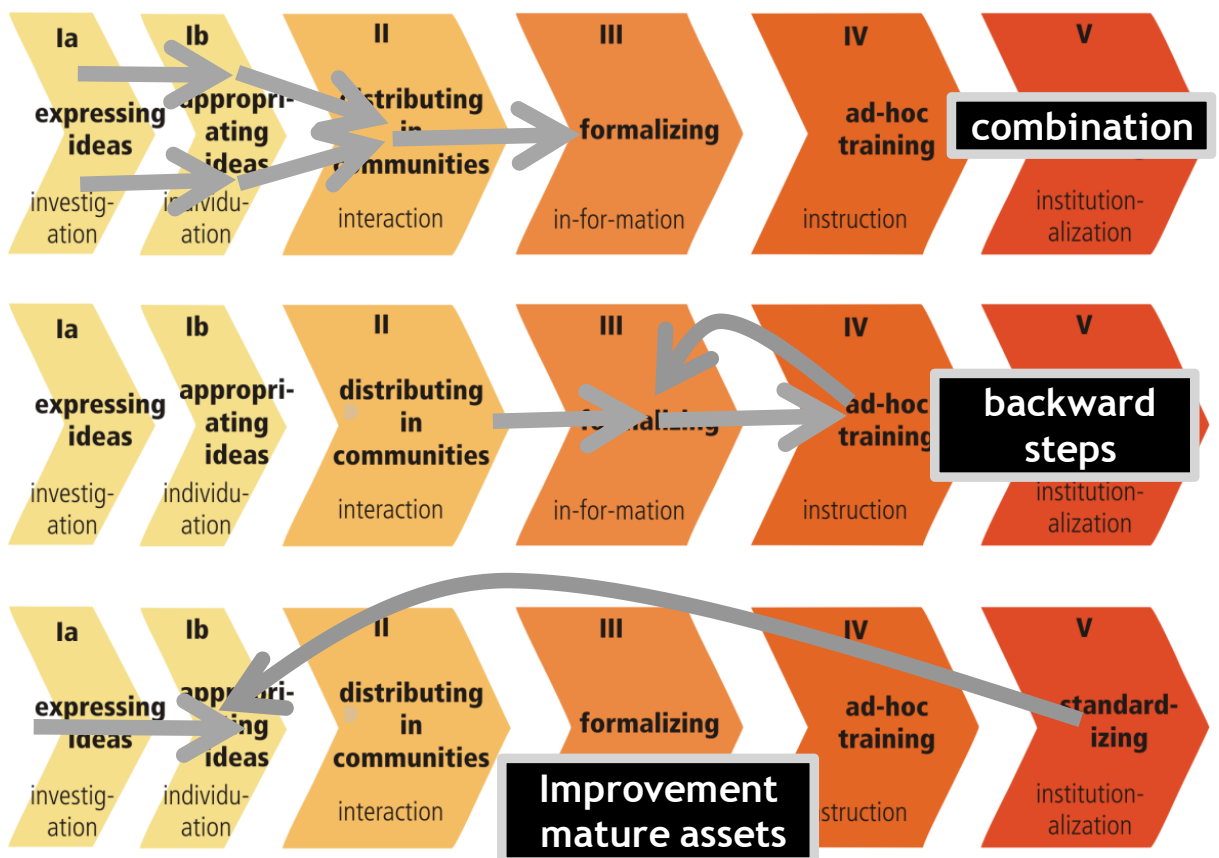
Figure 39: Patterns in knowlegde maturing processes

5.1.2 *Process for developing the knowledge maturing model v3*

While v2 of the model was clearly focused on a more precise understanding of knowledge maturing in an interdisciplinary context, and to explore in more depth real-world practices through ethnographically

informed studies as well as possibilities for knowledge maturing processes in the design studies, the goals in year 2 have been more specific:

- How can we make the phenomenon of knowledge maturing observable, and thus work towards verifying the propositions and practical implications of the model? How can we evaluate components of the model v2?

- How can we satisfy the demonstrator development needs by bridging the gap between the still macroscopical perspective of the knowledge maturing model v2 and the concrete supportive measures of (socio-)technical solutions? How can we evolve the knowledge maturing model as the shared artifact of the project?

- How can we embed the aspect of guidance in organizational management and leadership activities?

In order achieve these goals, we approached the model development in year 3 in the following way:

- **Internal evaluation of status quo.** As it is an important shared artefact for the project, one of the most important steps is the collective reflection on what we have achieved and where the participants see the need of further development.

- **Analysis of 1st annual review recommendations and other external (scientific) feedback.** As the model is also a scientific contribution, it needs to respond to the scientific discourse, which includes identifying neglected aspects, relating and possibly contrasting it to other theories.

- **Identification of key priorities.** Based on the previous two activities, we have identified key priorities on which we wanted focus on for v3 of the knowledge maturing model

- **Collection of results from the representative study (feedback from practice).** The major activity of WP1 in the second year was the representative study in which we could get feedback from practice both in a confirmatory and exploratory way. Particularly, the representative study was used to operationalize the notion of knowledge maturing by making it measurable (knowledge maturing indicators) and identify activities that are the most promising to support (knowledge maturing activities). Furthermore, the study has yielded also narratives that helped to make progress in theory development.

- **Collection of needs and experiences from the demonstrator development.** By conceptualizing tool support and co-developing it together with end users in a participatory process, the project was able to gain feedback from applying the model: what is particularly useful? What is missing? The demonstrators' conceptual verification activities comprised exemplified and contextualised thought experiments and practical demonstrations that will also help to shape the nature of knowledge maturing, rather than just realise it in practical organisational contexts. This applies to both activities and indicators, but also on the characteristics of the different phases.

5.1.2.1 Internal evaluation of the status quo

Internal evaluation conducted as part of an online survey in preparation of the Graz consortium meeting in September 2009 where the results were discussed and actions defined. The online survey consisted of the following questions:

- What are the strengths of the model?

- What are the weaknesses of the model?

- What are its main distinctive propositions?

- What are relationships to other topics to be explored?

As for the strengths, most answers were in agreement that the model v2 is "comprehensive" (in terms of linking together the relevant concepts in the project/domain), and at the same time "concise and clear", which was seen as a major achievement (given the complexity of the topic). During the discussion at the consortium meeting, retaining this conciseness and clearness was seen as a major challenge in the further development of the model.

As for the weaknesses, mainly the current presentation (which causes misunderstandings) was seen as problematic as it suggests that the model is rather "mechanistic" and "inflexible". When the model is presented for the first time, the phase model is misunderstood as a prescriptive process model. The current visualization does not make it easy to see that

- not everything has to go all the way through the process (in fact, on the contrary, most knowledge will remain on lower levels of maturity)

- in concrete process instances, there are many combinations, forks, cycles etc. (this is due to the fact that the model is not understood as an analytic macro model, but rather as a normative model of how it should be)

The second issue that was mentioned in the evaluation was more from a theoretical point of view. The pragmatic approach of the model development up till then (which was also due to the multiple purpose of the model) has led to a sometimes heterogeneous collection of different conceptions that are of different origins.

Finally, the model was seen as not "really operable", indicating a gap between the theory level and the practical implications.

5.1.2.2   *Review recommendations*

In the discussions with the expert panel at the first annual review of the project and the subsequent review report, several important points were mentioned as an input for the model v3 development:

- The current model does not differentiate between different types of knowledge so that it might appear as if everything has the same pace. However, in organizations knowledge development processes are clearly not synchronous or at the same speed, but are very different. Here a differentiation is needed with respect to multiple time scales.

- The current model has a clear bias towards an accumulative view of knowledge development. But there is also the problem of decay of knowledge.

- The uptake of the knowledge maturing model in the technical development was not as far-reaching as it could have been, which might indicate that there is a gap between the abstraction level of the model, and the level of conceptual development for the technical strand of the project.

- While an extensive state of the art analysis has been conducted in the first year, not all parts have been sufficiently integrated or related in the model development.

- As of the v2 of the model, it is was not clear how the conception of boundary objects, which is particularly relevant in the case of heterogeneous Communities of Practice, relates to the knowledge maturing model.

- The model lacks an explicit consideration of cultural aspects, which might lead to an unreflected Anglo-Saxon cultural bias.

5.1.2.3   *Key priorities for year 2*

Based on this analysis, we have identified the following key priorities for the further development of the model. These comprise with respect to investigation of existing theories and approaches the following questions:

- **Is knowledge maturing a process of continuous evolutionary change?** The current visualisations suggest an ideal and smooth process of incremental change. But how do we turn with more turbulent environments?

- **Is more mature knowledge always better? And: Is all knowledge equal?** Related to the previous aspect, we need to differentiate be aware of different types of knowledge and the relevance of maturity for the organisation.

- **How can activities be described and linked to knowledge maturing?** Tools support concrete activities so that the model development needs to bridge the gap between the macroscopical perspective and the activities. For that purpose, we need to find a way to describe activities in a better way.

- **How to guide/influence knowledge maturing activities?** In addition to the Seeding-Reseeding-Evolutionary Growth theory by Fischer (see D1.1), can we identify additional conceptualisations for intervention into knowledge maturing processes.

- **What is the role of artefacts for knowledge maturing?** As they are the most accessible traces of knowledge maturing, we need to understand more closely their role for knowledge maturing.

These questions will be addressed by a focussed state of the art analysis and relating other theories to the knowledge maturing model. Based on these findings (see 5.2), we have concentrated in year 2 with respect to components of the model on the following aspects:

- **Conceptualisations of guidance.** So far the model development has concentrated on understanding how knowledge matures. Based on that, we need to move forward to conceptualise how knowledge maturing can be improved by influencing it purposefully.

- **Indicators for observing knowledge maturing.** One major aspect of the model development in year 2 is the further development of the indicators across the different strands of the project (empirical, conceptual, technical, and evaluation). Specifically, the following questions need to be addressed: what do they measure and how does it relate to knowledge maturing? What are their potential problems/limitations? How does it relate to guidance?

- **Activities.**

  o   Which activities are important?

  o   Which activities are supported not so well in companies?

  o   How can we describe the activity support of the demonstrators in a systematic way?

5.2 Analysis of existing theories and approaches

Knowledge maturing is a boundary-crossing concept, and the questions outlined above touch several theories which might be useful to answer them. However, we are aware that the problem is that these theories are not coherent and have very different theoretical backgrounds and objectives, and are hard to integrate in a single concept. Therefore, our efforts in the following concentrate on complementing our theoretical conceptualisations with explanations for specific aspects of knowledge maturing from different fields. In the tradition of Spiro's cognitive flexibility theory (Spiro et al., 1888), we aim in the following at gaining a deeper understanding (together with our empirical and technical developments) and at deriving from this understanding a better support for knowledge maturing.

5.2.1 Is knowledge maturing a process of continuous evolutionary change?

Currently, the knowledge maturing model is focussed on accumulative improvement: steps build upon each other, from immature to more mature. The model suggests that this is not only how it usually takes place, but how it should take place in the ideal case. This evolutionary perspective is in contrast to observations where revolutionary change plays a major role – a phenomenon that is not obvious to relate to the phase model of knowledge maturing.

Christensen (1997) has analyzed innovation processes and identified a dichotomy of sustaining and disruptive innovation. A sustaining innovation improves the performance of existing products incrementally, thus addressing the same customer group. Disruptive innovation is characterized by elements that are at first not valued by existing customer groups. Such innovations will appear as cheaper, simpler and even with inferior quality if compared to existing products, but some marginal or new segment will value it. This perspective has similarities to a paradigm change in the Kuhnian theory (Kuhn, 1962). Christensen sees a key problem in the fact that that established companies may listen too much to their customers. If they reject innovative ideas, these ideas get shelved. Furthermore, established companies usually address big markets, not small ones.

The underlying problem was analyzed by (March, 1991) as the dilemma between exploitation (reusing existing competences with certain return) and exploration (considering new competences with uncertain return). While exploitation is likely to be positive in short-term, it will be negative in long-term so that short-term incentives tend to be towards exploitation, which corresponds to the sustaining innovation of Christensen.

In recent years (see, e.g., the case studies in (Tuomi, 2002)), disruptive innovation has been of increasing importance. Major breakthroughs, particularly in the field of information technology, have the character of disruptive innovation, e.g., retail and second-hand shopping (Amazon, Ebay), advertising (Google), music (Apple), mobile phones (Apple) or social networks (Facebook).

Conclusions: To relate this to knowledge maturing, we first need to clearly separate an innovation from knowledge. Following Schumpeter (1934), innovations represent ideas that are successfully applied in practice (e.g., in the form of a product, a new way of production, a new or better service etc.), while knowledge is the capacity to develop a product, to organize the production process etc. Knowledge is a prerequisite for an innovation, while an innovation is an impact that knowledge can have.

This implies that "sustaining innovation" corresponds to an evolutionary development of knowledge with small, incremental improvements. In this case, knowledge that is already on a high level of maturity (e.g., already on the standardization level when a product is already in the large-scale production phase) is improved by potentially picking up some new idea. But the knowledge remains on the high level of maturity. "Disruptive innovation", on the other hand, has as a prerequisite that you have built up a new strand of knowledge (i.e., "revolutionary" knowledge development) before becoming an innovation. This new strand of knowledge starts at early phases of maturity and does not get "absorbed" by mature knowledge and corresponding practice, but replaces it.

There is a fundamental difference how to support evolutionary vs. revolutionary knowledge development. While in the first case, we have to provide functionality so that we can easily change things, we have to collect feedback from customers or others and make that available, and we need to support filtering of new ideas which could be incorporated. All aims at incremental and continuous improvements and developments. In the second case, we need to create rooms for new developments, which are not constrained by existing knowledge structures, we need to be able to start again from scratch.

5.2.2 Is more mature always better?

So far, our conceptualization of knowledge maturing has restricted itself to identifying a process from less mature to more mature knowledge, It has left it open whether it is "good" to advance along this process in any case, i..e. if it were ideal to be on the left side of our model. However, when it comes to guiding knowledge maturing, it is important to consider where it is important to come to a higher level of maturity

and where not. Therefore, we engage in this section into a deeper reflection on the question: Is more mature always better?

5.2.2.1 Sedimentation

The concept of sedimentation is an interesting metaphor for looking at accumulations of knowledge. As there are two distinct and different ways of using knowledge to the good or to the bad, this concept can have positive or negative connotations depending on the goal structure of a system confronted with sedimentation. If, for example, a river brings in new material that sediments to form new land that can then be inhabited, this is generally viewed as a positive development, while the same river might not be navigable anymore and the sediments need to be removed which is a costly process and thus is generally viewed as a negative development. Taking that metaphor to knowledge, we can say that knowledge (1) enables and (2) limits processes of perception and the view of the world and thus can guide and constrain effective action (Tuomi, 1999b), mediating between stability and change in organizations (Tuomi, 1999a). Let us start with looking at concepts of sedimentation that view it as something positive.

Sedimentation of knowledge refers to a multi-stage process and can mean, e.g., that so-called ontogenic change leads to new, and effective, habits and concepts. These concepts, in turn, can sediment into structural knowledge (Tuomi, 1999a). Following Berson and Vygotsky, Tuomi defines intelligence as continuous process with knowledge as its accumulated product (Tuomi, 1999a). So-called meaning structures underlie effective action. Sedimented, "sticky" or institutionalized meaning structures, also called knowledge structures, are differentiated from emerging structures that are organized in the process of perception by meanings which "carve new forms in the sedimented structure" (Tuomi, 1999a). The theory resonates well with its concepts of knowledge structures (cognifacts), tools (artefacts) and sedimented social structures (sociofacts). The underlying system of meaning processing is in continuous change, in Heraclit's terms, the flow. Ontogenic knowledge, i.e. knowledge learned along the lines of the process described so far, is differentiated from phylogenetic knowledge which is inherited, collective knowledge. Ontogenic refers to learning that happens during the life-time of a specific individual as opposed to phylogenetic which refers to the learning by a species that is basically inherited. Moreover, active, self-referential meaning processing as described above happens before the background of sedimented knowledge. Again, phylogenetic structures, i.e. instincts, are differentiated from learned structural knowledge. Figure 40 shows these four basic types of knowledge which are closely connected to each other, e.g., cognition is always performed in a socio-cultural context, as also emphasised by (Ravenscroft, 2004).

Figure 40: Four basic types of knowledge (Tuomi, 1999a)

The metaphor of sedimentation means here that the sedimented out of these four types of knowledge, i.e. habitual and instinctive knowledge, are difficult and slow to change (see Figure 41). Sedimentation thus refers to the time required to change them and to the time for which they are assumed to be stable.

Figure 41 elaborates on knowledge generation and learning and further differentiates this model into an individual and a social level with organisational learning covering aspects of both as well as in a self-referential part (meaning processing required) and a non-referential part (habits and reflexes that do not require meaning processing). On both, the individual and the social level, the differentiation between active and structural depicted in Figure 40 has been taken up as individual versus cultural knowledge generation (change in cognitive knowledge) and formation of habits and routines (change in habitual knowledge). The figure also points towards the thinking that changes in phylogenetic types of knowledge cannot be isolated into individual and social, but are closely and inseparably connected with each other.
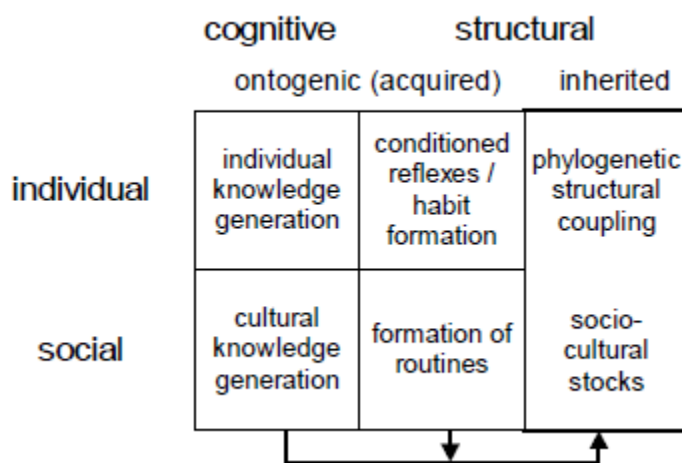
Figure 41: The five types of learning (Tuomi, 1999a)

In the following, we will briefly reflect on how these theoretical considerations could be taken up in systematic interventions in organisations guiding knowledge maturing. The concept of sedimented knowledge is extended to cover the metaphor of minerals and rocks used, e.g., by Watson (2006). We also reflect on the guidance aspect of sedimented knowledge that might be used in order to bolster confidence of individuals, communities or entire organisations in applying knowledge in a time in which many organisations face (hyper-)turbulent environments which leave many anxious to act upon the knowledge they have acquired.

An important aspect of this guidance is to foster confidence of knowledge workers. Therefore, it is deemed useful to elicit the "solid knowledge rocks" out of the waves of transient knowledge in and beyond organisations which help to render confidence for employees searching for stability and sustainability of their learning choices. This is useful in order to cope with the constantly shifting focus of awareness, the dynamic development of goals and the knowledge base on an organizational perspective.

Identification of "solid knowledge rocks" out of the waves of knowledge development in and beyond organizations helps to render confidence for employees searching for stability. This is to make sense of the potentially large volumes of knowledge chunks and the constantly shifting focus of awareness on an organizational perspective.

The distinction of solid rocks and waves is important due to their supposed influence on guidance, e.g., "solid rocks" might provide good candidates for being recommended for reuse by a larger target group. The behaviour of people following waves appears to be rather important. These waves are at some point fashions influencing people's perception of their environment and thus they are able to steer the focus of awareness of individuals, groups or entire organizations, e.g., as can be observed in the strongly interlinked worlds of what has come to be called social software. Abrahamson (1991) adopted the fashion wave theory, previously used in aesthetic-oriented disciplines, to business. He described management efforts as subject to management fashions which he explains by the fact that there are social expectations

and norms that force managers to adopt new techniques which they think will lead to rational management progress (Abrahamson, 1996).

In mineralogy, the hardness of minerals can be determined by scratch tests. Each mineral can scratch other minerals with the same or a lower hardness. Watson (2006) introduced information hardness and classified information with respect to ten grades of hardness. The hardness of knowledge rocks would be considered as a measure for what impact an amalgamation of knowledge elements has on other amalgamations of knowledge.

The following figure gives a visualization of this important distinction between solid knowledge rocks, i.e. sedimented knowledge, and emerging, competing knowledge internal and external to an organization, community or individual, i.e. transient knowledge. Transient knowledge may settle – or sediment – along the "shore" of solid knowledge rocks or those may erode.
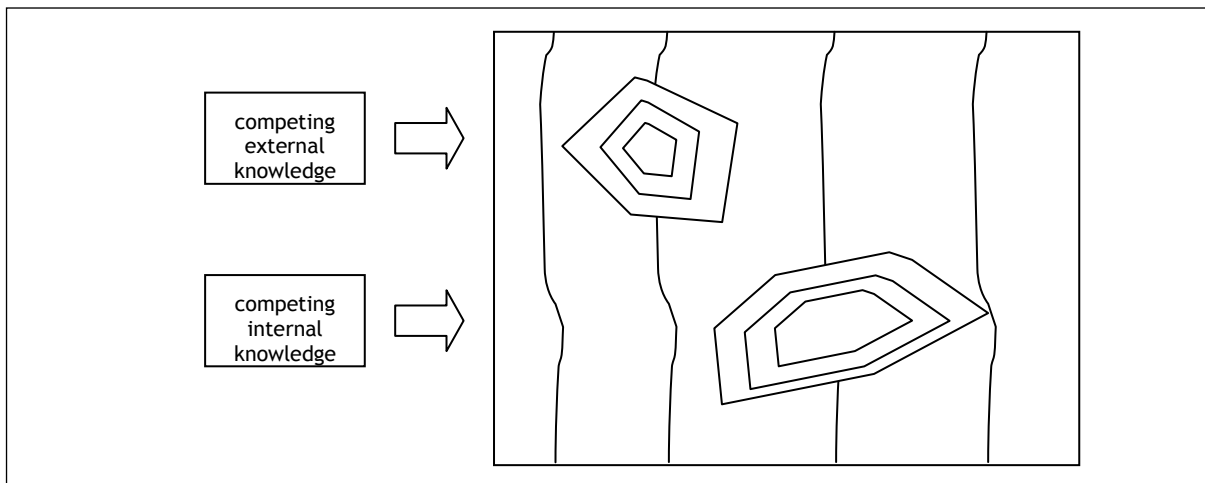
Figure 42: Solid knowledge rocks built of minerals facing waves of competing knowledge

Erosion is caused by waves containing different kinds of minerals (concepts, knowledge elements) or even knowledge rocks (amalgamations of knowledge elements). Sources of such waves can be both internal and external to the organization. Knowledge rocks can be considered as continuously faced with waves flushing through. Depending on how well new knowledge elements/rocks fit to existing rocks, they might sediment. Depending on their "hardness", new minerals might also leave scratches and erode existing knowledge rocks. One could assume that knowledge rocks are in continuous competition with one another. Considering Porter's five forces, waves could contain (or could be triggered by):
-   new external or internal knowledge arising (thread of new entrants)
-   external or internal knowledge seen as substitute (thread of substitute products)
-   existing external or internal knowledge (competition of existing organizations of one sector)
-   information need/demand of customers (bargaining power of customers)
-   information supply of vendors (bargaining power of suppliers)

These concepts and theories have in common that they take natural analogies to individual, social and lastly organisational knowledge generation and creation. Tuomi distinguishes sedimented from non-sedimented knowledge in a mutually exclusive way, and thus there are no degrees of sedimentation. This is a difference to the information hardness theory which differentiates degrees of hardness and also to our knowledge maturing model with its various dimensions and degrees of maturity. Also, the emerging knowledge might be explained in part by the fashion waves theory mentioned above (Abrahamson, 1996). If one carries the metaphor of sedimentation to the knowledge maturing concept, the degree of stability of knowledge increases over the phases of the knowledge maturing model. The amount of meaning processing, i.e. the amount of knowledge generation and learning in the self-referential, acquired part of organisational learning, required to change knowledge consciously and in a goal-oriented way might also increase. Also, the units handling knowledge change from individuals over communities to organizations as sets of communities.

As the knowledge maturing model focuses on an organisation as the primary unit of analysis, the emphasis is on the ontogenic types of knowledge as well as the social practices and routines in that organisation. The latter are already much more difficult to change than the habits of individuals due to the fact that a collective of agents needs to change its behaviour and reluctance to change is multiplied when comparing to an individual. Still, we are talking about learned knowledge, not inter-generational knowledge. A change of the phylogenetic types of organisational knowledge might compare to the changing of the business rules in an industry sector by disruptive innovations which then become absorbed in the industry's socio-cultural rule system. This analysis allows to more clearly position the knowledge maturing model with respect to types of knowledge that it focuses primarily and what it means that we aim at goal-oriented *learning on a collective level*.

5.2.2.2 *Core rigidity – a strategic perspective*

Rigidity has already been touched upon above when discussing the issue of trying to change social routines and practices. In the following, we will elaborate a bit more on the problem of core rigidity in organisations and therefore the negative connotation of sedimentation as something that constrains organisations in pursuing necessary or effective change.

The resource-based view (Wernerfelt, 1984) in general provides a sound basis for the link between strategic management and knowledge management in general and knowledge maturing in particular. However, this link, though established conceptually, remains quite vague. Process orientation can provide an instrument to integrate the external orientation of the market-based view (Porter, 1985) and the internal orientation of the resource-based view on the one hand and provide a framework for a more concrete derivation of KM strategies on the other hand.

The definition of corporate goals and corporate analysis identify on the one hand strategic business units (SBU) and on the other hand fields of core competencies. These tasks are at first independent of the organizational design which represents the next step of the strategic management process. Besides designing the organizational structure, it is necessary to design the corresponding tasks and workflows. This can be done by defining business processes. Business processes can be organized in terms of strategic business units or fields of core competencies. That means that processes can be designed guided by market- as well as resource-oriented considerations.

The market-oriented corporate strategy is strongly oriented towards customers and markets which is all the more emphasized by the concept of process orientation. The latter means the design of customer-related business processes. In this case, the design of business processes is guided by delivering value to the customer who triggers and receives the output of the value chain (="end to end-view", see (Davenport et al., 1996)) and does not focus organizational core competencies.

With respect to the resource-based corporate strategy which is at first oriented towards internal factors, process orientation can provide a useful means to avoid the danger of "core rigidity" (Leonard-Barton, 1992). Core rigidity means that an organization does not consider market-oriented factors, like new business fields, customer groups, new competitors and therefore might lose competitiveness. Many authors of the resource-based view suggest to consider market-oriented factors when identifying core capabilities or competencies (e.g., Prahalad and Hamel, 1990, Leonard-Barton, 1992, Teece et al., 1997). However, it remains unclear what instruments could be used to support the definition of KM strategies that simultaneously consider internal and external factors. Process orientation can be such a vehicle.

This is due to the fact that the implementation of business processes inherently considers market-oriented factors because of its "end to end view" from customer to customer. If the resource-based view is compared to the market-oriented view with respect to design business processes, it might well be that the two resulting sets of business processes are equal, independent of the orientation of the strategy that guided the design process.

Another factor for avoiding core rigidity is the breath of the knowledge base: A narrow knowledge base can lead to core rigidity whereas a broad knowledge base enables the combination of different knowledge threads and improves flexibility.

Guidance activities in general and a concrete intervention into the way an organization handles knowledge in particular have to be balanced. The model of a quadrant of intervention describes this aspect (Raub and Romhardt, 1998). A dimension of an intervention can be described as having two opposite interventions into an organizational knowledge base as the ends and every combination of the two along the dimension (e.g., internal orientation vs. external orientation or orientation towards known knowledge vs. orientation towards the development of new knowledge). Either of the two interventions can be exaggerated leading to problems of "over-stretching" an organization. Only the right combination of the two which can be found in one quadrant leads to positive results. Raub and Romhardt discuss their model with the two poles external orientation and internal orientation. The corresponding exaggeration of these two poles can be called "over-stretching" and "core rigidity" (see figure 43, see also (Raub and Romhardt, 1998)).
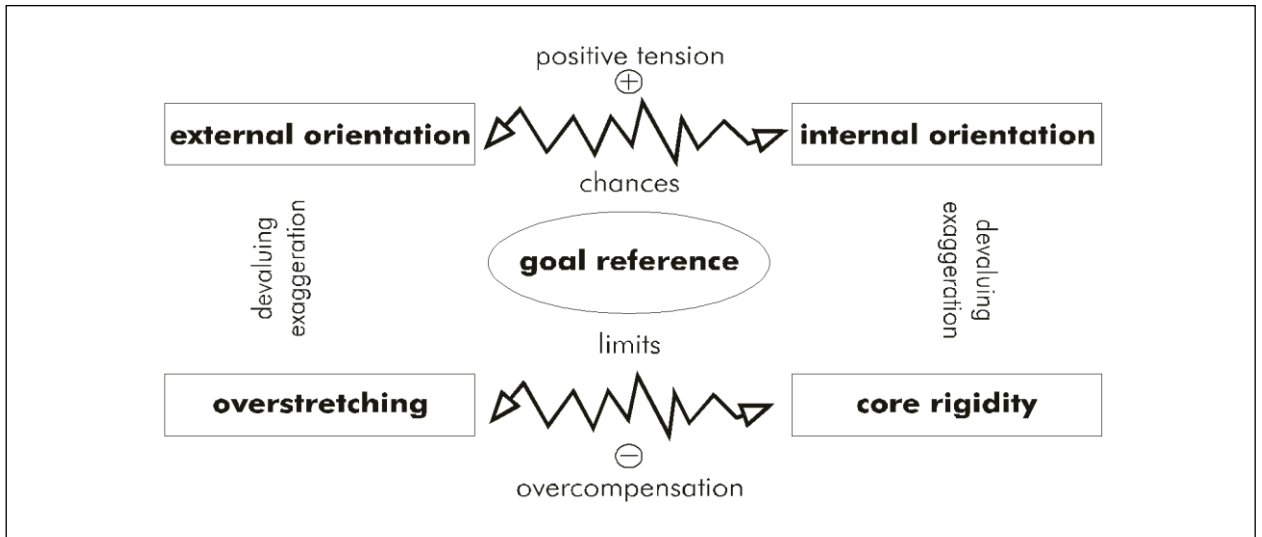
Figure 43: An example for a quadrant of intervention "reference to goals"

The most important lesson to be learned of this approach is that if a KM initiative solely concentrates on one end of a dimension of intervention and completely neglects the other end, it misses the potentials of a positive tension between the two interventions and can also lead to exaggeration of one strategy. Thus, it is important to describe possible dimensions of interventions so that organizations can choose between a set of positive combinations of strategic choices.

Summing up, the knowledge maturing model uses process symbols (chevron symbols) to represent its individual phases or steps. Business processes are closed, repeating set of interconnected tasks performed by (human or machine) agents in a temporal or causal order required to fulfil a business purpose the aim of which is to create value. Thus, the knowledge maturing model also implies that knowledge that has gone through the entire set of interconnected tasks has more value than knowledge in the beginning. Thus, in the general model and without questioning the goals of the organization applying the knowledge maturing model, more mature knowledge is "better" in the sense that it has more value. "More value" might denote for example that an individual, a community or an organizational unit is committed to the knowledge, that it has been reflected on and checked by a collective of people, that it has been consolidated, didactically enhanced or otherwise refined so that it can be more easily handed on or put into a form that is more easily applied by those who need the knowledge.

Thus, value in the case of the knowledge maturing model points to qualitative rather than quantitative consideration:

It is not more knowledge, but more *mature* knowledge that counts in our model.

A crucial question in this respect is whether knowledge is more or less contextualized when travelling the phases of the knowledge maturing model. On the one hand, more mature could mean that the knowledge is more specific to the organization, more profoundly embedded in its context, dependent on environmental factors and thus fragile with respect to its applicability in changing environmental

circumstances. In this connotation, special attention needs to be paid to guiding knowledge maturing if organisations are part of or entering disruptive or hyper-turbulent environments. On the other hand, more mature knowledge could also be considered as more independent of specific cases, more abstract and detached from its context of creation, applicable to a variety of cases and thus less susceptible to environmental changes.

5.2.3 How can activities be described and linked to knowledge maturing?

The ideas of the Russian educationalist and psychologist, Vygotsky, and the research strand that builds upon it seems to be a good starting point for understanding informal learning activities (for a first overview of the basic concepts of activity theory and the relation to knowledge maturing activities, see section 3.3.4). Vygotsky was interested in applying Marxist social theory to individual psychology. The approach he takes to cognitive development is sociocultural, working on the assumption that 'action is mediated and cannot be separated from the milieu in which it is carried out' (Wertsch, 1991). The current model of knowledge maturing contains correspondencies with Vygotsky's (1978) thinking. These are discussed in the following, along with some post-Vygotskyan work that is additionally considered (e.g., Bakhtin, 1986, Ravenscroft et al., 2007, Engeström, 1987).

Leontev (1978), drawing on Vygotsky's foundational work, points out that there is a crucial difference between an individual action and a collective activity and extends Vygotsky's original model into a model of a collective activity system. Leontev's conceptualization includes division of labour, which helps to differentiate between what is accomplished collectively or individually. Leontev further adds a distinction between activity, action and operation, as three different levels of human practice in order to delineate an individual's action from the collective activity (Leontev, 1978). Leontev's work has given rise to Activity Theory. The Activity Theory model contextualises the interaction between humans and computers with the activity systems in which it takes place, recognising the mediation of instruments and tools, rules and divisions of labour.

Activity Theory appears to be a promising basis for analysing knowledge maturing processes and situating tool development for MATURE. Vygotsky considered that "higher mental functions are, by definition, culturally mediated" (Vygotsky, 1978). Social processes give rise to individual processes and both are essentially mediated by artefacts (Cole and Werstch, 1996). This can help us in situating the role of a Learning and Maturing Environment (integrated PLME and OLME, see D2.2/D3.2) as tools within the wider environment. Vygotsky's ideas have been associated with Bruner's idea of scaffolding learning (Wood et al., 1976). Taking the idea of scaffolding within a Zone of Proximal development may offer an approach to the development and functionality of a learning and maturing environment (LME).

Although Vygotsky's work is considered as socio-cultural, activity theory arguably provides a more rigorous account of relations between learners and their social and cultural context, e.g., as it is conceived in MATURE. It is a development of Vygotsky's (1978) work that provides a framework for learning and development which accepts that meaning arises and evolves during interactions that are influenced by the social relations within a community of practice. Hence, human practices are conceived as developmental processes "with both individual and social levels interlinked at the same time" (Kuuti, 1997). An activity is considered the minimal meaningful context for individual actions which means they are not rigid and static, but continuously changing and developing. These activities are related to various artefacts, such as signs, methods, machines and computers that serve as mediational tools. The mediated processes involving subjects and tools are directed towards an objective that results in an object. In this respect we can regard the objective as motivation for performing the activity. Relating subject and object to the community in which the activity takes place we obtain the complete activity system (Engeström, 1987). Indeed, the relationship between subject and objective is not only mediated by tools, but also by community member who contribute to it, mediated by rules and norms that determine the relationship between subject and community and organised by a division of labour that determine the specific roles of participants in the work process.

The basic idea of activity theory is that an activity is undertaken by a human agent *(subject)* who is motivated toward the solution of a problem or purpose *(objective),* which is mediated by tools and/or signs *(artifacts)* in collaboration with others *(community).* The structure of the activity is constrained by

cultural factors including conventions *(rules)* and distribution of tasks *(division of labor)* within the context. Activity theory does not only provide a conceptual framework that realises the importance of artifacts in everyday existence from which we can understand activities, actions and operations and reveal subjective motives, goals and instrumental conditions, respectively (see also section 3.3.4). It also predicts that consciousness is not simply situated inside the head of an individual, but is the product of the interaction. It is realized through material activity between an individual and objective forms of culture created by the labour of mankind.

In order to show the concrete relationship and applicability of Activity Systems, in the following we exemplify this with the help of a scenario at our application partners, the particular case of careers guidance which is a focus for demonstrator 1 and 3. Applying an activity theory framework to the study of careers guidance practice gives us the following:

- **Subject:** careers guidance practitioners (goal-directed actions; beliefs; ideas; mental models)

- **Object:** careers guidance practice (patterns of behaviour; relations with clients);

- **Outcome:** clients receiving improved career guidance (effectively informing, assessing, advising counselling, enabling, advocating, feeding back, teaching, networking, managing and innovating);

- **Mediating artifacts** (tools or instruments): socio-cultural ideas about guidance practice (tools; theories; approaches; historical traces and cultural meanings associated with careers, occupations and identities);

- **Rules:** changing frameworks for regulation of practice (focus of guidance practice; statutory entitlements; service targets);

- **Community:** extent to which value systems are shared (ideas about 'good practice', meeting targets, nature of professionalism);

- **Division of labour:** between practitioners, specialists and assistants (roles and relationships).

The 'value added' of applying Cultural Historical Activity Theory (CHAT) to the enhancement of careers guidance practice is that it provides a richer framework to the search for new understandings in attempts to contextualise, enrich and renew careers guidance. In particular, an activity theory perspective would take such attempts to improve practice as its relevant unit of analysis, and thereby situate careers guidance practice within appropriate social, cultural, historic and political contexts. More generally, when there is a change to a particular area of a system, effects can result as a consequence of that change in areas separate to where the changes were made; activity theory emphasises the value of analysing those effects.

Thus we are able through Activity Systems to recognise and model the complexity of knowledge maturing processes such as those revealed through the Mature-IP ethnographic study.

Figure 44 below, shows an activity system for Personal Advisers (PAs) in Connexions Kent (although it should be noted that, in reality, people will participate in multiple and inter-linked activity systems.)

Professional Development materials
Careers Guidance materials
Careers web sites
Courses
Careers company ICT infrastructure,
intranet and tools
Social networking tools

Personal
Advisor

Knowledge
acquisition

Enhanced practice

Code of practice / ethics
Reporting requirements
Organisational rules
Governmental guidelines
for careers practice /
outcomes

PAs in district or subject teams
Community of practice for Careers Guidance

Role within Careers Company
Role within team
Management structure of careers company

Figure 44: Activity System for Personal Advisors in Connexions Kent

The Activity System model can provide:

a) An understanding of the role of any particular artefact or tool within the wider activities of individuals and organisations

b) An understanding of the context in which activity takes place and which the tools are designed to support (particularly the role of rules, communities and the division of labour)

c) A framework for evaluating the potential of tools to support individual activities within the workplace

d) A framework for analyzing the contextual circumstances of a group of people working with tools in order to perform sequences of actions in the context of an organization

Fairly obviously, we learn throughout our lives, in all kinds of different setting and contexts. The MATURE project is examining knowledge maturing and learning in the workplace. Much of workplace learning may be informal. Indeed, Jay Cross (2006) argues that formal training and workshops only account for 10-20 per cent of what people learn at work, and that 80-90 per cent of our learning takes place outside formal settings. Jay Cross goes on to say: "Most corporations over-invest in formal training while leaving the more natural, simple ways we learn to chance." It may be worth comparing activity systems for formal learning in institutions with activity systems relating to informal learning in enterprises."

Formal education systems are heavily rule bound, with rules determining both the contents and usually the process of learning. The divisions of labour are strongly defined, especially with regard to the roles of managers and teachers within the system. The community is that of the institution, which once more is heavily prescriptive regarding tools and objects, with outcomes frequently being seen as the formal acquisition of qualifications. In this the subject – or learner – may have less choice in the selection of the tools which mediate the learning. Indeed, in this activity system the selection of tools is intended more to preserve the rules and the division of labour and to contain the outcomes, than it is to support learning per se.
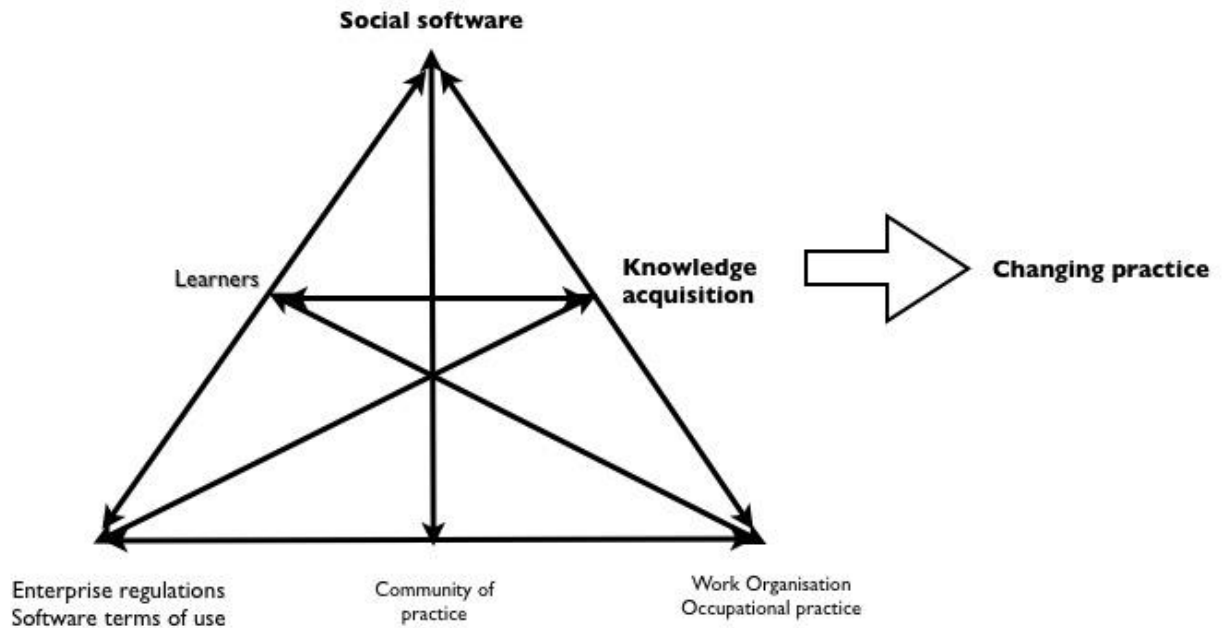
Figure 45: An Activity System for informal work based learning

Figure 45 presents an Activity System for the use of social software for learning in the workplace. Firstly the division of labour is very different and more likely to be influenced by work place organisation than by teachers or trainers. If the object is knowledge acquisition as is the case in formal trainings, the outcomes are not acquiring qualification, but may well be bounded by work processes, for instance through the need to solve a problem or through the introduction of new technologies or innovation in the workplace. The division of labour still remains important to the activity, especially the object, in permitting or restraining the time and the access of the subject to the tools they need to undertake the activity. Once more the tools will mediate the activity of learning. But here the prescription may be less, in that the community itself will influence the tools and may be a broader community of learners or a community of practice, recommending tools based on a collective experience. However, rules may still apply especially through the terms and conditions of service and use of any particular social software service. As artefacts the tools, in this case social software, remain culturally, historically and institutionally situated. But, for informal learning and work based learning, the tools are less likely to be culturally bound to the institution of the school. Thus, more often, we may see the appropriation of cultural tools or artefacts used in wider society and repurposed for learning (or of tools used in work processes), than the use of explicitly 'educational software'. However, over a period of time, as the practice of the use of such tools for learning becomes culturally embedded within society, it may start to influence the selection of tools and instruments for learning within institutions framed through the rules and division of labour of the education systems.

Relating such a work-based activity system to the knowledge maturing model, 'knowledge maturing' may be seen as the object / outcome of an activity system. However that outcome or object – as embodied in an artefact, becomes an instrument and mediating factor for the further development of knowledge. Indeed, in this role it may change the context in the form of the rules, community and division of labour (re Vykotsky's observation that the environment is changeable and dynamic). If the outcome is embodied as formalised and abstracted knowledge, it is possible that it might change the rules (mode of operation) of an organisation and might give rise to changes to the division of labour (in the form of new or revised tasks).

However, there is not a natural progression from informal learning towards formalised and decontextualised knowledge. Indeed, the very presence of the activity system indicates that however the outcome is used within an organisation, it will be necessarily contextualised by the activity in which it is incorporated. The process of knowledge maturing can also be conceived of as a process of transformation. Because knowledge maturing processes are social, they also imply social transformation in terms of

individual and organisational learning within communities. In contrast to information processing which by itself does not necessarily lead to knowledge development, knowledge maturing involves changing and developing competences on the part of the subject within the activity system - in other words learning.

Conclusion: Vzgotsky's ideas provide a potential framework for considering knowledge maturing processes within the workplace and for positioning the development of tools to support those processes. Critical to such a framework is the understanding that action is mediated and cannot be separated from the milieu in which it is carried out. Social processes give rise to individual processes of learning and action and both are essentially mediated by artefacts which are culturally, historically and institutionally situated.

This framework, as developed through Activity Theory, can provide a theoretical grounding for the further development of the knowledge maturing model and for the understanding of knowledge maturing processes. In particular, it can permit an understanding of the relation between individual and organisational learning, both of which are related to social processes. Therefore, the activities supported in the demonstrator development have been described with the help of this formalism (see D2.2/D3.2). See also section 5.3.2 for further work on the knowledge maturing activities.

5.2.4 How can knowledge maturing activities be guided/influenced?

Vygotsky's theory of the development of higher mental processes can provide a foundation and inspiration for many contemporary approaches to learning that emphasise the necessity for collaborative, argumentative and reflective discourses (e.g., Ravenscroft, 2004).Vygotsky emphasised the role of highly structured and culturally coordinated activity in the development of higher mental processes, e.g., creating zones of proximal development (ZPD). "The zone of proximal development defines those functions that have not yet matured but are in the process of maturation, functions that will mature tomorrow but are currently in embryonic state. These functions could be termed the "buds" or "flowers" of development rather than the "fruits" of development." (Vygotsky, 1978) There is a direct correspondence with the MATURE model's notion of seeding (Vygotsky calls them buds). Knowledge matures along the ZPD in developmental stages. These maturations may be cyclical, with some functions matured (the actual developmental level) and some functions in a dynamic developmental state; i.e. within the ZPD, what can be done with assistance of a "more capable peer". Thus, for Vygotsky, development follows learning, i.e. learning is an overarching structure to development, although the relationship is complex.

But what does it mean to have a ZPD in the workplace? The idea of the ZPD can be posited as also taking place in a non sequential and episodic manner within a workplace (Pachler et al., 2010). Indeed, the process of knowledge maturing itself leads to a ZPD in the gap between the competences acquired to deal with previous stages of knowledge usage and the new competences required for knowledge maturing. Vykotsky called those teachers - or peers - who supported learning in the ZDP as the More Knowledgeable Other. "The MKO is anyone who has a better understanding or a higher ability level than the leaner particularly in regards to a specific task, concept or process. Traditionally the MKO is thought of as a teacher, an older adult or a peer" (Dahms et al., 2010). Thus, for the MATURE project, the Personal Learning and Maturing Environment could be seen as providing access to learning from experts or from peers through social networks.

(Ravenscroft et al., 2010) have argued that what is likely to be also of interest to MATURE is the more spontaneous creation of a ZPD in response to a problem, which may be a less formal, and less 'rigid' realisation of the ZPD. Also, as they point out, the roles within a work-based ZPD may be more fluid and dynamic, so who are the learner and more learned other may change and switch based on the problem or the different stages of problem solving. The role of ICT technology is also highly influential in how the ZPD is organised and the semiotic systems that realise a learning interaction. This re-thinking of Vygotsky is linked to the Demonstrator dealing with the 'Collaborative Development of Understanding' that is described in D2.3/3.2 and also described more concisely in (Ravenscroft et al., 2010). In these articles, clear connections and illustrations are also given which clearly link the technical developments of this Demonstrator to the phases of knowledge maturing and the production of Boundary Objects related to knowledge maturing.

Moreover, the MKO can also be viewed as a learning object or social software which embodies and mediates learning at higher levels of knowledge about the topic being learned than the learner presently possesses. Of course learners operate within constraints provided in part by the more capable participants (be it a teacher peer, or software), but an essential aspect of this process is that they must be able to use words and other artefacts in ways that extend beyond their current understanding of them, thereby coordinating with possible future forms of action. "If we ask what makes such intermental functioning possible, we must certainly speak about issues such as context, the existing level of intramental functioning, and so forth. However, there is an essential sense in which intermental functioning and the benefits it offers a tutee in the zone of proximal development would not be available if one could not perform, or at least participate in performances, that go beyond one's current level of competence. In this sense, social interaction is not a direct, transparent, or unmediated process. Instead, it takes place in an artefact-saturated medium, including language, and this is a point that Vygotsky took into account in a thoroughgoing manner" (Cole and Werstch, 1996).

The role of an LME may be not only that of a tool to provide access to 'more capable participants" but as part of a system to allow learners to link learning to performance in practice, though work processes. And taking a wider view of artefacts as including information or knowledge accessed through a LME, reflection on action or performance may in turn generate new artefacts for others to use within a ZPD.

Such user-generated artefacts could then serve to support the scaffolding of learning for others. Scaffolding was not a term originally used by Vygotsky, but is one of a number of somewhat similar ideas around learning which have come to be associated with Vygtotsky's ideas (Emihovich and Lima, 1995). Emihovich and Souza Lima say: "Because of Vygotsky's influence we are now hearing much more about such concepts as cognitive apprenticeships (Collins et al., 1989), reciprocal teaching (Palinscar and Brown, 1984) and situated learning (Lave and Wenger, 1991). In all of these cases, the teacher (or more capable adult or peer) plays a critical role in guiding the child's participation in activities intended to increase her or his understanding of a particular concept."

"Scaffolding is a six-step approach to assisting learning and development of individuals within their zone of proximal development." (Feden and Vogel, 2006) Knowledge, skills and prior experiences, which come from an individual's general knowledge, create the foundation of scaffolding for potential development. At this stage, students interact with adults and/or peers to accomplish a task which could possibly not be completed independently. The use of language and shared experience is essential to successfully implementing scaffolding as a learning tool. (Feden and Vogel, 2006, cited in Dahms et al., 2010).

Within this perspective a LME could be seen as allowing the representation of knowledge, skills and prior learning and a set of tools for interaction with peers to accomplish further tasks. The LME would be dynamic in that it would allow reflection on those task and further ass to the representation of prior knowledge, skills and experiences. In this context experiences are seen as representing performance or practice. Through access to external symbol systems (Clark) such as metadata, ontologies and taxonomies the internal learning can be transformed into externalised knowledge within an LME and become part of the scaffolding for others as a representation of a MKO within a Zone of Proximal Development.

The idea of boundary objects provides the basis for the development of learning artefacts, to support learning within Zones of Proximal Development and linked to the emergence of knowledge maturing (seen as action as well as documented knowledge) within enterprises.

5.2.5 What is the role and nature of social interaction as part of knowledge maturing?

The theory of Symbolic Interactionism (SI) focuses on face to face communication between people using a common language (symbolic medium). SI is related to the mutual and multiple dependency between an individual's mind and the social context he or she is acting in. SI also deals with the processes of personal knowledge achievement and the genesis of an individual's consciousness. Based on considerations of Mead the use of common language as a 'logical universe of significant symbols' contributes to the genesis of an individual's identity (ontogenic development influences personal habits and concepts) as well as to the phylogenetic development of an organization's or a society's consciousness. Thus, SI

explains the change of cultural norms and social regulations as well as a person's contribution and involvement in the change of social consciousness. Relevant theoretical concepts of SI are:

- Communication and Social Interaction

- Socialisation

- Social and personal identity

5.2.5.1   *Communication and social interaction*

Communication and social interaction are constitutive for the development of a person's mind (e.g. achieving knowledge during formal and informal learning processes, development of attitudes, capacity to act) and vice versa are the bases for changes in a society's consciousness or for transitions regarding rules, norms and patterns of interaction in a group. Communication and interaction are mediated by the use of language and its 'significant symbols'. Individuals act toward real objects regarding the meaning they ascribe to them. These assignments between real objects and symbolic descriptions of the objects (meaning, concepts, text and language) are results of negotiations and dialogues between acting people. The meaning of symbols and the related objects of the real world are results of ongoing negotiations and interpretations between interacting people. Thus, people create meaning during social interaction. Interaction itself is mutually interpreted and defined by the actors and not only a spontaneous reaction to the counterpart's activity.

As a consequence for knowledge maturing, this indicates:

- There is no room for a naïve view of how knowledge is communicated along the maturing process where you "transfer knowledge" or "package knowledge in artefacts". Rather, this interaction has to be seen as complex negotiation and interpretation processes. This signals that developing a shared understanding and agreement are important part of knowledge maturing that can be only achieved through dialogues on different levels.

- Patterns of interaction within and between different groups are important factors to be taken into account, which can be influenced by possibilities for informal learning, freedom for discussion and opinions, freedom for creative and innovative action, etc; binding character of rules and obligations in a group with regard to processes… Barriers in dysfunctional maturing processes may be traced back to such issues, which complements the motivational perspective of the knowledge maturing model.

5.2.5.2   *Co-operation and Externalisation of Knowledge and Experiences*

"…interaction (that is, face-to-face, interaction) may be roughly defined as the reciprocal influence of individuals upon one another's actions when in one another's immediate physical presence" (Goffman, 1959). This basic concept of interaction leads to patterns of interaction within groups and also may scaffold co-operation between persons and group members. Symbolic interaction is not only restricted to language and the genesis of consciousness and knowledge in a person's mind but may also lead to the externalisation of knowledge e.g. by creating different types of text or other media.. Thus, the theory of SI can be linked with the concept of external memory. The instantiation of knowledge in a persons mind that we call cognifact, is closely linked to personal expertise as a result of formal and informal learning processes. The other relevant strand is the creation of artefacts, another instantiation of knowledge. Artefacts are all kinds of reproducible physical or digital results of an externalisation process, e.g. books, digital media as an external memory (Keil-Slawik, 1992). Creating an artefact goes along with the abstraction from the subject domain and therefore is equivalent to a de-contextualisation of the content. By writing a paper for example, we often abstract from the reality-oriented scenarios we have in mind and generalise concepts from a concrete context into an adequate but more abstract form. The result is a paper with de-contextualised content, which can become persistent and can be transferred to someone else. The distribution of artefacts is the basis for sustainable knowledge emergence, as communication alone cannot achieve this high factor of dissemination and persistence. For example, if a person reads a book he or she

interprets it with the previous knowledge and he or she may gain new knowledge that is probably re-contextualised within a different context. The re-contextualisation goes along with a possible blurring of the precise meanings of the book's author. Blumer states that every action and behaviour always involves earlier experiences and knowledge. So the emergence of knowledge (in this personal perspective the learning) is not an isolated process but contextually bound. Furthermore, knowledge is also kept in our society, in our behaviour and in social norms. This aspect provides us with a third instantiation of knowledge, the sociofacts. Individuals, who are communicating with each other take into account the possible expectations of their counterpart. The generalised other, the abstract concept of normative mutual expectations and perspectives depending on the different roles and attitudes of the communicating partner influences the de- and re-contextualisation process by social norms and regulations, and thus contributes to the sociofacts. While these unwritten rules of communication are informal, partly imprecise and not sanctioned by law, sociofacts also include formal regulations like job-related rules, workflow regulations and even laws. As shown above, knowledge emergence is not restricted to personal knowledge or artefacts but also happens within social collaboration.
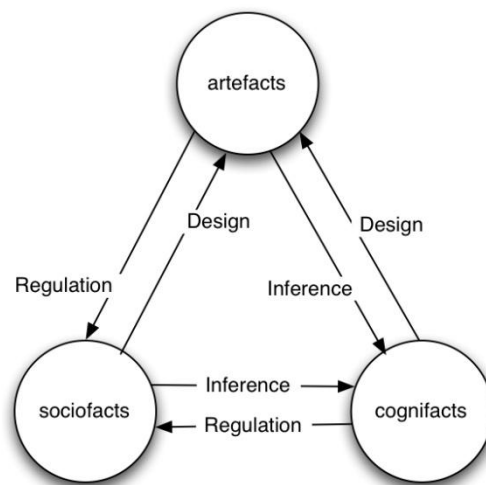
Figure 46: Technological triangle by Engbring (2003)

Moreover, these three elements are firmly interlinked with each other. The technological triangle (Krohn, 1992, Engbring, 2003) shows the connection between the three knowledge instantiations: artefacts, sociofacts and cognifacts (see figure 46). Engbring states that the creation of artefacts depends on cognitive capabilities and social preconditions and that artefacts regulate the social conditions and lead to new cognitive abilities.

Conclusions: Interaction and communication between group members (individuals) also lead to the externalisation of knowledge. Therefore, knowledge maturing is linked to (a) individual and group related (informal) learning and knowledge achievement also including social norms and attitudes, (b) changes in the quality of artefacts (documents, media, software, technical products…), and (c) changes in interaction and communication structures, tasks, processes, different kind of activities.

Communication between members of different groups (individuals with different social identity) may create a type of artefacts that contain represent knowledge from different theoretical (social) background, which take the role of boundary objects.

5.2.6 What is the role of artefacts for knowledge maturing?

A very promising approach to reflect on the role of artefacts for knowledge is to look at the boundaries between different communities of employees within a workplace and the artefacts (documents, graphs, computer software) that are used to communicate between communities of practice (Kent et al., 2007). Following the analysis of Bowker & Star (1999), "boundary objects" are "objects that both inhabit several communities of practice and satisfy the informational requirements of each of them", thus making possible productive communication and "boundary crossing" of knowledge. Boundary objects are the

focal points of interconnections between communities, and they are not simple containers where you embed and re-extract knowledge. They must be capable of transporting knowledge between different contexts, which requires robustness on the one side, but also interpretative flexibility so that other communities can construct and integrate the conceptions into their own mental models.

While boundary objects could be a wide range of things like conversations, spaces for interaction, interests, rules, or plans, which do not require explicitness, the most common perspective found in literature on boundary object is that they are artefacts, following also Wenger's (1998) concept of reification as creating meaningful artefacts that aggregate community results and make them persistent. In terms of knowledge maturing, the notion of boundary objects helps to explain a potentially beneficial role of artefacts in the knowledge maturing process: they are essential for "developing and maintaining coherence across intersecting social worlds" (Star and Griesemer, 1989). As knowledge maturing often happens through crossing boundaries (when increasing the scope of contributors or users, e.g., moving from a small team to the whole organisation), particularly those artefacts are important that are in the boundary zone of an activity system, i.e. the space where participants of different activity systems meet (Konkola, 2001). Creating, developing, and sharing those has to be the primary focus.
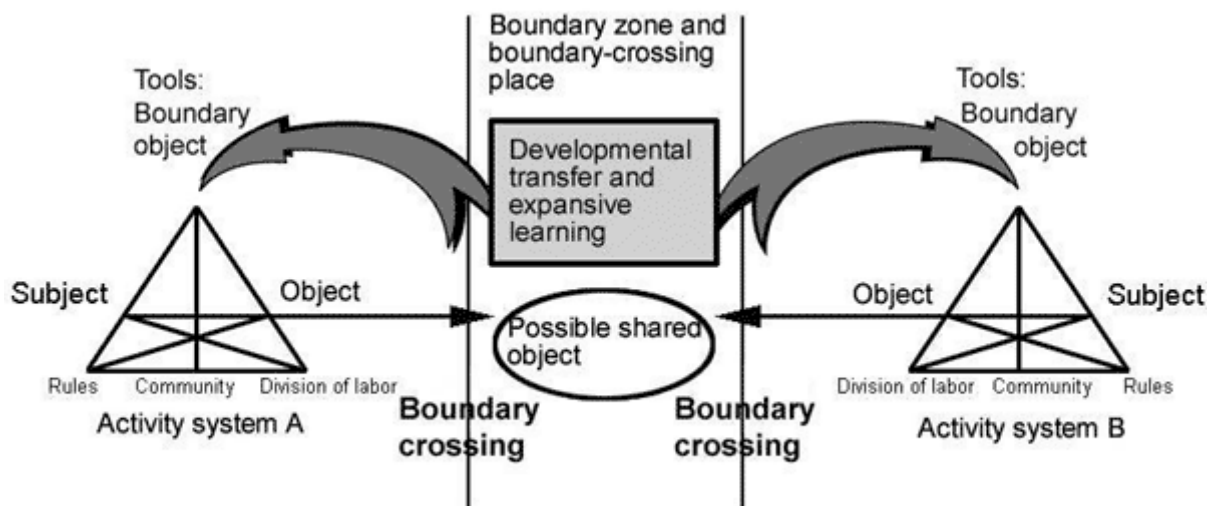
Figure 47: Boundary objects and activity systems

Based on an earlier project on knowledge maturing and organisational performance in career guidance, an approach to learning based on the design of symbolic boundary objects has been developed which were intended to act as a facilitator of communication across community boundaries, between teams and specialists or experts. Effective learning could follow from engagement in authentic activities that embedded models which were made more visible and manipulable through interactive software tools. In bringing the idea of boundary objects to the present research, we realised that a sub-set of general boundary objects could be 'TEBOs' (technology-enhanced boundary objects), i.e. digital resources within a learning and maturing environment (LME), such as a Wiki article laying out an idea for a different community of practice or a document containing lessons learned intended to be transferred to project teams in a different organisational unit.

This approach makes use of the notions of boundary object and boundary crossing. The ideas of boundary crossing and tool mediation (Tuomi-Gröhn and Engeström, 2003, Kaptelinin and Miettinen, 2005) and situated learning with a close alignment to the importance of a focus upon practice (Brown et al., 1989, Hall, 1996) informed considerations of the role of technologically-enhanced boundary objects in knowledge maturing processes in different contexts. One specific concern is to make visible the epistemological role of symbolic boundary objects in situations in which people from different communities use common artefacts in communication. A fruitful approach to choosing ways to develop

particular boundary objects is to focus on what (Onstenk, 1997) defines as **core problems**: the problems and dilemmas that are central to the practice of an occupation that have significance both for individual and organisational performance, e.g., the problems associated with providing advice relevant for career planning which is taken as one example application scenario related to MATURE application partners. One method this development project used was therefore to engage in a dialogue with guidance practitioners about common scenarios involving Labour Market Information (LMI) which could inform the development of prototype technologically-enhanced boundary objects (TEBOs). The development of a tool was therefore informed by a consideration of the following issues:

- Importance of developing methods and strategies for co-design with users
- Need for conceptual tools to help people understand the models and ideas which are part of LMI
- Need for a more open pedagogy (than is typical of much existing technology-enhanced learning, *and* existing workplace training practice)
- A system in which boundary objects are configurable by end-users (practitioners) and by guidance trainers to be used in multiple ways
- Need to build an understanding of how TEBOs may be used in ways that are empowering for practitioners, and ultimately for clients too.

These concerns could be coupled with another set of issues concerning appropriate skill development:

- Need for time for people to interact, reflect, use concepts etc.
- Trying to reach a stage where practitioners have justifiable confidence in the claims they make and can exercise judgement about the value of information when faced with unfamiliar LMI
- Choosing between a range of possible use-contexts
- Decide how to employ support from communication and discussion tools
- Developing and transmitting Labour Market intelligence – importance of communicating to others
- Preconfigure certain ways of thinking through use of scenarios; discussions can point into and lead from scenarios.

The above sets of issues provided a clear steer to the type of investigations that would be needed to investigate how TEBOs might be used to support the learning and development of guidance practitioners. Such TEBOs could be shared vocabularies that can be collaboratively developed like demonstrator 2 and 3. There are also broader questions about the overall design of the learning system (OLME) and how users might interact with the system in practice.

Future development work with TEBOs would need to address how individual practitioners interact with the learning resources of the envisaged system as a whole, as well as meeting the following challenges:

- Identify the key set of TEBOs needed to support the learning and development of guidance practitioners in understanding LMI;

- Identify the *conceptual* challenges in interpreting the output of TEBOs: graphs; labour market predictions; charts; employment data; financial models etc.;

- Identify the connected *communicative* challenges in identifying the merits and disadvantages of different choices according to different personal needs, and communicating personalised advice based on LMI?

- Identify the appropriate pedagogic scenarios for the use of TEBOs in learning within a personalised/adaptive learning system;

- Support practitioners in how to visualise, analyse and utilise labour market information in new ways in the guidance process they offer to their clients.

Overall the work with the prototype TEBOs showed that it should be possible to exploit the rich potential of TEL systems to support learning through the visualisation, consolidation, representation and transformation of knowledge. The set of BOs and TEBOs to be developed in future should be theoretically-informed, more comprehensive and visually compelling in line with previous research. For example, the value of multiple representations of information, including dynamic visualisations of data

and relationships has been well documented, along with a recognition of the importance of a sound underpinning model of the basis for conceptual understanding (Ainsworth and Th Loizou, 2003, Schnotz, 2002, Hegarty, 2004, Lowe, 2003, Lowe, 2004, Ploetzner and Lowe, 2004, Chandler, 2004, van Someren et al., 1998, Narayanan and Hegarty, 2002),

5.3 Experiences from demonstrator development

This section briefly explains the influx of experiences from design and development activities for all demonstrators concerning the knowledge maturing model, structured into indicators (section 5.3.1 and activities (section 5.3.25.3.2).

5.3.1 Indicators

The knowledge maturing indicators (see sections 3.3.5 and 4.6) as measures of knowledge maturing, reflected in a change of state, and/or maturity, reflected in an on-going state, influence the definition of maturing services on the one hand, and on the other hand provide a mechanism for evaluating implemented approaches of the MATURE project regarding the impact of applying design artefacts on knowledge maturing. As a consequence, the set of knowledge maturing indicators have been co-evolving in the empirical, the conceptual and technical, as well as the evaluation strands of the project.

Demonstrator teams were contextualising and evaluating indicators as part of their design activities (as reported in D2.2/3.2 on the demonstrators), facilitated by WP1. As each demonstrator focused on a certain part of knowledge maturing, only a portion of the indicators could be applied in each demonstrator, but also additional indicators were created to respond to specific evaluation needs or as part of heuristics used. An overview of the used indicator instantiations can be found in section 5.5.1 in D4.2 When instantiating and using the indicators, the demonstrators have gained a deepened understanding that was fed back into model development. Apart from suggesting new indicators, the most important lesson was that we need a better structure for the indicators which more clearly expressed what the indicator actually measures and how this relates to knowledge maturing. The dimensions "digital resource", "person", "process", and "combinations" were not sufficient to clarify what we are using the indicators for. Furthermore, it has turned out to be important to distinguish between state-oriented indicators and event-oriented indicators. This will be addressed in section 5.4.1.

5.3.2 Activities

The demonstrators aim at supporting knowledge maturing activities (which were described in the use cases). Therefore, it is important to explore the link between the general knowledge maturing model and the context-specific knowledge maturing activities and their support.

Towards that end, MATURE has perceived Activity Theory (see sections 3.3.4 and 5.2.3) as a promising underlying base theory. Activity Theory concepts and considerations beyond the basic theory have helped us frame the contextual factors that are at play when deploying software solutions such as the MATURE demonstrators.[42] In order to better understand the demonstrators from the theoretical point of view regarding knowledge maturing, we developed an analysis model that was inspired by the popular visualization of Activity Theory concepts as multiple connected triangles were introduced by Leontev (1978) and transformed into a powerful tool by Engeström (1987), who used them as a vehicle to analyse the framing contextual factors of actions (see sections 3.3.4 and 5.2.3). However, as Activity Theory has become a global multidisciplinary research approach (Engeström, 2000), it is not surprising that its concepts have undergone re-interpretation along with its reuse in different research contexts and for different purposes. Its intended use by Engeström sees the concepts being taken in order to make sense of

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[42] Please note that the usage of the notion "activity" within Activity Theory is not the same as the MATURE usage of "knowledge maturing activity" which reflects a general use of the term with a connotation of costs and value creation that is at the centre of business organisation, e.g., represented in activity-based costing although Activity Theory can certainly be applied in order to understand contextual factors at play when deploying MATURE knowledge maturing activities.

actions observed in real-world settings in terms of their impact on the participants and their developmental potential. This model of the human activity system is used descriptively to support uncovering the anatomy of these actions as successive, momentary instantiations of a wider and more stable system of collective activity (Engeström, 2000). Actions and operations are relatively independent, but subordinate units of analysis that can be understood only when interpreted against the background of entire activity systems (Engeström, 2000). Subsequently, deviations from standard scripts, called disturbances, are studied that are indicators for systemic contradictions and change potentials of an activity (Engeström, 2000) which are made transparent and thus can be subjected to further development by the participants of the activity system.

According to Engeström (1987) there are four levels of possible contradictions in and between activity systems. Primary contradictions are related to contradictions at singular node, e.g., the subject that might be driven by different motives. Secondary contradictions derive from the direct interaction of nodes, e.g., between subjects and tools which might not be appropriate to the subjects' goal. Contradictions between an activity and its more advanced form appear as tertiary contradictions. Finally, quaternary contradictions appear between different activities. Discovery and analysis of these contradictions can help to further develop the activity system, e.g., by introducing improved instruments. In the analysis described in the following, analysis of contradictions is possible as the description of the demonstrators opens up such opportunities when applied in application partner settings. Summing up, concepts of Activity Theory as used in activity theoretical studies of work are descriptive concepts that help frame and interpret actual observed happenings, i.e. actions, operations, in investigations of real-world organizations.

Inspired by these considerations, we have adapted and narrowed the concepts of Activity Theory to the particular aspects of knowledge maturing. In particular, we analysed the potential activities supported by the demonstrators on the basis of activity systems as they were introduced by Engeström. We have concentrated so far on the particular maturing aspects of the various demonstrators to better understand the knowledge maturing processes in there. On the one hand, this required a simplification of the activity systems to keep the representation comprehensible, while, on the other hand, an extension with respect to dynamic aspects appeared to be necessary (Halverson, 2002). To achieve this goal, we performed a projection of the concepts in the model of the human activity system (Engeström, 2000, Engeström, 1987) onto those aspects which we deem important to describe knowledge maturing fostered by our demonstrators. The primary goal of this projection is to provide an instrument that allows for a comparable description of the intended impact of demonstrators on knowledge maturing. We used concepts and terminology that we introduced in deliverable 1.1 (see also the short summary in section 5.1.1). Figure 48 shows the projected activity system using the familiar visualization of the activity triangle.
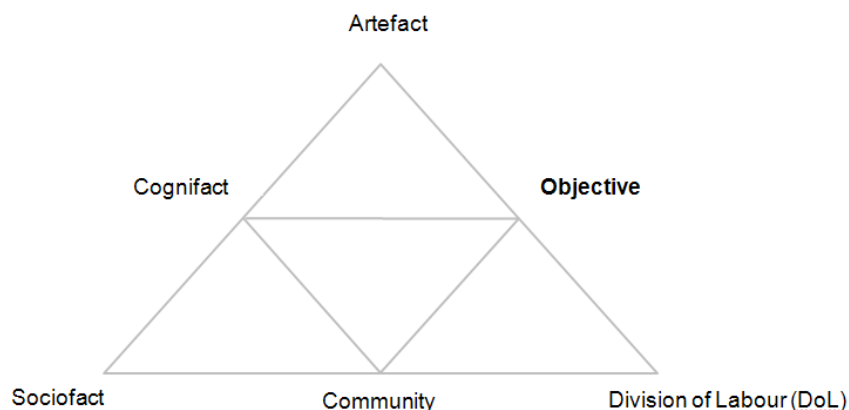
Figure 48: Structure of the maturing activity system

The projected system, which we call maturing activity system (MAS), describes selected aspects of Engeström's model of human activity system in a maturing-specific way. The left-hand side of Figure 48 exchanges subject, rules and tools for a trisection of concepts representing knowledge manifestations

(cognifact, sociofact and artefact). These manifestations had been determined and defined in the knowledge maturing model (cf. deliverable 1.1 and section 5.1.1). Regarding the tool component, this projection means a narrowing from tools in general, such as search engines, workflow management systems, etc. to those "tools" which represent codifications of knowledge, for example, wiki articles, web documents, task patterns, tags etc. The reason for this latter narrowing down of the concepts is grounded in our intention to concentrate on the impacts of the demonstrator as tool on cognifacts, artefacts and sociofacts while we neglect other tools in our analysis of demonstrator impacts on knowledge maturing. While the two concepts *community* and *division of labour* are left unchanged, we concentrate on objects or objectives respectively and do not (yet) consider outcomes separately as our analysis of demonstrator impact on knowledge maturing represents desk research in the sense that we consider requirements and contextual factors of the intended application scenarios in a generic way refraining from concrete application domains (e.g., career guidance). Thus, we do not explicitly distinguish between intended and unintended consequences of the actions taking place framed by the MAS so far. Re-introducing the distinction between object and outcome might be an interesting way to move forward in our analysis studying the happenings taking place in appropriating the MATURE systems.

We have introduced different types of arrows represented as arrow as can be seen in Figure 49 and Figure 50. In order to describe the dynamics within a MAS, i.e. what impacts on MAS concepts occur when certain functions of the demonstrators are performed. Figure 49 only describes those interactions that were considered of primary importance in our analysis of the demonstrators.
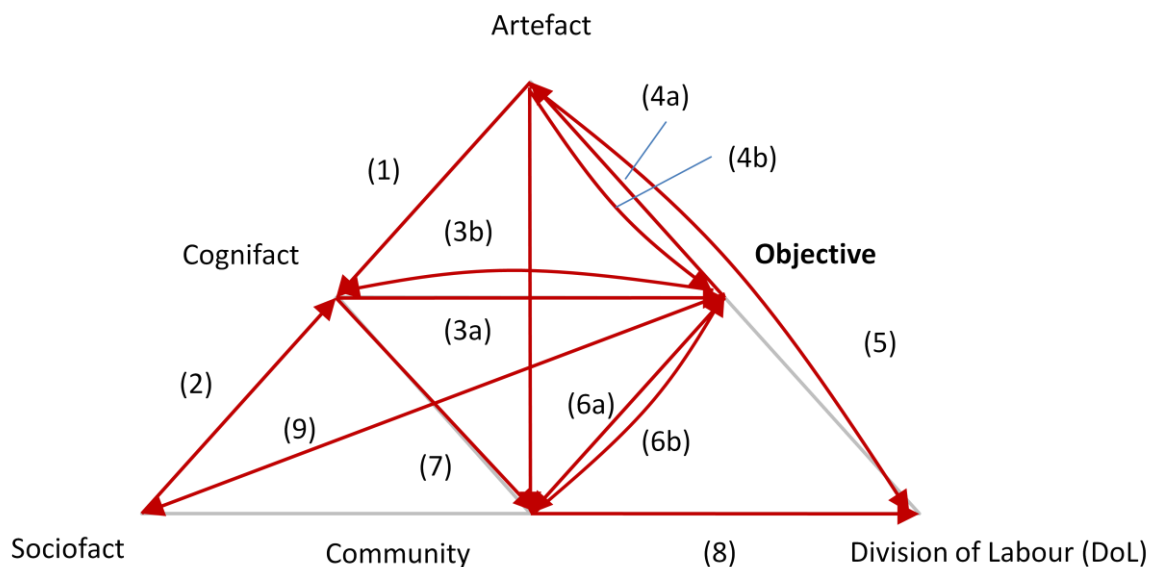
Figure 49: Interactions of a MAS

In the following we will explain the meaning of the arrows Figure 49:

(1) **Artefact – Cognifact Interaction**: The subject gets information and guidance from the artefact in order to construct knowledge about how to perform the intended action, e.g., a tag cloud that provides guidance for search or a task pattern that supports execution of a task.

(2) **Sociofact – Cognifact Interaction**: The subject usually adapts the way how an action is performed to the rules and norms and shared experience of the affected community. For example, a user who defines tags for a community is aware of the naming scheme and practice of this community and uses this knowledge.

(3) **Cognifact – Objective Interaction**:

    (3a)   Based on the respective cognifacts, the subject performs actions to achieve a certain objective.

    (3b)   Direct feedback from the action's outcome leads to personal learning that becomes manifest in cognifacts, for example, the information that a career adviser gets from her

client.

(4) **Objective – Artefact Interaction:**

    (4a)   The outcome of an action results in the creation or update of an artefact. For example, participation in the assessment of a web document results in the enhancement of the dialogue artefact or a task object is enhanced by resources used in execution.

    (4b)   Artefacts directly influence execution of an action to achieve an objective. For example, data from a task are automatically transferred to a task pattern when the user creates such a task pattern from a task without the deviation via cognifacts.

(5) **Division of labour – Artefact Interaction:**

    Artefacts directly influence the division of labour. This is the case for example in executable process models which control the sequence and interaction of individual activities.

(6) **Community – Objective Interaction:**

    (3a)   In collaborative actions such as negotiations, the subject directly works together with other members of the community.

    (3b)   The result of an action causes an announcement and involvement of the community. For example, after publishing a web document, other members of the community are automatically informed that the new artefact is available so that the community can contribute to its assessment.

(7) **Cognifact – Community Interaction:** The subject directly announces the execution of an action to the community in order to invite members to collaboration.

(8) **Community – DoL Interaction**: The contribution of the community can also consist of the execution of subtasks.

(9) **Objective – Sociofact Interaction**: From the collaborative execution of an action results a shared understanding of this action and the way of collaborations as a sociofact.

The activities described in MAS do not only show direct effects but also influence the organisation in a long-term way. We have taken these effects into account by introducing a second type of arrows represented as dashed, directed lines as depicted in Figure 50:
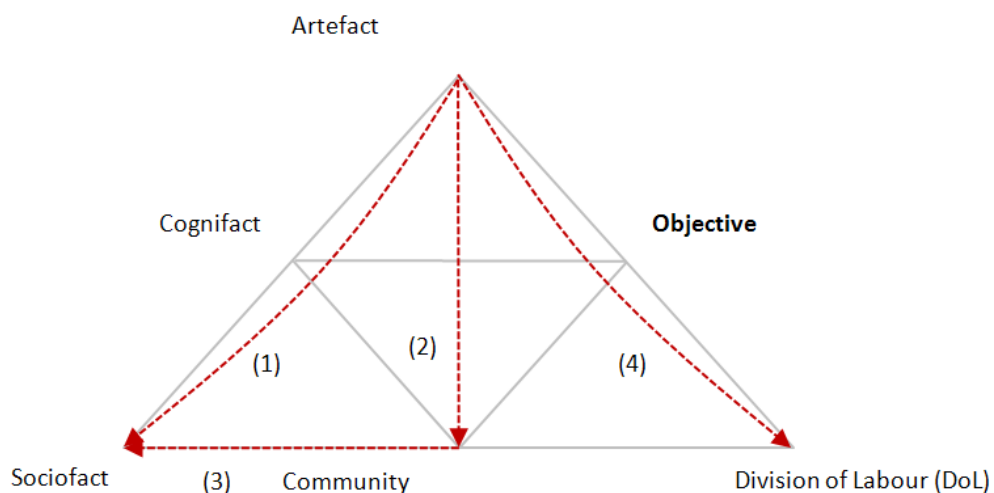
Figure 50. Long-term effects in MAS

Figure 50 shows 4 types of long-term effects that mainly result from gradual, evolutionary developments fostered by performing actions as those described in Figure 49. The difference of the long-term effects to

the previously considered consists in the fact that they are not direct consequences of the respective actions. The considered types of long-term effects are the following:

(1) Artefacts influence sociofacts. For example, if a group of people agrees on a set of tags this influences the rules applied for later tagging by this group as well as others who become aware of the agreed setting.

(2) Artefacts influence communities. For example, people who took part in the negotiation of an artefact can become experts for a certain topic and in this way become informal members of an expert community so that other users might address them looking for support.

(3) Artefacts influence the division of labour. Artefacts such as task patterns describe ways how work is to be split up between involved parties and which roles other people play in this collaboration.

(4) Communities setting sociofacts. By the assignment to a particular artefact resulting from the participation in the assessment of this artefact, a community indirectly sets a sociofact that influences others in their execution.

Due to their indirect character, these long-term effects are more diffuse compared to the direct interactions. Nevertheless, considering these effects helps understand the maturing process in its long-term potential impacts. It is apparent that not all effects are considered here, but only those which we deemed central for the analysis of demonstrators from a maturing perspective.

The MAS approach has been applied to all demonstrators and the results are described separately for each of them in deliverable 2.2/3.2. A central assumption in the description of the demonstrators is that the maturing process is mainly driven by the actualisation of knowledge and the learning from action, in particular if the results of this learning become manifest in knowledge representations such as cognifacts, sociofacts and artefacts. In this way the maturing process is driven by cyclic development between knowledge actualization and manifestation. By applying the MAS approach, we intend to answer the following questions:

1. Which knowledge maturing cycles appear in the demonstrators?

2. How do these cycles drive the spreading of knowledge in organisations?

3. How does the respective functionality of the demonstrator specifically support these cycles and which further functionalities could intensify the effects?

4. Are there any knowledge maturing patterns across all demonstrators?

5. How can we combine the demonstrators to further foster the knowledge maturing process?

6. What can we learn with respect to knowledge indicators form the discovered patterns?

7. How does the analysis help us to further develop the general knowledge maturing model?

Regarding the last point we already observe a convergence of the different approaches described in the deliverable D1.1 and explicated in D2.1 and D3.1.

5.4 Knowledge Maturing Model Revisited

5.4.1 Knowledge Maturing Indicators

As expressed before, knowledge maturing indicators are an important instrument to operationalise knowledge maturing which refers to a phenomenon not directly accessible. Indicators

- operationalise the notion of knowledge maturing and provide answer to the question: how can we observe or assess knowledge maturing?

- provide a basis for guidance activities in a closed-loop approach: analyzing the current status, designing and applying interventions, and evaluating their effect, and thus provide an answer to

the question: how can we systematically and traceably intervene into knowledge maturing with the help of guidance activities?

- help shaping goals and measures in broader initiatives for knowledge management which have suffered from a lack of clearly definable measures that can be managed and thus provide an answer to the question: how can we align interventions into knowledge maturing with the portfolio of management instruments already in use in an organisation?

One of the main issues encountered in the demonstrator development, to a lesser degree also in the interviews, was related to the fact that our indicators do not measure knowledge maturing or maturity directly: They require operationalisation with respect to concrete contexts because it is not always clear what they measure and how or under which conditions we can relate the results of their evaluation to knowledge maturing. This has led us to work on a new systematisation that takes up and goes beyond the results of the reflection on the types of factors presented in section 4.6.2 and is presented in the following.

First of all, it is important to distinguish different ways of "measuring" knowledge maturing, depending on what you want to achieve with it:

- **State-based approach.** Here, indicators measure the maturity of a certain piece of knowledge, or more likely of an artefact or the level of competence of a person. This perspective is interesting when it comes to assessing the status of an artifact or the appropriateness of suggesting a person to contact for a certain topic.

- **Event-based approach.** Here, indicators measure that knowledge maturing has happened, e.g., that a transition between phases took place. While this could be indirectly used to discover state changes, it is also interesting to see if the process of knowledge maturing goes well and if certain interventions were successful (by aggregating event information).

Furthermore, it is also useful to distinguish between different levels of granularity regarding the point of reference. On the one end, you consider a certain piece of knowledge and want to know whether it is mature or whether it has matured. On the other end, you take a global perspective and you want to know whether the organization's knowledge maturing processes perform well, which is important to integrate knowledge maturing support into KPI-driven management systems.

Figure 51 gives an overview of the relationships between criteria assessed by knowledge maturing indicators and complementary concepts such as innovation, quality or performance management. It reiterates the strong demand for aligning knowledge maturing in general and its assessment in particular with complementary initiatives that has already been discussed when reflecting the knowledge maturing stories in section 4.8. The criteria will be analysed in more detail in the following.

5.4.1.1 Knowledge Maturing Criteria

As it was impossible to come up with direct, context-free and universally applicable *measures* for knowledge maturing or knowledge maturity, knowledge maturing *indicators* were conceived as observable events or states that need to be interpreted carefully in order to support the evaluation of the construct knowledge maturing which is difficult to measure and thus, especially in combination, suggest that knowledge maturing has happened. These were based on the observations as part of the ethnographic studies (see D1.1, see also section 3.3.5). As part of year 2 activities, we targeted at deepening the understanding of the link between observable events and states and knowledge maturing. This was done in two strands: (1) empirically in the representative study (where we collected quantitative and narrative input, see section 4.6), and (2) practically in the demonstrators (where indicators were applied and implemented, see D2.2/3.2).
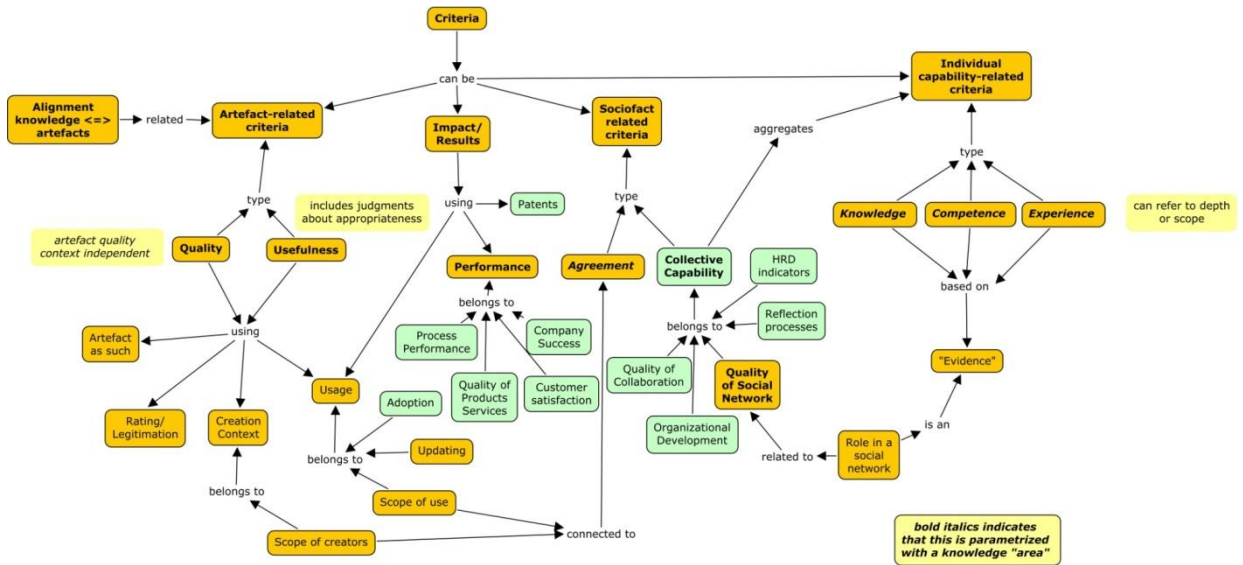
Figure 51. Context map of knowledge maturing indicators and related concepts

Amalgamating this deepened understanding as laid out above and in sections 3.3.5 and 4.6, we aimed at an intermediate layer between knowledge maturing and the indicators and explanatory connections between them. The result is presented in the following sections. Reflecting the findings on the background of our model for the definition of knowledge using the concepts cognifacts, sociofacts and artefacts (see D1.1 and section 5.1.1), the main criteria we have identified are (see figure 52):

- **Artefact-related** comprising indicators which measure something related to any form of artefact (corresponding to the dimension of the same name).

- **Individual capability-related** comprising indicators on the individual's experience, competence, or knowledge.

- **Sociofact-related** covering indicators measuring quality of social interaction or meta-competencies on a collective level.

- **Alignment of artefacts and cognifacts.** This was the result of analysing the demonstrators which all aim at aligning the maturity or formality of artefacts with the maturity of the underlying knowledge, avoiding over- and under-formalization.

- **Impact & Results.** This was one of the major additions by interviewees that we can indirectly measure maturity of knowledge through the output it generates. However, these are also most context-specific, i.e. they need to take into account the goals of the business system, business processes as well as complementary initiatives, such as quality management initiatives.
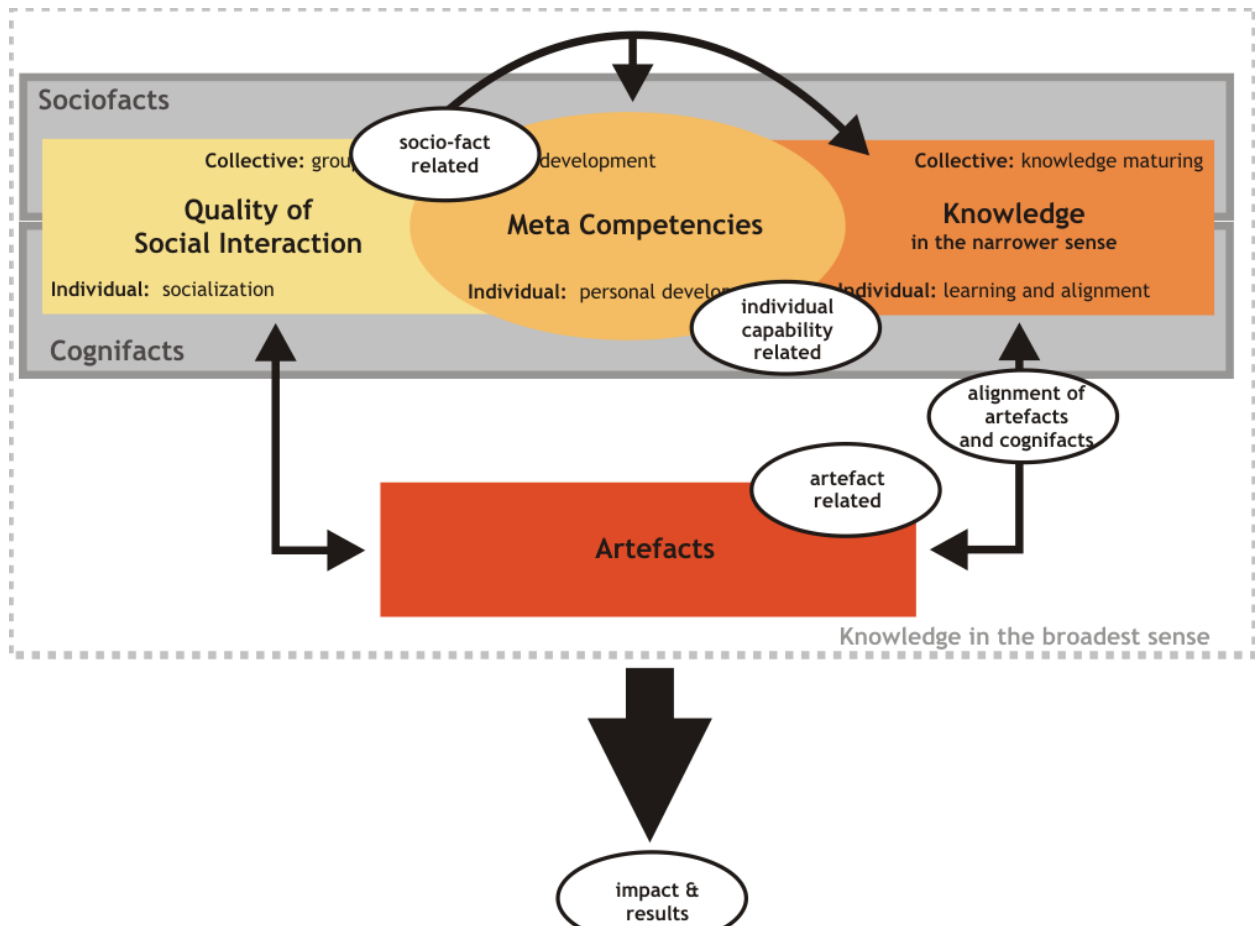
Figure 52. Knowledge Maturing Criteria

In the following sections, we explain how these criteria relate to knowledge maturing and which sub-criteria we have discovered.

5.4.1.2 *Artefact related criteria*

Artefact related criteria seem to be the most straightforward criteria to use because artefacts (if they are in a digital form) are easy to access and analyse. But what can we derive from characteristics of artefacts about the collective knowledge in an organisation that they supposedly help to materialise?

The underlying *assumptions* are the following:

- A higher quality (fitness for use or usefulness) of artefacts reflects the maturity of the underlying knowledge. One cannot produce a high-quality artefact without having sufficiently mature knowledge.

- Because knowledge maturing expands the scope of the "audience" of that knowledge, this usually involves boundary crossing for which appropriate artefacts are produced as boundary objects so that one can also assume that artefacts will be produced. However, this is also a limitation: this criterion can only cover knowledge that can be and is made explicit.

- A different perspective is a more collective one that does not aim at an individual piece of knowledge, but rather at an organizational capacity: if the organization is able to produce high-quality artefacts, it has also effective knowledge maturing processes. This was particularly a perspective that was mentioned by interviewees in the representative study. It resonates well with quality management initiatives with their strong underlying assumption that high process quality leads to high product or service quality.

For artefact-related criteria, we have identified two sub criteria:

- **Quality.** This refers to characteristics that are inherent to the artefacts or at least not dependent on a context, e.g., the customer context. This includes indicators for the artefacts as such, e.g., readability, link density, structuredness, etc. (see Braun and Schmidt, 2007).

- **Usefulness.** Quality does not mean that it is useful for someone if quality is not defined with respect to fitness for use and thus from a customer perspective[43] (e.g., Juran, 1988), but e.g., as conformance to requirements from a producer perspective. High quality artefacts in that latter sense can be useless, while low quality artefacts can sometimes help. So this sub criterion includes judgments about appropriateness.

Both sub-criteria can utilize the same kind of indicators, but with different interpretation (and potentially slightly different settings), e.g., rating/assessment: you can assess a document with respect to quality from a context-free producer perspective, from an application perspective taking into account the context of creation, i.e. you can assess it according to how useful it was for your own problem situation in which you have used it, or taking into account the context of potential re-use, i.e. reflecting the customer perspective. Likewise, you can interpret usage indicators in terms of usefulness or quality, e.g., if it gets updated, it could be traced back to its low quality, or to its usefulness, which makes it worth updating. Further criteria related to quality or usefulness derives their information from the creation context: who created it, how diverse was the group, for which purpose was it created? and from the context of reuse: who might reuse it, how diverse might that group be, for which purpose might it be reused? Figure 53 shows a context map of artefact-related criteria as explained here.
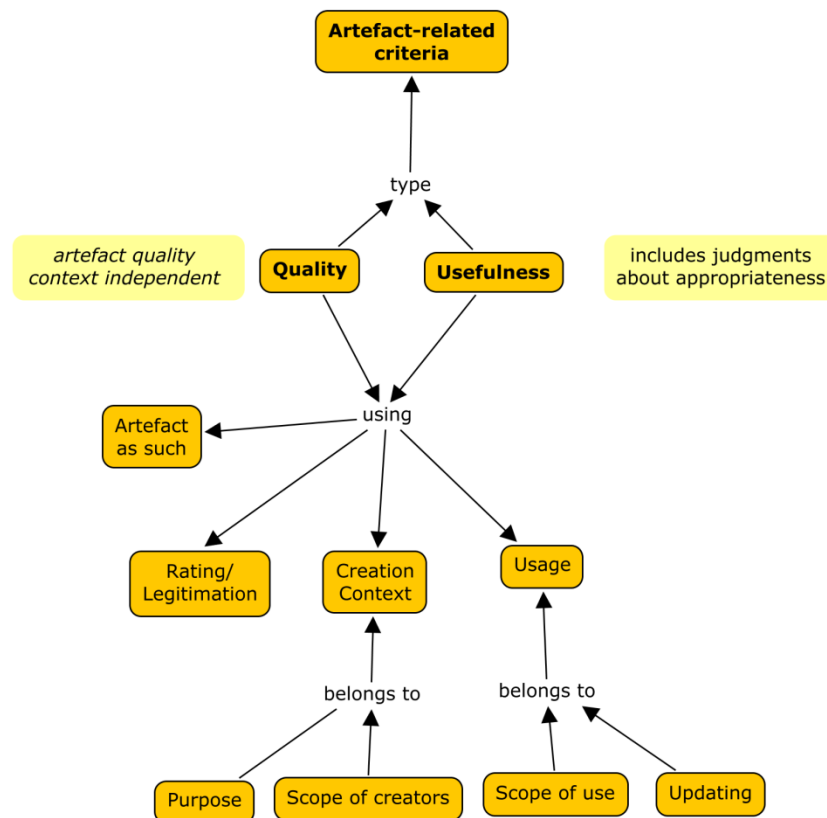
Figure 53. Artefact-related criteria

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[43] Customer refers here both, to organization-external customers as well as organization-internal customers, in the sense of knowledge transfer these would be the recipients who demand knowledge.

5.4.1.3 *Individual capability-related*

This criterion covers the contribution of individual learning to knowledge maturing. We have distinguished knowledge maturing from individual learning: the former is an advancement of knowledge on the collective level while the latter is limited to advancements on the individual level, so that individual learning is a prerequisite for knowledge maturing, but not sufficient.

More precisely:

- Knowledge maturing requires individual knowledge, experience, or competence. Individuals can only improve existing practice, or create new practice if they have the capacity for that.

- If sharing and passing on of knowledge works well, then learning of the individual leads to collective learning, too.

- However, as part of the qualitative data collected during the interviews, interviewees frequently had concerns that experience can also have an opposite effect on knowledge maturing as it makes you professionally blinkered (skilled incompetence) so that we cannot simply take a cumulative perspective (i.e., the amount/duration of experience)[44]. It was suggested that the diversity of experiences needs to be taken into account. In some cases even, employees coming from outside were seen as one of the major triggers for knowledge maturing, sometimes much more than internal sources.
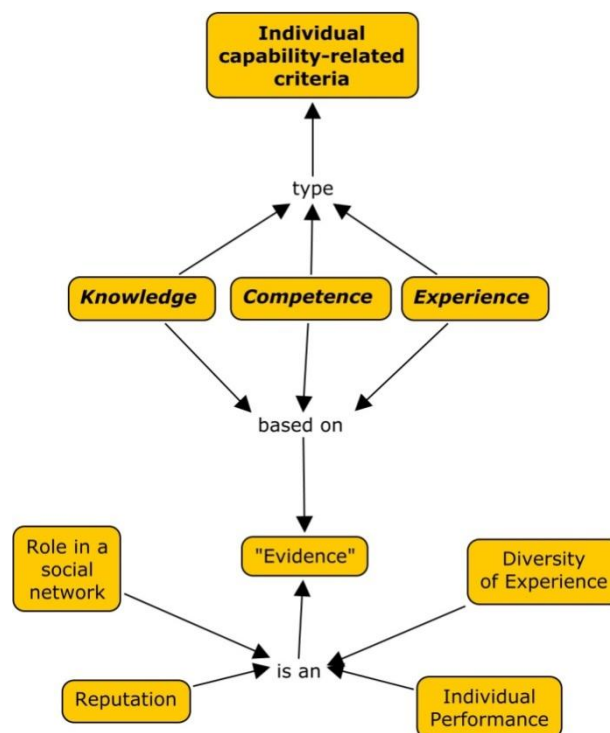
Figure 54. Individual Capability-Related Criteria

Even if we argue that individual capability is a good criterion for knowledge maturing, it remains a hard problem to assess it, which is well-known in the areas of competence management (competence diagnosis), and also emerging domains like e-portfolios and certification of informal learning outcomes.

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[44] This argument, although to a minor degree, can also be taken in the case of the quality of artefacts – the higher the quality, the more hesitant people might be to change the artefact. This once again stresses the importance of the differentiation between universal, context-free measures of knowledge maturing which we could not find and knowledge maturing indicators which require further interpretation.

In those domains, you speak of "evidence" for a certain competency or experience. It remains a challenging task because:

- competence, knowledge, experience, are frequently as unobservable as knowledge maturing is,

- it is of no big use to consider "experience" or "competence" of an individual in general, because they are always related to certain competency domain or area of experience which further increases the complexity,

- evidence is always highly contextualized and it is not obvious to separate context from a more general competency so that it is always methodologically challenging.

Some commonly used types of evidence include individual performance (in a task, project etc.), reputation (pre-dominant in the scientific field), diversity of experience, or the role in a social network, which is related to the socio-fact dimension. Demonstrator 3 on People Tagging has investigated this in more detail for its search heuristics. Figure 53 shows a context map of artefact-related criteria as explained here.

5.4.1.4 Socio-fact-related

Socio-facts which comprise rules, collective practices etc., are much less accessible for assessment than the artefact-related criteria. Still, sociofacts represent an important source for learning about knowledge maturing.
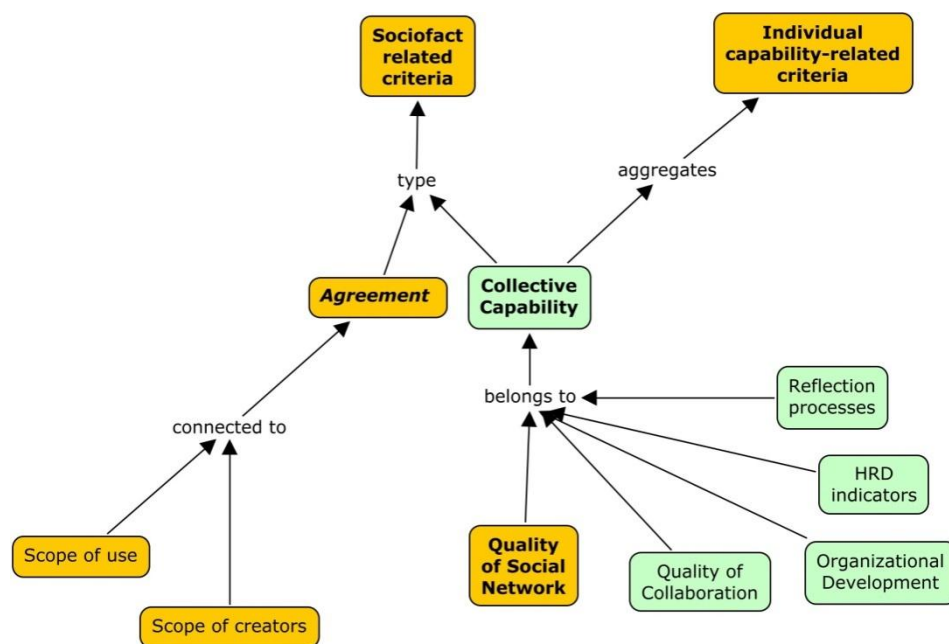
Figure 55: Sociofact-related Criteria

- On a more specific level, it is assumed that the more mature knowledge about a subject is, the higher the level of agreement is in the collective. This is most obvious if it is about ontological knowledge, i.e., knowledge how to describe things: a shared vocabulary can only be mature if it is really shared and agreed upon by the respective group. But this can also be illustrated for process knowledge: if an expert designs a process, this is still immature; it only becomes mature if the process becomes part of daily practice, contributing the knowledge how to operationalise it. This has an overlap with artefact-related criteria like scope of use or scope of creators which indicate a degree of agreement.

- On a more collective level, it is assumed that organizational competencies to learn are a prerequisite for mastering knowledge maturing processes. A learning organization is more capable of knowledge maturing. Again, this perspective was largely introduced through the interviews, where a lot of indicators around human resources development, quality of collaboration, the presence of reflective processes, or even the fact that the organisation develops further were mentioned[45]. This can be viewed as a collective capability, which aggregates individual capabilities.

Figure 53 shows a context map of artefact-related criteria as explained here.

5.4.1.5 *Impact & Results*

The impact-related criteria follow the philosophy of typical KPI systems (key performance indicators) in companies where the focus is on what criteria are measurable and have a clear relationship to organisational goals. This set of criteria thus materialises an important connection between knowledge maturing and the (operational) management, reporting and controlling system of an organisation. Organisations are not interested in capability as such, but in the success of applying it in a concrete business process, activity or market situation. The assumptions behind it are the following:

- If knowledge how to produce, organise, consult, … is mature, then the results are better than with immature knowledge. This follows the perspective that knowledge is a resource or production factor. Building collective knowledge, thus, is capacity building for the organisation. But this also implies that the value of knowledge is connected to a purpose, which was mentioned in interviews ("because it doesn't help to have the knowledge somewhere and it doesn't get used"). Here, we clearly see a differentiation between "pure" knowledge and "relevant" knowledge.

- Efficient processes must be well understood and agreed upon with the stakeholders, thus requiring mature process knowledge.

- On the collective level, it assumes that the success of the organisation/team is connected to whether knowledge maturing takes place successfully: "I would say that the actual product or service reflects how the company deals with knowledge".

- A major limitation of this criterion is that it is by nature a retrospective criterion: it can only measure the impact/result of knowledge acquired in the past. It cannot judge the future impact or future results. Indicators here have a clear bias towards supporting evolutionary development and sustaining innovation, and tend to undervalue revolutionary developments and disruptive innovation.

For this criterion which was under-developed in our original set of indicators, we received many additional suggestions from the interviewees. This can easily be explained by the fact that indicators related to this criterion are already part of everyday (management) practice in companies. One interviewed company even views their (performance) indicators as their major management instrument, including tracing RoI, but also as an incentive system for self-organised change processes in divisions and departments across a geographically distributed company network.

It was frequently suggested that the test whether knowledge is really more mature (and not just better formalised, e.g., in a guideline or process model) is the actual adoption: does it get applied? Is it part of everyday practice? Is the process model "lived by"?

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[45] One reason explaining this might be that interviewees elaborate on the association between our knowledge maturing models and well-known maturity models of organisations, such as the capability maturity model. These and the differences and similarities with our model have been analysed extensively in D1.1.

From companies with physical goods, patents were seen as easy to measure and also a significant indicator[46].

Additional indicators include process performance, the quality of products or services (including error rates, but also more soft issues like product identification), customer satisfaction, or the overall company success (e.g., in selling products or acquiring follow-up projects). Figure 53 shows a context map of artefact-related criteria as explained here.
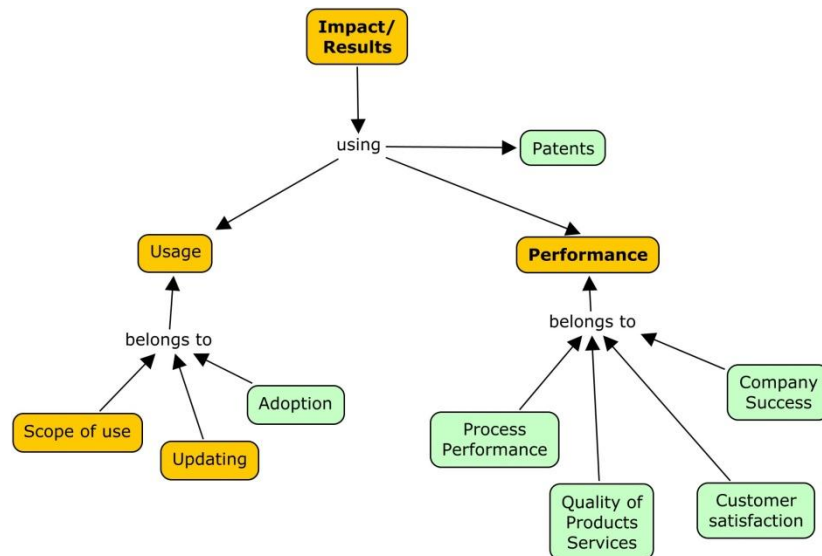
Figure 56. Impact-related Criteria

5.4.1.6   *Alignment of artefacts and cognifacts*

From the reflection on the demonstrators, one important additional aspect has emerged that did not easily fit into the other categories: the alignment of artefacts and cognifacts. The underlying assumptions here are

- Artefacts are required for effective knowledge maturing, especially in their function as boundary objects.

- Their format or level of formality has to be appropriate for the actual maturity of knowledge, avoiding over-formalisation and under-formalisation.

This can be found in the four demonstrators:

- Demonstrator 1 aims at creating and (co-)developing appropriate artefacts for career guidance, aligning artefact quality with the knowledge of personal advisers.

- Demonstrator 2 aims at supporting a community to organize and maintain a shared collection of resources, aligning the vocabulary used with the shared understanding of the community.

- Demonstrators 3 aims at developing the knowing-who in an organization and the systematic capacity building, aligning the shared vocabulary to describe interests, capabilities and competencies with people's needs.

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[46] Although many interviewees see the ambivalence of too strongly relying on this indicator.

- Demonstrator 4 aims at developing process-related knowledge, aligning the representations as task patterns or process models with the maturity and stability of the process knowledge as such.

While this criterion is important to consider, it is also very difficult to measure. However, during the evaluation activities we will seek to address this criterion.

5.4.2 Guidance

Since the original knowledge maturing model v1, guidance has been a complementary process to the knowledge maturing process which was based on the assumption that knowledge maturing denotes mainly a "bottom-up" perspective while guidance was the "top-down" perspective. The term **guidance** in this context can be defined as **any influence on the direction ("goal") or the quality (in terms of effectiveness and efficiency) of knowledge maturing processes by entities not directly involved in them**. Such guidance can range from an unintended "influence" (e.g., via the mere existence of artefacts) via explicit shaping of context conditions (e.g., giving room for collaboration, recommendation of artefacts) up to direct interventions into the setting of goals or even operational procedures (e.g., decisions on what to pursue and what to discard, prescription of artefacts).

Guidance is not limited to persons as the "guiding" entity (like, e.g., leadership with respect to knowledge maturing), but is also exercised by artefacts (like documents containing guidelines), or sociofacts (like social rules, or a shared understanding). In the following, we have a closer look at these different forms of guidance.

5.4.2.1 Artefact-based guidance

Artefacts have an important function in knowledge maturing processes; they facilitate exchange and cooperation, and promote boundary crossing between different communities. This function has so far been mainly seen as artefacts being part of knowledge maturing processes by documenting their (intermediate) results. However, this is only one part of their role in knowledge maturing processes. They also guide other knowledge maturing processes in which they are not the object of development (this is related to the artefact cascading maturing in the analysis in D2.2/D3.2). The existence of a process model, even if it is not lived by, will influence future reflection on practice and the maturing of knowledge how to do certain things. Either you take the artefact as a starting point which you improve, or you completely oppose the model and argue against it. But you are not free from influence.

There is definitely a positive effect of artefact-based guidance: existing artefacts provide scaffolding; you can compare new developments to established artefacts, so this is important for the Zone of Proximal Development. The risk of artefact-based guidance lies in the constraints they impose on new ideas and developments. They tend to foster continuous evolution and sedimentation instead of revolutionary developments.

Not all artefacts have the same degree of influence on future knowledge maturing processes. The degree of influence of artefacts depends on many factors, which include:

- **Awareness of existence**. The existence of an artefact only affects knowledge maturing processes if the actors are aware of it. A filed guideline nobody knows about hardly can have any influence, whereas the same guideline will have an impact on the way of thinking if everyone is aware of it.

- **Legitimation**. Even if the content of a document is the same, it makes a difference whether it is an official document endorsed by top management or just authored by an employee. In the first case, it is more authoritative, thus considered more important. In the second case, it has to convince by its usefulness. The same applies also to persons as authorities for certain topics through their reputation.

- **Commitment.** The guiding influence of an artefact also depends on the amount of support it gets. In addition to legitimation, support can also be provided in the form of self-commitment by

members of groups, teams, communities or other organizational units, i.e. the amount of identification of these entities with the knowledge materialised in the artefact.

- **Quality and usefulness**. Besides organisational legitimation, commitment or personal reputation, there is also inherent reputation of an artefact that originates from its quality and usefulness/appropriateness which in turn usually correlates with the maturity of knowledge it represents: more mature knowledge guides the development of new knowledge which – in a Kuhnian perspective – can lead to both stabilizing, but also revolutionary effects.

- **Level of formality**. The level of formality (or degree of structuredness) plays a big role for artefact-related guidance. Higher level of formality on the one hand constrains the freedom of action by eliminating ambiguity; on the other hand it helps to gain efficiency. This applies to all forms of artefacts: highly structured documents vs. informal notes, formal process models vs. task notes, formal ontologies vs. informal tags. This also applies on a meta-level: the formalism chosen/prescribed/recommended for a knowledge maturing activity influences the progress so that it is important to consider the appropriateness.

These factors also show that artefact-related guidance can be influenced through managerial or tool-based guidance (see also below). Management can decide on what and how much to legitimate, groups, communities or other organisational units can decide on to what and to what extent they commit themselves, thus balancing the positive and negative effects. Tools can be used to create more awareness, and they impose a certain level of formality.

If we have a look at the demonstrator developments in terms of artefact-based guidance, we discover the following:

- *Demonstrator 1*. In this demonstrator, the main form of guidance is through (i) creating awareness and (ii) quality and usefulness. By increasing sharing of artefacts and improving "findability", i.e. that they can be found more easily, more employees become aware of the existence of artefacts. The transparency of maturity indicators (like, e.g., readability) and the relation to (a) person(s) helps artefacts with a high quality or (a) reputed author(s) to exercise more guidance without constraining too much.

- *Demonstrator 2* focuses on developing a shared understanding of community. The most important element is the co-developed shared vocabulary. Here, there are many forms of (subtle) guidance: existing tags (maturing phase Ib-III) that are recommended are guiding tag assignment (phase Ib), existing semantic structures (phase II-III) guide the incorporation of new elements (III). And through documenting dialogues, you give more legitimation or commitment respectively to parts of the structure. Furthermore, the level of formality of (i) the ontology and (ii) the dialogues guides the activity of the community.

- *Demonstrator 3* is related to demonstrator 2 as it also puts the vocabulary into a central place, so the same guidance aspects apply.

- *Demonstrator 4*. In this demonstrator, the pre-modelled process (phase IV) gives a frame to task patterns (phase II-III), and existing task patterns (phase II) guide individual task management (phase Ib).

5.4.2.2 *Sociofact-based guidance*

Not only artefacts, but also sociofacts influence knowledge maturing processes as knowledge maturing is a social learning process. The challenge with sociofacts is that they are usually much less visible, but their guidance effect can be much more intense. Based on the work so far, we can identify the following most important types of sociofacts that have a guiding effect:

- **Culture.** Many interviewees in the interviews have explained aspects of their team or corporate culture as an influencing factor for knowledge maturing (see, e.g., section 4.3.3 on barriers when

the most frequently used code was organisational culture). Some also reflected on their professional culture; national culture was, however, perceived as having hardly any effect in the interviews. Culture includes shared values and unwritten rules about socially acceptable behaviour. It influences whether sharing is good, whether new ideas are welcome, how open organisational members are to externals etc. This implies that companies assumedly have different strengths in terms of knowledge maturing, e.g., some are good in the early phases, while others are good in the late phases – because their culture is more towards communication, in one case even termed "over-communication" or more towards formalisation as visible in the group of organisations clustered as "hesitant formalists" (see section 4.7).

- **Collaboration and communication structures.** This is another important type of sociofact: established practices of collaboration which do not need to be negotiated on every occasion. If there are regular team meetings where you can naturally bring up new ideas, this will be the forum for discussion. If there is no such meeting, or if this meeting is not for discussion, then you have first to create such a forum. From the interviews, there was also the issue with idea management where individuals submit proposals for improvement in a formalised way and this is reviewed by an expert panel. In this case, there is no established collaboration structure, and the established practice promotes individual ideas so that ideas do not get discussed. The complete opposite was true with a group culture, in which it was not appropriate to trace an idea back to an individual as it was always a group that would be the unit to hand on an idea. Sometimes, both collaboration practices even co-existed in the same organisation (see the stories analysed in section 4.8). Similarly, the quality of informal communication channels, both within and across organisations, has an impact on how knowledge maturing processes actually happen.

- **Shared practices.** Work and business processes have been probably the most prominent socio-facts in an organisational context. Even more than collaboration and communication structures, they determine how everyday tasks are executed, they structure the division of labour etc. As a consequence, they are the primary frame of reference for knowledge maturing processes, particularly those concerned with knowledge how to do things.

In our second year demonstrators, we have also addressed the sociofact-related form of guidance. This especially applies to demonstrators 3 and 4.

- In *demonstrator 3*, we explicitly aim at developing the knowing-who in an organisation, i.e., at developing the collaboration and communication structures. Thus, demonstrator 3 influences how these structures guide knowledge maturing processes. Furthermore, the people tagging design framework supports coordinating the guiding effect of the organisational culture with the potential changes to the collaboration and communication structure by adapting the tool functionality (see D2.2/D3.2).

- Demonstrator 4 explicitly aims at developing shared practices, but it also exercises guidance through the prescriptive process model. Because this process model has only a limited level of detail, it has the function of a scaffold for individual task management.

5.4.2.3   *Managerial guidance*

Managerial guidance for knowledge maturing is embedded in general management and leadership functions in organisations the purpose of which is the definition of organisational goals and the alignment of individual activities with those goals. Managerial guidance for knowledge maturing is thus interlinked with organisational goals, which typically implicitly or explicitly constitute a goal hierarchy, from very general and abstract to more specific, up to employee-level goals (as visible e.g., in management-by-objective approaches). Key performance indicators (KPIs) are typically used to measure to which degree goals have been reached.

In analogy to that, the knowledge maturing indicators from the previous section can be used to trace the effect of interventions into the organisation with respect to knowledge maturing. We can make use of the

indicators at different levels, depending on the level of the intervention. From the discussion in the previous section, it has become clear that these indicators are context-dependent heuristics to approximate actual knowledge maturing processes. This means that from the presented collection and based on the identified underlying assumptions, a reasonable set has to be selected and often refined to match the needs of a company and the requirements and context of a specific situation.

But what can management interventions look like? Based on the interviews, we could identify the following:

- **Setting goals and thus giving priority.** Without prescribing what to do or what to change, management can influence maturing processes through setting goals to be achieved and/or giving priority to certain maturing activities or processes. The first aspect stimulates change with a certain organisational effect, thus guides the creativity towards a certain goal. The second changes the allocation of resources and could address the (most frequently) mentioned barriers of (1) lack of time and (2) low awareness of the value and benefit, such as creating a working group with a clear mission linked to organisational goals.

- **Shape work environment and work organisation.** Interventions could also include changing the work environment and/or the work organisation. In the first case, this refers, e.g., to improving, or deploying tools for maturing support; in the second case, this refers to division of labour, the conscious, goal-oriented shaping of communities-of-practice and business processes.

- **Organise and coach learning processes.** Interventions can take place both on an individual or on a collective level. On an individual level, this encompasses typical human resource development activities aimed at individual development (through trainings, coaching etc.). On a collective level, this is also about organisational learning, e.g., establishing reflective practice, continuous improvement processes, but also more local aspects, such as interventions into group processes, e.g., according to the seeding-evolutionary growth-reseeding philosophy (see D1.1).

So far, management interventions have not been directly addressed in the demonstrators. However, demonstrator 3 aims at informing human resources development so that they can intervene through triggering training activities or similar. Demonstrator 4 offers the possibility for prescribing a process, thus allowing for shaping the work environment.

5.4.3 Knowledge Maturing Phase Model v3

While the phases I-III could be interpreted well and remained stable in the interviews, we were able to capture a lot more detail about the phases IV and V. Specifically, we found two primary interpretations about what happens after the formalizing phase. Resonating well with learning theory that distinguishes between intended and unintended learning, a similar distinction could be made with respect to training. Two settings were dominant in the reports given by the interviewees: (1) an instructional setting and (2) an experimental setting. Figure 57 shows the revised knowledge maturing phase model v3 (compare to the model v2 presented in section 5.1.1).
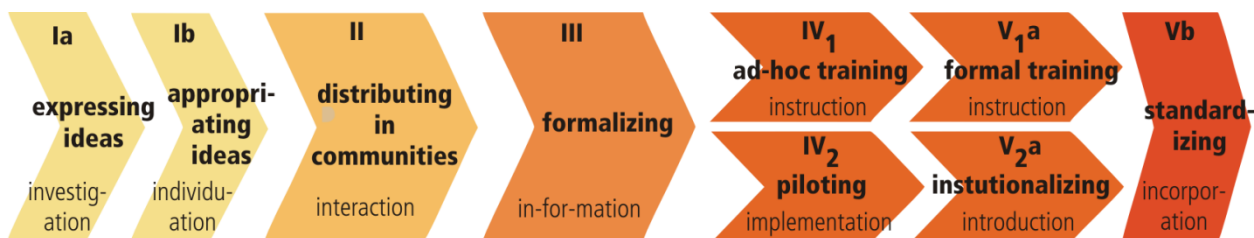
Figure 57: Knowledge Maturing Phase Model v3

In the first case, the **instructional setting**, knowledge is conveyed to a target group of users in a dedicated instructional activity. Examples for interviewers' connotations are presentations to audiences

that have not been familiar with the activities happening so far, but could benefit from them, workshops or informal learning activities aimed at introducing a new member to a group's or a project team's activity system.

In the second case, the **experimental setting**, knowledge is arranged and transformed so that it can be applied in a dedicated, specific experiment involving not only the creators of knowledge, but other stakeholders. This prepares for a larger scale application. Examples for interviewers' connotations are pilot studies, pilot projects, ramp-up activities or the beginning of a roll-out.

These two cases are made visible in figure 57 as two parallel strands (IV1, V1a versus IV2, V2a).

Certainly, these two settings are not mutually exclusive. Nevertheless, many interviewers could relate to one of them as being the dominant activity happening in their environments. Depending on which setting was dominant, also the subsequent phase either follows an instructional path or an institutionalization path. The ultimate maturity phase for both would be some form of standardisation or certification. However, this final phase is comparably rarely achieved, particularly in organisations that operate in dynamic or even (hyper-)turbulent environments.

- **Ia. Expressing ideas (investigation):** New ideas are developed by individuals either in highly informal discussions or by browsing the knowledge spaces available inside the organisation and beyond. Extensive search and retrieval activities often result in loads of material influencing idea generation. Knowledge is subjective, deeply embedded in the originator's context and the vocabulary used for communication might be vague and restricted to the originator.

- **Ib. Appropriating ideas (individuation):** New ideas or results found in the investigation phase that have been enriched, refined or otherwise contextualized with respect to their use are now appropriated by the individual, i.e. personalised and contributions are marked so that an individual can benefit from its future (re-)use. While many initiatives for knowledge management have focused on sharing knowledge or even detaching knowledge from humans as "media", at least in a more individualistic culture, individuals also require support for appropriation.

- **II. Distributing in communities (community interaction):** This step is driven by social motives and the benefits that individuals typically attribute to sharing knowledge. These are, among others, belonging to a preferred social group, thus increasing the probability of getting back knowledge from the community when one needs it. From the perspective of semantics, a common terminology is developed and shared among community members.

- **III. Formalising (in-form-ation):** Artefacts created in the preceding phases are often inherently unstructured and still highly subjective and embedded in the community context which means they are only comprehensible for people in this community due to assumed shared knowledge needed to interpret them. In this phase, structured documents are created in which knowledge is de-subjectified and context is made explicit with the explicit purpose to ease the transfer to collectives other than the originating community.

- **IV$_1$. Ad-hoc training (instruction):** Documents produced in the preceding phase are typically not well suited as learning materials because no didactical considerations were taken into account. Now the topic is refined to improve comprehensibility in order to ease its consumption or re-use. Individual learning objects are arranged to cover a broader subject area. Tests allow to determine the knowledge level and to select learning objects or learning paths.

- **IV$_2$. Piloting (implementation):** Typically, not every implementation detail can be foreseen in the preceding phase. Thus, in many cases before a larger roll-out, a piloting phase deliberately deals with collecting experiences with a test case before a larger roll-out of, e.g., a product, a service to an external user community, such as customers or other stakeholders, or new organisational rules, procedures or processes to an organisational-internal target community such as project teams, work groups, subsidiaries or other organisational units.

- **V$_1$a. Formal training (instruction):** In an instructional setting, the subject area becomes teachable to novices. A curriculum integrates learning content into a sequence using sophisticated

didactical concepts in order to guide learners in their learning journeys to capture a subject area thus increasing the probability of successful knowledge transfer. Learning objects are arranged to courses which cover a broader subject area. Learning modules and courses can be further combined into programs used, e.g., for preparing for taking on a new role or for career development.

- **V₂a. Institutionalising (introduction):** In the organisation-internal case, formalised documents that have been learned by knowledge workers are solidified and implemented into the organisational infrastructure in the form of processes, business rules and/or standard operating procedures. In the organisation-external case, products or services are launched on the market. They are institutionalised into the portfolio of products and services offered by the organisation.

- **Vb. Standardising (incorporation):** The ultimate maturity phase is very similar for both paths, the instructional and the experimental path, and covers some form of standardisation or certification. On an individual level, certificates confirm that participants of formal trainings achieved a certain degree of proficiency. On an organisational level, certificates allow organisations to prove compliance with a set of rules that they have agreed to fulfil, e.g., with service level agreements or with respect to regulations such as Basel II or SOX[47]. Concerning products and services, certificates show compliance to laws, regulations or recommendations that a product or service, can, should or must fulfil before being offered on a certain market.

5.5 Conclusion

With the developments in year 3, the knowledge maturing model has evolved towards the operational level: knowledge maturing indicators for making knowledge maturing observable and measurable, knowledge maturing activities and their guidance. The main inputs to that development were the empirical results from the representative study, the demonstrator developments and their participatory design and evaluation activities, and a focussed exploration of the state of the art with respect to specific questions.

The new knowledge maturing model "universe" is summarised in Figure 58. At the top is the original starting point: the **phase model**. It embodies the main proposition: the process of knowledge development can be structured into distinct phase with specific characteristics that are useful because learning in this process takes different forms depending on the phase, and because barriers can be identified between those phases. To better understand what we mean by "knowledge maturing", the **dimension model** complements this perspective by separating individual from collective dimensions, artefacts, sociofacts, and cognifacts. Towards the operational level, **knowledge maturing activities** are activities of individuals or groups. These activities are described in a generic way so that they occur in different phases of maturity. However, in the demonstrators it has become visible that these activities are different depending on the phase of maturity. **Demonstrators** as the technical realisations developed in the second year support those activities in a context-specific way. These have been analysed more closely with the help of Maturing Activity Systems to understand the constituents of a knowledge maturing activity. and their interaction. Demonstrators also instantiate **knowledge maturing indicators** (as observable events or states that allow to measure that knowledge takes place), both on a technical level and on an evaluation level. Knowledge maturing criteria structure these indicators by what they actually measure and how and under which circumstances there is a connection to knowledge maturing. The criteria were aligned with the dimension model.

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[47] This can even lead to business process automation in which the highest degree of programming is achieved in an organisation-theoretical sense.

PHASE MODEL
- identifies distinct phases
- suggests an ordering

DIMENSION MODEL
- identifies different knowledge dimensions

have characteristics depending on

operationalise maturity and maturing in

refer to

KNOWLEDGE MATURING ACTIVITIES
= activities of individuals or groups contributing to knowledge maturing
- general activities that keep the collective learning process running
- specific activities for transitions/overcoming barriers

Knowledge Maturing Activities

Knowledge Maturing Criteria

structure and explain

KNOWLEDGE MATURING INDICATORS
= observable events or states that allow to measure that knowledge maturing takes place

Knowledge Maturing Indicators

are context-specific instantiations of

MATURE Activity Systems

instantiate and use

are analysed using

support

DEMONSTRATORS

implement

Guidance Model

incorporate into design

related to

MOTIVATIONAL ASPECTS
- analysis framework for motivational aspects
- phase-specific intervention possibilities

Figure 58: Knowledge maturing model elements and their relationships

6   Summary and Outlook

Within year 2 in WP1, two main strands of activities have been performed:

- design, execution, and analysis of an empirical study with 126 representatives of medium-sized and large European organisations

- development of the knowledge maturing model v3, taking up the input from the empirical study, from a focussed start of the art analysis, and interacting with the implementation and evaluation of the demonstrators

The main results of year 2 are depicted in Figure 59: the refined version of the knowledge maturing indicators, the refined version of the knowledge maturing activities together with an analysis of the demonstrators (maturing activity systems), the guidance model, and the knowledge maturing phase model v3. With these results, WP1 has been able to go well beyond the analytical knowledge maturing model at the end of year 1 and put clear focus on how to guide and support knowledge maturing, both conceptually and particularly with the help of tools. This has also helped the project to identify generic aspects and contextual dependencies, which is important for the further development.

The knowledge maturing model development has continued to act as the conceptual anchor of the project, enriching the ongoing discussions with narratives from the empirical studies, and developing the phase model, knowledge maturing indicators and activities as boundary objects between the different work packages. It has again proven successful to foster a high degree of interaction (and early exchange of results) between WP1 and the other work package through the use of the wiki, flashmeetings, and face-to-face meetings, and through an overlap of participants in WP1 and the technical developments.

Building on the ethnographically informed study in year one and the representative study in year two, a further empirical study is planned for the third year of MATURE. For this In-Depth study, it is planned to create a number of cases, i.e. organisations or networks of organisations studied in more detail, based on analyses to be conducted by MATURE partners. These cases will be categorized on basis of the three types of organisations with regard to knowledge maturing found via cluster analysis in the representative study. Whereas the representative study aimed at getting a broad picture of knowledge maturing in different organisations, a smaller set of specific concepts will be aimed at for the In-Depth study. Of particular interest will be aspects of personal workplaces. In addition, the further developed version of the Knowledge Maturing Model (v3) will be used to guide study design and to emphasize on points like the transition between KM phases. Besides model-oriented and person-oriented aspects, also guidance-oriented aspects are of primary interest within the MATURE project and therefore topics of interest for the In-Depth study.
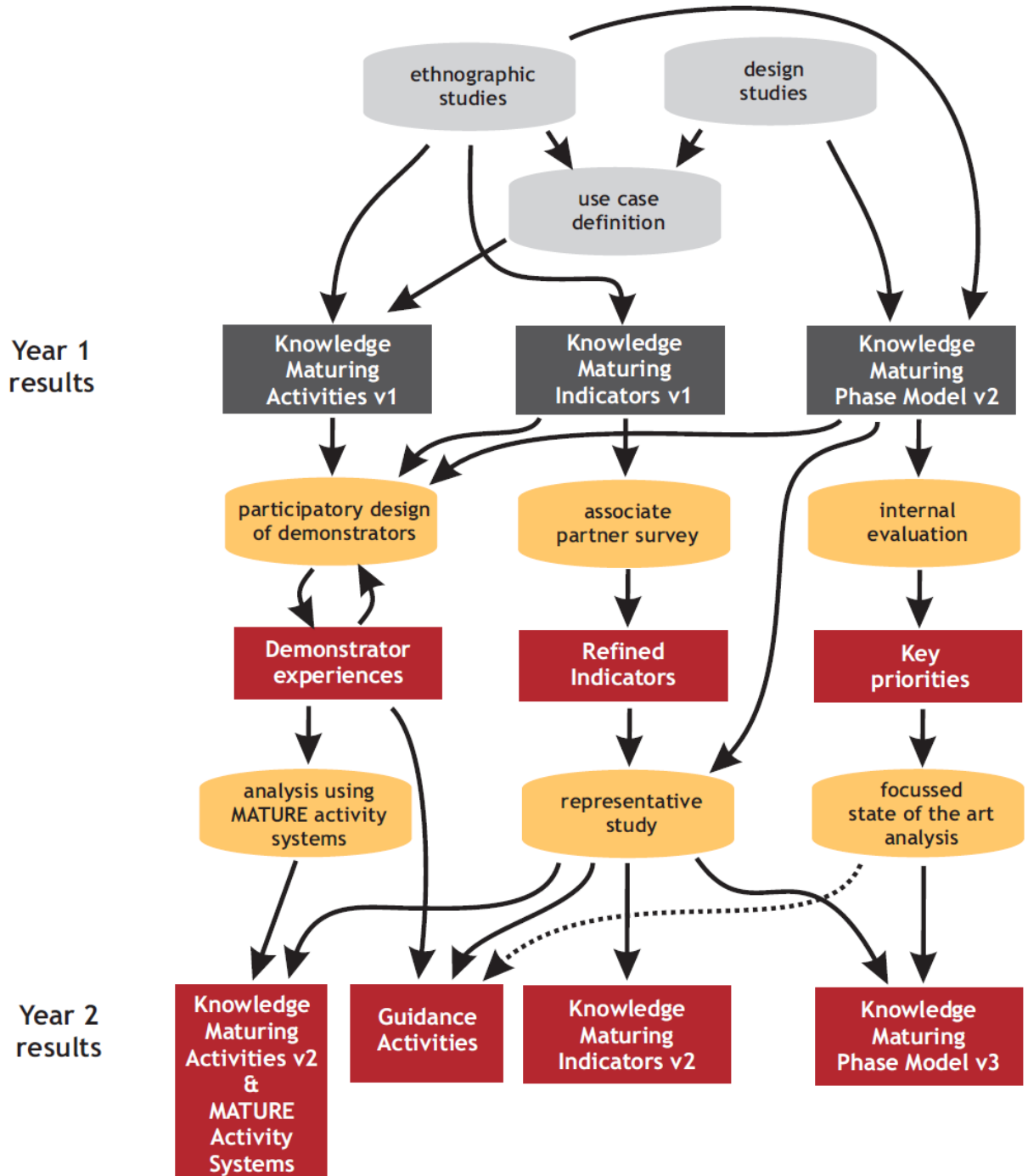
Figure 59: Summative overview of year 2 activities and results

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8 Appendix

8.1 Survey on Knowledge Maturing Indicators

8.1.1 Provided Information

Defining Knowledge Maturing

In MATURE, knowledge maturing is defined as **goal-oriented learning on a collective level,** where:

- *goal-oriented* describes knowledge maturing as a process with a direction (goals can be individual, team and organisational goals, they can be fuzzy or concrete and may change over time)

- *collective level* can refer to a team, an organisation, a community etc and makes clear that knowledge maturing is usually not the result of an activity of an individual, but of an interconnected series of activities of interacting individuals

Knowledge Maturing Model

The following figure presents a model for knowledge maturing from left to right. The left side represents emerging knowledge whereas the right side relates to more mature knowledge.
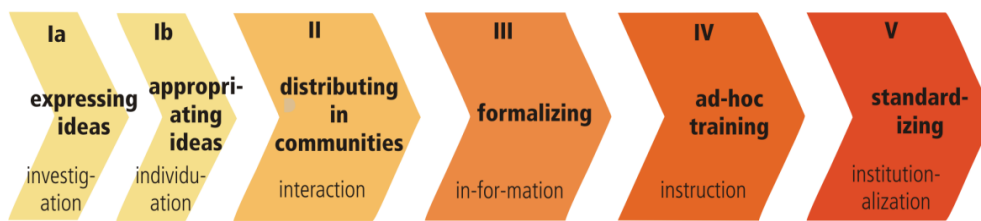
- **Ia. Expressing ideas (investigation):** New ideas are developed by individuals either in highly informal discussions or by browsing the knowledge spaces available inside the organisation and beyond, e.g., in the Web.

- **Ib. Appropriating ideas (individuation):** New ideas or results found in the investigation phase that have been enriched, refined or otherwise contextualized with respect to their use are now appropriated by the individual.

- **II. Distributing in communities (community interaction):** These are, among others, belonging to a preferred social group, thus increasing the probability of getting back knowledge from the community when one needs it. From the perspective of semantics, this accomplishes an important maturing step, i.e. the development of common terminology shared among community members, e.g., in discussion forum entries or Blog postings.

- **III. Formalising (in-form-ation):** In this phase, purpose-driven structured documents are created, e.g., project reports or design documents or, with a stronger knowledge connotation, rich case descriptions, lessons learnt or good practices, in which knowledge is de-subjectified and the context is made explicit.

- **IV. Ad-hoc training (instruction):** The topic is refined to improve comprehensibility in order to ease its consumption or re-use. The material is ideally prepared in a pedagogically sound way, enabling broader dissemination.

- **V. Standardising (institutionalisation):** Finally, formalized documents that have been learned by knowledge workers are solidified and implemented into the organisational infrastructure in the form of processes (described e.g., by business process models), business rules and/or standard operating procedures (possibly implemented into enterprise systems such as workflow management systems).

Note:

Since the questionnaire was available online, we cannot rule out with 100% certainty that there were no responses from someone outside the target pool. But given the targeted nature of the solicitation (i.e., personalized emails), the length of the questionnaire, and the domain-specific knowledge that is necessary to answer the questions, we believe that the risk of contamination, if any, to our sample is very low.

8.1.2 Online Questionnaire

How can we assess changes in the maturity of knowledge?

We plan to use knowledge maturing indicators to (semi-)automatically recognize that knowledge of an organizational unit has matured. As knowledge can be related to different media, questions one to six of the questionnaire are structured according to knowledge that:

- is embedded in a digital resource, e.g., a word file containing a lesson learned

- resides within a single person, e.g., experiences about a certain topic

- exists in processes, e.g., an established process, practice or routine to validate a new medicine

Questions seven to twelve concentrate on combinations of these.

1. *I think the following item would be a very good indicator for knowledge maturing of digital resources in my organization.**
   A digital resource ...

- was accepted into a filtered domain
  (e.g. an article was published on the company's intranet)

- became part of guideline/standard
  (e.g. a pdf file became part of a user manual)

- was changed
  (e.g. a document was edited)

- was chosen
  (e.g. a specific document was chosen out of a list of search results)

- became part of a collection of similar information
  (e.g. a folder containing documents on the same topic)

- was created/refined during a meeting
  (e.g. a project report was refined during a meeting)

- was prepared for a meeting
  (e.g. a PowerPoint presentation was prepared for a project meeting)

- was created in order to increase level of integration
  (e.g. a presentation was created by using information from two different sources)

- was made accessible to a changed user group
  (e.g. access to a key performance indicator (KPI) was restricted to the department head)

- was sent to customer
  (e.g. a presentation was emailed to a customer)

- was changed in type
  (e.g. a contract was converted from a doc to a pdf file)

- was not changed for a certain period of time
  (e.g. a document was not changed during the last two months)

2. *I think the following items would be further good indicators for knowledge maturing of <u>digital resources</u> in my organization.***

3. *I think the following item would be a very good indicator for knowledge maturing of <u>persons</u> in my organization.**
   A person ...

- acquired qualification
  (e.g. an employee attended a training course)

- was faced with a change in social network
  (e.g. a new contact was added in someone's social network)

- changed the role or responsibility
  (e.g. an employee took on the role of a project manager)

- participated in a project
  (e.g. an employee was responsible for a certain topic within a large project)

- participated in a discussion
  (e.g. an employee wrote comments on a bulletin board)

- was member of the current organisation for a certain time
  (e.g. an employee was with a company for three years)

- had a certain amount of professional experience
  (e.g. an employee had 10 years work experience in his/her current career)

4. *I think the following items would be further good indicators for knowledge maturing of <u>persons</u> in my organization.***

5. *I think the following item would be a very good indicator for knowledge maturing of <u>processes</u> in my organization.**
   A process ...

- was certified (standardised)
  (e.g. a process was certified according to ISO 9000 standard)

- was changed in the pattern of create, check, use of information
  (e.g. information is now checked during the execution of a process)

- was documented
  (e.g. a process was verbally described and depicted in a process model)

- was improved
  (e.g. execution time or costs were reduced)

- was changed according to the number of cycles (loops)
  (e.g. on average, three call-backs were necessary in order to successfully complete a user request)

- was changed according to the number of decisions
  (e.g. on average, three approvals were needed in order to complete an offer before the change)

- was changed according to the number of participants
(e.g. five people had to be involved in order to successfully complete a process before the change)

- was repeated successfully a certain number of times
(e.g. a process was executed successfully for the fourth time)

6. *I think the following items would be further good indicators for knowledge maturing of <u>processes</u> in my organization.***

7. *I think the following item would be a very good indicator for knowledge maturing of a <u>combination of digital resources and persons</u> in my organization.**

- a digital resource was changed after the person had learned something in this context
(e.g. an employee changed a document after return from a training)

- a digital resource was accessed by a changed group of persons
(e.g. a document was used by more users than before)

- a digital resource was rated by a person
(e.g. a document was rated important by a manager)

- a digital resource was created or changed by a person that had a role with a certain reputation
(e.g. a document was signed by the department head)

8. *I think the following items would be further good indicators for knowledge maturing of a <u>combination of digital resources and persons</u> in my organization.***

9. *I think the following item would be a very good indicator for knowledge maturing of a <u>combination of digital resources and processes</u> in my organization.**

- a <u>digital resource</u> describing a <u>process</u> was changed
(e.g. process model of a pre-existing workflow was changed)

- a <u>digital resource</u> was changed in a <u>process</u>
(e.g. a manual was edited after customer request)

- a <u>digital resource</u> was used as input for a <u>process</u>
(e.g. a document containing Lessons Learnt became part of a training course)

10. *I think the following items would be further good indicators for knowledge maturing of a <u>combination of digital resources and processes</u> in my organization.***

11. *I think the following item would be a very good indicator for knowledge maturing of a combination <u>of persons and processes</u> in my organization.**

- a <u>person</u> was involved in a <u>process</u> a certain number of times
(e.g. an employee took part in a process execution 60 times)

- a <u>person</u> was involved in a <u>process</u> for a certain period of time
(e.g. an employee took part in the same process for six years)

- a <u>person</u> was the owner of a <u>process</u> for a certain period of time
(e.g. an employee was responsible for the process for six years)

12. *I think the following items would be further good indicators for knowledge maturing of a <u>combination of persons and processes</u> in my organization.***

13. *Would you like to provide any kind of feedback to this survey or questionnaire?***

Thank you very much for taking part in this survey.

* items were evaluated according to a 7 point Likert scale:

- fully disagree

- disagree

- slightly disagree

- undecided

- slightly agree

- agree

- fully agree

** open question

8.1.3 Evaluation of collected Data

On June 2nd 2009 the MATURE associate partner mailing list contained 61 contacts from 45 associate partners. The online questionnaire was completed 14 times (n=14). Hence, a rate of return of around 31.1% (based on the number of partners), respectively 23 % (based on the number of contacts) was achieved.

In the following, an evaluation of the collected data is provided. For each of the 37 knowledge maturing indicators, that was part of the closed questions, a box plot is displayed (see figure 60 to figure 65). The x-axis of the box plots (see figure 60 to figure 65) depicts the 7-point Likert scale:

1   fully disagree

2   disagree

3   slightly disagree

4   undecided

5   slightly agree

6   agree

7   fully agree

For each open question a table is provided that contains (1) the answers to the respective open question and (2) the impact of the answer to the further development of the knowledge maturing indicators (see table 25 to table 31).

1. *I think the following item would be a very good indicator for knowledge maturing of digital resources in my organization.*
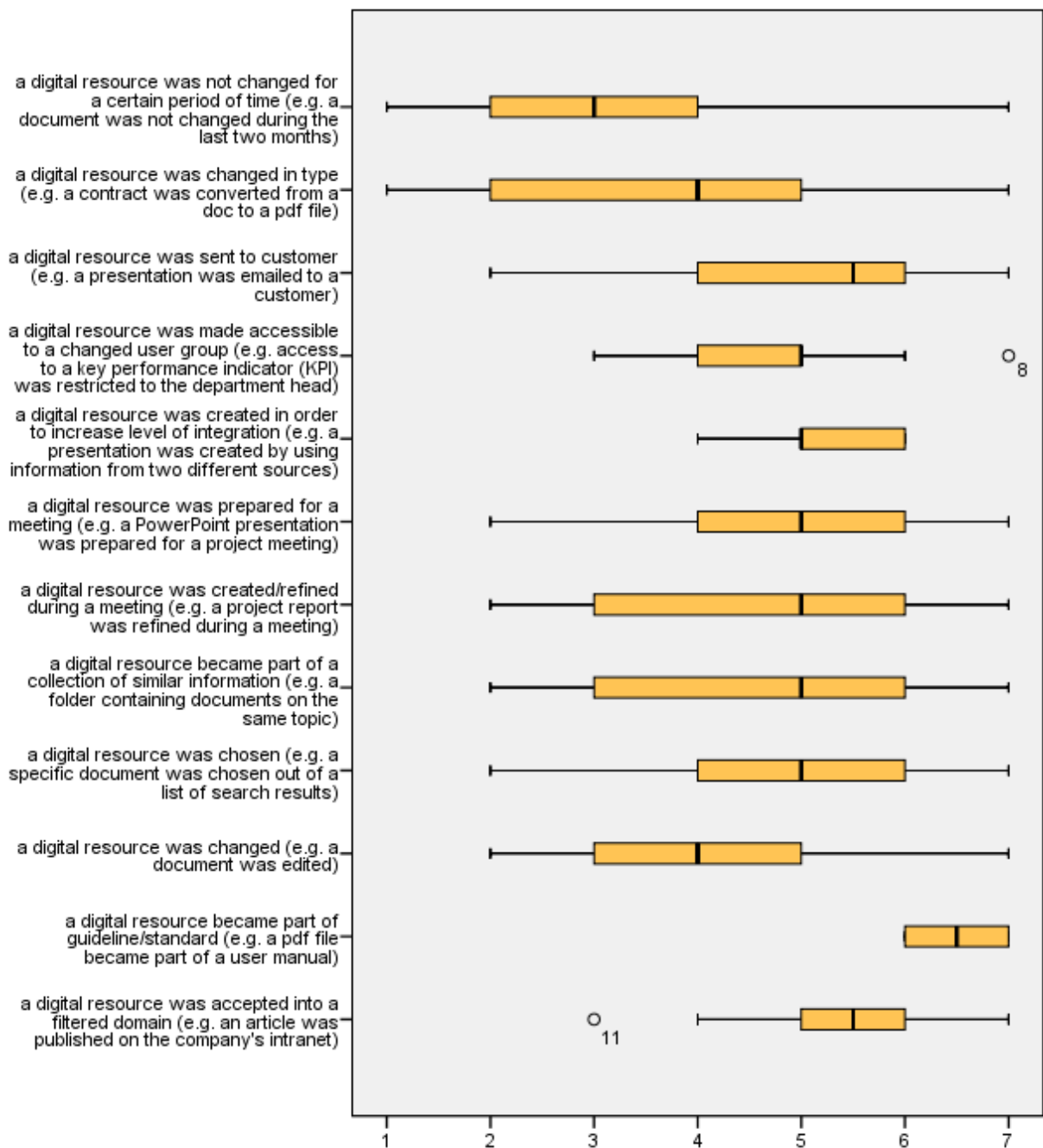
Figure 60: Box plots, results of question 1, survey on knowledge maturing indicators

The knowledge maturing indicators "a digital resource was not changed for a certain period of time", "a digital resource was changed in type" and "a digital resource was changed" are, according to the opinion of the associate partners, of minor importance for recognizing that knowledge embedded in digital resources has matured (see figure 60). Hence, these knowledge maturing indicators are not subject of further investigation during the MATURE project. Nevertheless, because of an answer to the open question 2 (see table 25), the indicator "a digital resource was not changed for a certain period of time" was refined to "a digital resource has not been changed for a long period after intensive editing".

Summary: Two KMI were deleted from the list and, hence, are not part of further research.

2. *I think the following items would be further good indicators for knowledge maturing of <u>digital resources</u> in my organization.*

Answer	Impact of Answer
lots of collaborative diting of a document followed by a pause of activity	Refinement of the KMI "a digital resource was not changed for a certain period of time" to "a digital resource has not been changed for a long period after intensive editing"
The digital document is presented to the management of the company	Refinement of the KMI "a digital resource was sent to customer" to "was presented to an influential audience"
feedback from staff that documents were being used / referred to	because of the first part of this answer a KMI is introduced: "a digital resource has been used by a person" (this KMI becomes part of the combinations cluster of KMI); because of the second part (referred to), the KMI "a digital resource is referred to by another digital resource" is introduced
Incomming and Outgoing Calls, SMS	Introduction of a KMI: "a digital resource has been the subject of many discussions"
number of requests	can be considered as covered by the newly introduced KMI "a digital resource has been used by a person"
become part of an official library (e.g. Process asset library) Is part of a process Is an official practical example It is a defined good/best practice	can be considered as covered by the KMI "a digital resource became part of guideline/standard"
as part of training manuals or programmed into applications	can be considered as covered by the KMI "a digital resource became part of guideline/standard"
Integration into a Wiki-Type of search framework	can be considered as covered by "became part of a collection of similar information"
The number of exchanges in a forum about an article in a CMS for example	can be considered as covered by the newly introduced KMI "a digital resource has been the subject of many discussions"

Table 25: Answers to question 2, survey on knowledge maturing indicators

Summary: After the analysis of answers of the associate partners to question 2, two KMI were refined and three KMI were added to the list and, hence, are part of further research.

3. *I think the following item would be a very good indicator for knowledge maturing of <u>persons</u> in my organization.*

Figure 61: Box plots, results of question 3, survey on knowledge maturing indicators

The KMI "a person was faced with a change in social network" is according to the opinion of the associate partners of minor importance for recognizing that knowledge held by a person has matured. Hence, this KMI was considered to be not part of further research within the MATURE project.

Summary: One KMI was deleted from the list and, hence, is not part of further research.

4. *I think the following items would be further good indicators for knowledge maturing of <u>persons</u> in my organization.*

Answer	Impact of Answer
person is author of many publications/reports for this topic, person is hub in social network concerning this topic	because of the first part of this answer, a KMI was introduced: "a person is an author of many documents"
	because of the second part of this answer, another KMI was introduced: "a person has a central role within a social network"
A person teaches a subject he/she knows well	one KMI was introduced: "a person is approached by others for help and advice"
participation in sharing activity - focus groups, presentations	one KMI and its example were refined: "a person participated in a discussion (e.g. an employee wrote comments on a bulletin board)" to "a person has contributed to a discussion (e.g., employee participated in workshop)"
Density/rating of personal professional network	none

act as mentor for others is a recognized expert is memebr of an official board (of a certain topic)	can be considered as covered by the newly introduced KMI "a person is approached by others for help and advice"
When the opinion voiced or written reflected a matured interpretation of information	none
Active contribution in brain-storming sessions or meetings/discussions (relative 'air-time' to other participants)	can be considered as covered by the refined KMI: "a person has contributed to a discussion"
the number of different interactions of a person in an interactive blog/forum for example	can be considered as covered by the refined KMI: "a person has contributed to a discussion"

Table 26: Answers to question 4, survey on knowledge maturing indicators

Summary: After the analysis of answers of the associate partners to question 4, one KMI and its example was refined and three KMI were added to the list and, hence, are part of further research.

5. *I think the following item would be a very good indicator for knowledge maturing of <u>processes</u> in my organization.*
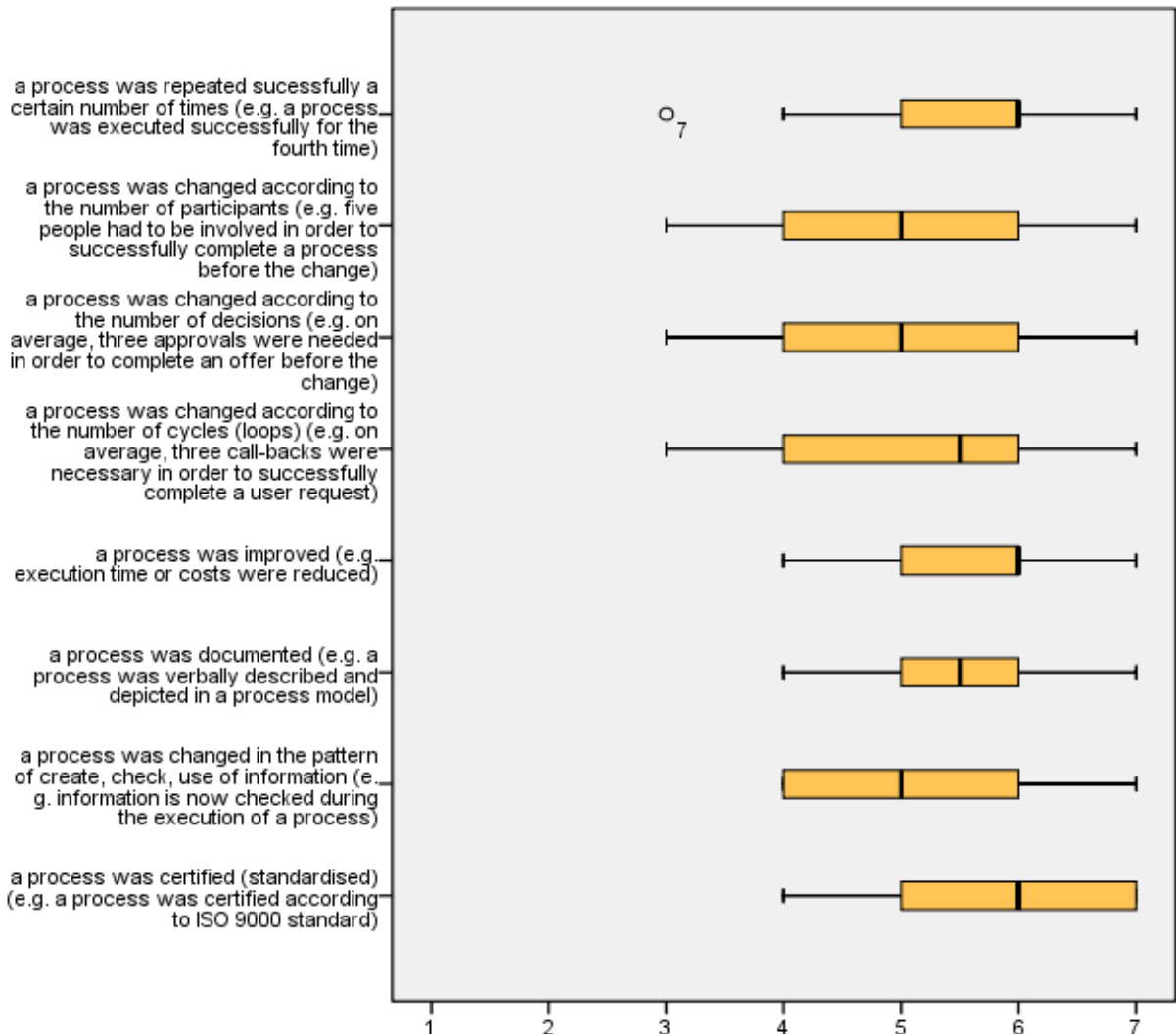
Figure 62: Box plots, results of question 5, survey on knowledge maturing indicators

The KMI "a process was changed according to the number of participants" and "a process was changed according to the number of decisions" are according to the opinion of the associate partners of minor

importance for recognizing that knowledge embedded in processes has matured. Hence these two KMI are not investigated further in the MATURE project.

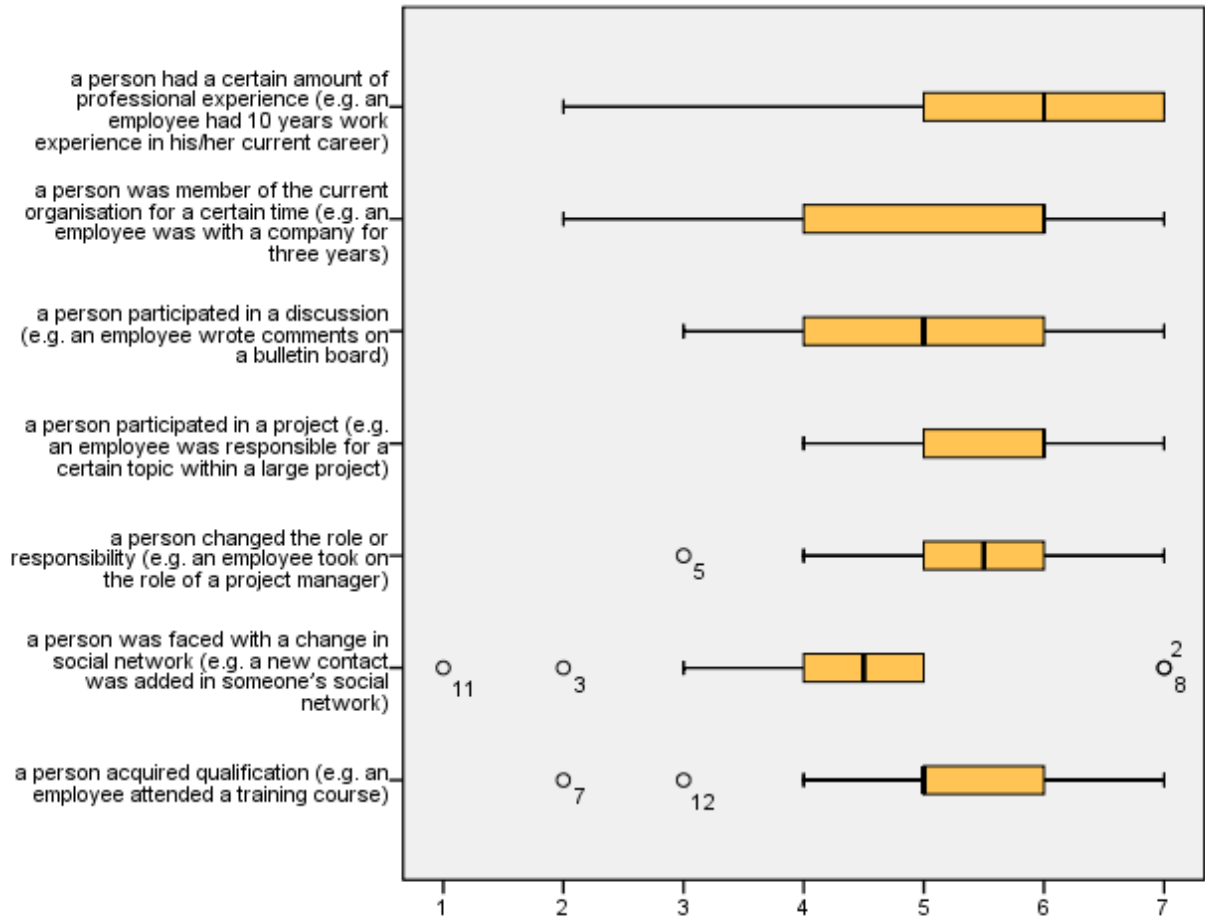Summary: Two KMI were deleted from the list and, hence, are not part of further research.

6. *I think the following items would be further good indicators for knowledge maturing of <u>processes</u> in my organization.*

Answer	Impact of Answer
approval of the process through the CEO or other management people	because of this answer the KMI "a process was internally agreed or standardised" is introduced; this resulted also in a refinement of the scope of KMI "a process was certified (standardised)" to "a process was certified or standardised according to external standards"
SAP	was interpreted as covered by "a process was certified or standardised according to external standards" and "a process was internally agreed or standardised"
nr of process cycles; competency profile of process	the first part of this answer can be considered as covered by "a process was repeated successfully a certain number of times"
Processes are used as defined Processes are accepted Processes were created and changed with an official process	can be considered as covered by "a process was certified or standardised according to external standards" and "a process was internally agreed or standardised"
When most, if not all, members of the organisation share the same view of what the process is.	can be considered as covered by "a process was internally agreed or standardised"
part of waiting time of the full process time	can be considered as covered by "a process was improved with respect to time, cost or quality"
The level of adherence to the documented process during the execution of it	This would be a refinement of the KMI "a process was documented". The KMI was collected, but discarded for the representative study.
if you can explicite a given methodology	can be considered as covered by "a process was internally agreed or standardised"

Table 27: Answers to question 6, survey on knowledge maturing indicators

Summary: After the analysis of answers of the associate partners to question 6, one KMI was refined and one KMI was added to the list and, hence, is part of further research.

7. *I think the following item would be a very good indicator for knowledge maturing of a combination of <u>digital resources and persons</u> in my organization.*
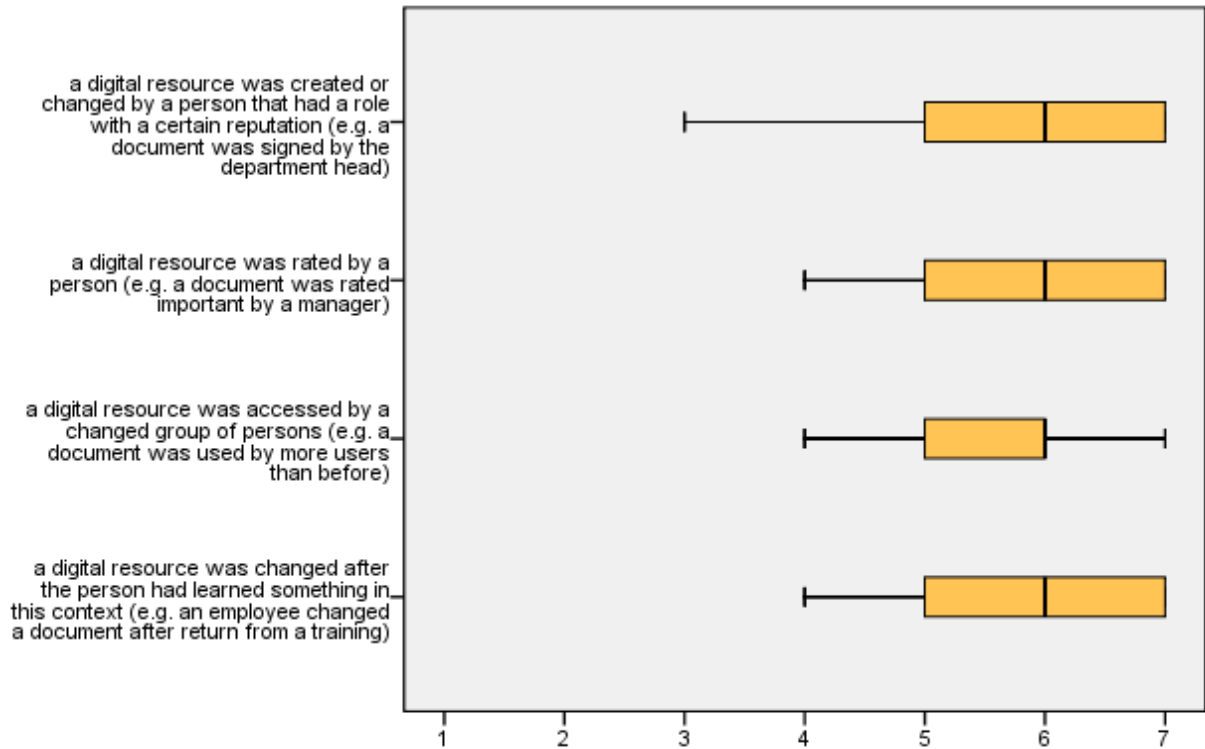
Figure 63: Box plots, results of question 7, survey on knowledge maturing indicators

As all of these KMI were considered as important for recognizing that knowledge embedded in work processes has matured (75 % of the associate partners agreed or fully agreed to all KMI), hence, all of those KMI will be part of further research.

8. *I think the following items would be further good indicators for knowledge maturing of a combination of <u>digital resources and persons</u> in my organization.*

Answer	Impact of Answer
To what extent the use of knowledge databases replaces the exploitation of the personal network within the organization	none, would be more an indicator for maturity of the whole organization
if a new resource emerge / is proposed after actions of some persons	could be considered as covered by several other KMI, e.g. "a digital resource was selected from a range of digital resources", "a digital resource "was created/refined in a meeting" etc.

Table 28: Answers to question 8, survey on knowledge maturing indicators

9. *I think the following item would be a very good indicator for knowledge maturing of a combination of <u>digital resources and processes</u> in my organization.*

Figure 64: Box plots, results of question 9, survey on knowledge maturing indicators

The KMI "a digital resource was used as input for a process" was not considered for further investigation, because of the ambivalent answers. It seemed that this KMI was understood differently by several respondents.

10. *I think the following items would be further good indicators for knowledge maturing of a combination of digital resources and processes in my organization.*

Answer	Impact of Answer
The level of keeping the digital resources and the process up-to-date so that obsolete or old information gets eleminated close to the event taking place	can be considered as covered by several KMI, e.g. "A digital resource has been changed after a person had learned something" or "a digital resource was prepared for a meeting"
if a person propose a simplification of a process	can be considered as covered by "a process was improved with respect to time, cost or quality"

Table 29: Answers to question 10, survey on knowledge maturing indicators

11. *I think the following item would be a very good indicator for knowledge maturing of a combination of persons and processes in my organization.*

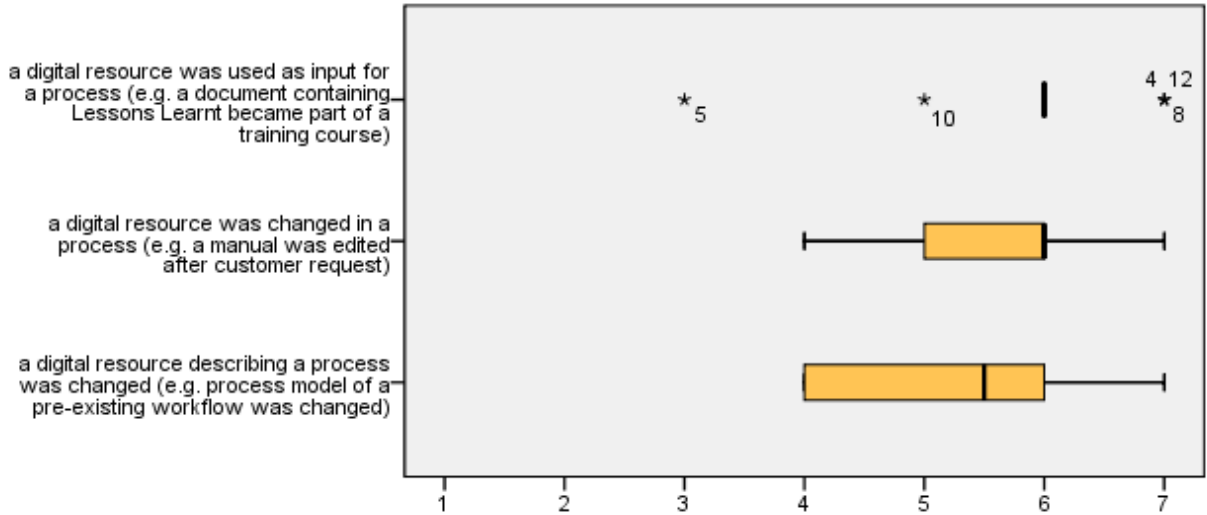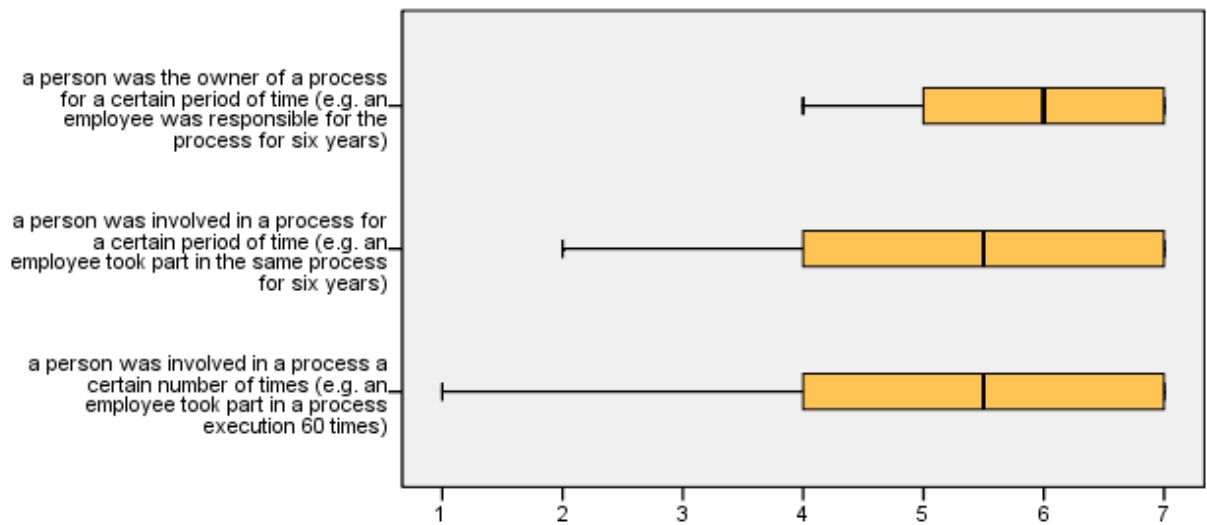**Figure 65: Box plots, results of question 11, survey on knowledge maturing indicators**

12. *I think the following items would be further good indicators for knowledge maturing of a combination of persons and processes in my organization.*

Answer	Impact of Answer
competency proficiency of person AND process	none
If the owner of the process calls for an independent review of the process through a diverse team outside of the existent organization (team) in order to identify efficiency opportunities	refers more to a potential improvement and, therefore, a potential maturation in future; can be considered as covered by "was improved with respect to time, cost or quality"
group proposal for a new methodology	refers more to a potential improvement and, therefore, a potential maturation in future

Table 30: Answers to question 12, survey on knowledge maturing indicators

13. *Would you like to provide any kind of feedback to this survey or questionnaire?*

Answer
A few questions were everybody "should" disagree might help to stay "awake"
I hope it is not to late to answer the questionnaire given that the deadline was the 6th june. Very interesting questionnaire, consideres a lot of real situations in companies.
We have to draw an interaction (system) diagram to understand the influence of each other. Don't forget that maturing needs some time, so there are a lot of delays around.

Table 31: Answers to question 13, survey on knowledge maturing indicators

8.2 Interview Guideline

8.2.1 English Version of Interview Guideline

This section contains the English version of the interview guideline as it was provided to interviewees prior to interviews.

Interview Guideline – Knowledge Maturing

I. Background Information

Interviewee

1. What is your position (job title) in your organisation and how long have you held it?

2. What is your professional background and how long have you been working in your profession?

3. How long have you been working for your organisation?

4. What part of your organisation will be the focus of this interview, e.g., factory, subsidiary, local office, organisation or entire corporate group?

5. To what sector does your organisation belong?

6. How many employees does your organisation have?

1-49	50-99	100-249	250-499	500-999	1,000-4,999	5,000 or more
☐	☐	☐	☐	☐	☐	☐

MATURE Project

MATURE is an interdisciplinary project aimed at: understanding knowledge maturing activities in a social context within and through companies; and providing supporting tools that help to overcome barriers in maturing processes. Knowledge can be represented in many ways, including for example:

- embedded in a <u>digital resource</u>, such as a word file containing a project report or procedure;
- held by a <u>person</u>, such as an individual organisational member with an experience of a certain topic;
- embedded in work <u>processes</u>, such as an established process, practice or routine shared by organisational members.

We define knowledge maturing as <u>goal-oriented learning on a collective level</u>, where:

- <u>goal-oriented</u> describes knowledge maturing as a process with a direction (goals can be individual, team and organisational, they can be vague, concrete or adaptable changing over time);
- <u>collective level</u> can refer to a team, an organisation, a community etc., knowledge maturing is not necessarily the result of individual activities, but the result of an interconnected series of activities.

The following figure presents a model of knowledge maturing; the left side represents emerging knowledge, whereas the right side relates to more mature knowledge.

Ia expressing ideas	Ib appropriating ideas	II distributing in communities	III formalising	IV ad-hoc training	V standardising
New ideas are developed by individuals either in highly informal discussions or by browsing the knowledge spaces available inside the organisation and beyond, such as on the Internet.	New ideas or results found in the expressing ideas phase that have been enriched, refined or otherwise contextualised with respect to their use are now appropriated by the individual.	Driven by social motives and the benefits that people typically attribute to sharing knowledge, ideas are shared, discussed, combined, and further developed within teams or communities.	Purpose-driven structured documents are created. These documents might be project reports, design documents or rich case descriptions. In these documents, knowledge is generalised and made explicit.	The knowledge is prepared to improve comprehensibility for a specific target group. Thus, reusability, consumption and dissemination should be made easier.	Documented knowledge that has been learned and applied by workers is established and implemented into the organisational infrastructure in the form of processes or standard operating procedures.

Figure 66: Interview guideline, page 1

II. Knowledge Maturing Phases

		Ia expressing ideas	Ib appropriating ideas	II distributing in communities	III formalising	IV ad-hoc training	V standardising
7. Which locally installed or web-based software is used for each phase?	"officially" endorsed by your organisation						
	"informally", i.e. software which is not supported by your organisation						
8. To what extent do you agree or disagree to the following statement? "My organisation encourages this phase and is open to quickly take up its results."		☐ fully disagree ☐ disagree ☐ slightly disagree ☐ undecided ☐ slightly agree ☐ agree ☐ fully agree	☐ fully disagree ☐ disagree ☐ slightly disagree ☐ undecided ☐ slightly agree ☐ agree ☐ fully agree	☐ fully disagree ☐ disagree ☐ slightly disagree ☐ undecided ☐ slightly agree ☐ agree ☐ fully agree	☐ fully disagree ☐ disagree ☐ slightly disagree ☐ undecided ☐ slightly agree ☐ agree ☐ fully agree	☐ fully disagree ☐ disagree ☐ slightly disagree ☐ undecided ☐ slightly agree ☐ agree ☐ fully agree	☐ fully disagree ☐ disagree ☐ slightly disagree ☐ undecided ☐ slightly agree ☐ agree ☐ fully agree
9. What barriers do you think affect this phase being performed in your organisation?							
10. To what extent do you agree or disagree to the following statement? "I think that this phase is performed successfully within my organisation."		☐ fully disagree ☐ disagree ☐ slightly disagree ☐ undecided ☐ slightly agree ☐ agree ☐ fully agree	☐ fully disagree ☐ disagree ☐ slightly disagree ☐ undecided ☐ slightly agree ☐ agree ☐ fully agree	☐ fully disagree ☐ disagree ☐ slightly disagree ☐ undecided ☐ slightly agree ☐ agree ☐ fully agree	☐ fully disagree ☐ disagree ☐ slightly disagree ☐ undecided ☐ slightly agree ☐ agree ☐ fully agree	☐ fully disagree ☐ disagree ☐ slightly disagree ☐ undecided ☐ slightly agree ☐ agree ☐ fully agree	☐ fully disagree ☐ disagree ☐ slightly disagree ☐ undecided ☐ slightly agree ☐ agree ☐ fully agree

11. *If you have agreed or fully agreed to the phases in question 10:*
Please could you explain why you think these phases are <u>performed successfully</u> in your organisation.

Page 2

Figure 67: Interview guideline, page 2

III. Knowledge Maturing Activities

These are individual or group activities that contribute to the development of knowledge within the organisation.

To what extent do you agree or disagree to the following statements?

Knowledge maturing activity	12. Activity is <u>important</u> for increasing knowledge maturity in your organisation.							13. Activity is <u>supported</u> in your organisation.							14. Activity is <u>performed successfully</u> in your organisation.						
	fully disagree	disagree	slightly disagree	undecided	slightly agree	agree	fully agree	fully disagree	disagree	slightly disagree	undecided	slightly agree	agree	fully agree	fully disagree	disagree	slightly disagree	undecided	slightly agree	agree	fully agree
Find relevant digital resources	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Embed information at individual or organisational level	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Keep up-to-date with organisation-related knowledge	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Familiarise oneself with new information	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Reorganise information at individual or organisational level	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Reflect on and refine work practices or processes	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Create and co-develop digital resources	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Share and release digital resources	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Restrict access and protect digital resources	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Find people with particular knowledge or expertise	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Communicate with people	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Assess, verify and rate information	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Other:	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

IV. Knowledge Maturing Indicators

We explore knowledge maturing indicators in order to (semi-)automatically recognise that organisational knowledge has matured.

15. *To what extent do you agree or disagree to the following statement?*
"I think the following item would be a good indicator for knowledge maturing."

A digital resource that...	fully disagree	disagree	slightly disagree	undecided	slightly agree	agree	fully agree
has been accepted into a restricted domain	☐	☐	☐	☐	☐	☐	☐
has become part of a guideline or has become standard	☐	☐	☐	☐	☐	☐	☐
has not been changed for a long period after intensive editing	☐	☐	☐	☐	☐	☐	☐
was selected from a range of digital resources	☐	☐	☐	☐	☐	☐	☐
became part of a collection of similar information	☐	☐	☐	☐	☐	☐	☐
was created/refined in a meeting	☐	☐	☐	☐	☐	☐	☐
was prepared for a meeting	☐	☐	☐	☐	☐	☐	☐
was created by integrating parts of other digital resources	☐	☐	☐	☐	☐	☐	☐
was made accessible to a different user group	☐	☐	☐	☐	☐	☐	☐
was presented to an influential audience	☐	☐	☐	☐	☐	☐	☐
is referred to by another digital resource	☐	☐	☐	☐	☐	☐	☐
has been the subject of many discussions	☐	☐	☐	☐	☐	☐	☐

Figure 68: Interview guideline, page 3

A person that...

has acquired a qualification or attended a training course	☐	☐	☐	☐	☐	☐	☐
has a central role within a social network	☐	☐	☐	☐	☐	☐	☐
changed its role or responsibility	☐	☐	☐	☐	☐	☐	☐
has contributed to a project	☐	☐	☐	☐	☐	☐	☐
has contributed to a discussion	☐	☐	☐	☐	☐	☐	☐
has been a member of the organisation for a significant period	☐	☐	☐	☐	☐	☐	☐
has significant professional experience	☐	☐	☐	☐	☐	☐	☐
is an author of many documents	☐	☐	☐	☐	☐	☐	☐
is approached by others for help and advice	☐	☐	☐	☐	☐	☐	☐

A process that...

was certified or standardised according to external standards	☐	☐	☐	☐	☐	☐	☐
was internally agreed or standardised	☐	☐	☐	☐	☐	☐	☐
was changed by adding or deleting steps	☐	☐	☐	☐	☐	☐	☐
was documented	☐	☐	☐	☐	☐	☐	☐
was improved with respect to time, cost or quality	☐	☐	☐	☐	☐	☐	☐
was changed according to the number of cycles (loops)	☐	☐	☐	☐	☐	☐	☐
has been successfully undertaken a number of times	☐	☐	☐	☐	☐	☐	☐

Combinations

A digital resource has been changed after a person had learned something	☐	☐	☐	☐	☐	☐	☐
A digital resource has been accessed by a different group of persons	☐	☐	☐	☐	☐	☐	☐
A digital resource has been assessed by a person	☐	☐	☐	☐	☐	☐	☐
A digital resource has been edited by a highly reputable person	☐	☐	☐	☐	☐	☐	☐
A digital resource has been used by a person	☐	☐	☐	☐	☐	☐	☐
A digital resource describing a process has been changed	☐	☐	☐	☐	☐	☐	☐
A digital resource has been changed as the result of a process	☐	☐	☐	☐	☐	☐	☐
A person has been involved in a process a number of times	☐	☐	☐	☐	☐	☐	☐
A person has been involved in a process for a significant period	☐	☐	☐	☐	☐	☐	☐
A person has been the owner of a process for a significant period	☐	☐	☐	☐	☐	☐	☐

16. Are there any other examples from your organisation that could be good indicators of knowledge maturing?

V. Perception of Success

17. *To what extent do you agree or disagree to the following statement?*
    "I think that my organisation is successful in supporting knowledge maturing."

fully disagree	disagree	slightly disagree	undecided	slightly agree	agree	fully agree
☐	☐	☐	☐	☐	☐	☐

18. *If you have agreed or fully agreed to question 17:*
    Please could you explain why you think that your organisation is successful in supporting knowledge maturing?

Feedback on the Interview

19. Would you like to provide any feedback on this interview?

20. Would you like to receive further information on the survey results or the MATURE project?

yes	no
☐	☐

Thank you very much for helping us with our research!

Figure 69: Interview guideline, page 4

8.2.2 Example Stories Provided in Interviews

For supporting the explanations of the knowledge maturing model, the interviewees used appropriate stories or relied on the most suitable of the following:

Story a)

A new employed product manager triggered the development and introduction of a new product which later became standardized within the organisation.

Ia - expressing ideas: Employees of an insurance company are discussing during a coffee break and realizing that many applications for life insurances had to be rejected as the applicants are exercising risky sports. After that, a new employed product manager had the idea to create a new insurance product.

Ib - appropriating ideas: Encouraged by his line manager, the product manager acquired knowledge about this topic and thus bought into the idea.

II - distributing in communities: He then discussed his idea for a new product with his colleagues and then receives the mandate to search for further information for developing an appropriate product.

III - formalizing: the product manager writes down his findings and after several reviews convinced his superiors who then started a pilot project.

IV - ad-hoc training: After being sent to a training course, the product manager used his knowledge within the pro-ject to teach the sales personnel. Appropriate brochures were developed and the organisation's information portal was updated.

V - standardising: After finishing the pilot project and further developing business rules and enriching the product, it was rolled out as part of the standard product portfolio.

Story b)

Employees of a franchiser were asked to develop a concept of an e-business solution in order to provide a standardized selling platform for franchisees.

Ia - expressing ideas: Several employees were asked to develop a Web 2.0 concept of an e-business platform which helps their franchisees to sell their products online. Each of the involved employees has developed an own idea.

Ib - appropriating ideas: During the next steps, all had to gain deep knowledge in possibilities, solutions and prob-lems in order to refine the ideas and adapt possible solutions to their concrete case.

II - distributing in communities: On a specific deadline, they had to present them to the department managers. In following discussions strengths and weaknesses were identified and the most promising approaches were chosen.

III - formalizing: After consolidating, a schedule, plan and priorities of how to implement the concept were set up.

IV - ad-hoc training: After setting up the first version online, a set of franchisees were taught via phone. Lectures how to use the new platform and how to gain the most value were added.

V - standardising: After further refinements, the solution has become the standard online selling platform for all franchisees.

Story c)

In response to new developments, a training department adapted parts of its training offerings.

Ia - expressing ideas: The training department employee searched her files as well as the internet for relevant material.

Ib - appropriating ideas: The employee tried to fit the idea as well as the material into her own context and decided whether to pursue it further.

II - distributing in communities: A new training offering was discussed with others within a similar context, which could be internally or within other institutions. Experiences of others were taken into account and reflected.

III - formalizing: The result of the group discussions and developments was written down as a plan for the piloting implementation, i.e., specifying the goals, what kind of additional resources do we need etc.

IV - ad-hoc training: A first pilot course of the newly developed didactical concept was conducted.

V - standardising: Clear assessment guidelines had been developed before the new training course became part of the official curriculum.

Story d)

An employee of the human resources department triggered the further development of a personnel policy docu-ment.

Ia - expressing ideas: A human resource development officer identified the need to update the organisation's personnel policy document which represented the main reference for current and new employees.

Ib - appropriating ideas: She decided that the updating process should contribute to the organisation's 'greening' policy, producing more environmentally friendly methods of distributing information, rather than continuing to rely on paper-based materials.

II - distributing in communities: This approach was discussed with colleagues, including managers and attracted much support.

III - formalizing: A working group was established to identify the potential and gaps of the existing ICT (information and communication technology) infrastructure to ensure that the vision could be realised.

IV - ad-hoc training: The IT specialist within the organisation, who was a member of this working group, agreed to develop staff training to support the switch away from reliance on paper-based versions of policies.

V - standardising: As part of the needs analysis, it was decided to develop a range of functionalities on the intranet to support staff development, like functional group discussion areas and on-line evaluation of training courses.

Story e)

In a medium-sized company, existing products are developed further.

Ia - expressing ideas: As part of customer care and sales activities and from internal employee suggestions, a com-pany gets new ideas for developing their existing product further.

Ib - appropriating ideas: The different ideas get filtered by judging how they fit into the company's strategy.

II - distributing in communities: The idea gets developed further within a team where it is discussed and elaborated.

III - formalizing: This is summarized in a specification for improvement of product functionality or development of an additional module.

IV - ad-hoc training: This specification is implemented and results in an optional add-on or update which is deployed to selected pilot customers.

V - standardising: After sufficient acceptance and refinement, the extension is integrated into the core product.

8.2.3 Distribution of interviews per country and partner

Land	Partner	To-Be
Austria	BOC	10
Belgium	FZI	10
Eastern Europe	UPB	10
Slovenia	TUG	10
France	CIMNE	10
Germany	FZI	20
	UIBK	10
	UPB	10
Greece	FZI	10
Ireland	LTRI	5
	UWAR	5
Italy	UIBK	10
Portugal	CIMNE	5
	UIBK	5
Scandinavia	FZI	10
Spain	CIMNE	15
	STRUC	15
Switzerland	FHNW	10
UK	LTRI	15
	UWAR	15
Sum		**210**

Table 32: Distribution of interviews per country and partner

8.3 Information on the MATURE project

MATURE Project

MATURE is an interdisciplinary project aimed at: understanding knowledge maturing activities in a social context within and through companies; and providing supporting tools that help to overcome barriers in maturing processes.

www.mature-ip.eu

Knowledge can be represented in many ways, including for example:
- embedded in a digital resource, such as a word file containing a project report or procedure;
- held by a person, such as an individual organisational member with an experience of a certain topic;
- embedded in work processes, such as an established process, practice or routine shared by organisational members.

We define knowledge maturing as goal-oriented learning on a collective level, where:
- goal-oriented describes knowledge maturing as a process with a direction (goals can be individual, team and organisational, they can be vague, concrete or adaptable changing over time);
- collective level can refer to a team, an organisation, a community etc., knowledge maturing is not necessarily the result of individual activities, but the result of an interconnected series of activities.

The following figure presents a model of knowledge maturing; the left side represents emerging knowledge, whereas the right side relates to more mature knowledge.

Ia expressing ideas	Ib appropriating ideas	II distributing in communities	III formalising	IV ad-hoc training	V standardising
New ideas are developed by individuals either in highly informal discussions or by browsing the knowledge spaces available inside the organisation and beyond, such as on the Internet.	New ideas or results found in the expressing ideas phase that have been enriched, refined or otherwise contextualised with respect to their use are now appropriated by the individual.	Driven by social motives and the benefits that people typically attribute to sharing knowledge, ideas are shared, discussed, combined, and further developed within teams or communities.	Purpose-driven structured documents are created. These documents might be project reports, design documents or rich case descriptions. In these documents, knowledge is generalised and made explicit.	The knowledge is prepared to improve comprehensibility for a specific target group. Thus, reusability, consumption and dissemination should be made easier.	Documented knowledge that has been learned and applied by workers is established and implemented into the organisational infrastructure in the form of processes or standard operating procedures

Figure 70: Mature information

8.4 Knowledge Maturing Indicators

8.4.1 Development of indicators from year 1 to the representative study

Medium	KM indicators D1.1	set of KM indicators used in associate partner study	set of KM indicators used in interview guideline of the representative study
artefacts	acceptance into filtered domains	A digital resource was accepted into a filtered domain (e.g. an article was published on the company's intranet)	A digital resource has been accepted into a restricted domain
artefacts	agglomeration of similar information according to one topic	A digital resource became part of a collection of similar information (e.g. a folder containing documents on the same topic)	A digital resource became part of a collection of similar information
artefacts	being part of guidelines/standards	A digital resource became part of guideline/standard (e.g. a pdf file became part of a user manual)	A digital resource has become part of a guideline or has become standard
artefacts	choice of an artefact presented by search	A digital resource was chosen (e.g. a specific document was chosen out of a list of search results)	A digital resource was selected from a range of resources
artefacts	created/refined during a meeting	A digital resource was created/refined during a meeting (e.g. a project report was refined during a meeting)	A digital resource was created/refined in a meeting
artefacts	documents prepared for meetings	A digital resource was prepared for a meeting (e.g. a PowerPoint presentation was prepared for a project meeting)	A digital resource was prepared for a meeting
artefacts	generic change of document	A digital resource was changed (e.g. a document was edited)	*not part of representative study because of results from study with associate partners (see section 8.1.3)*
		A digital resource was not changed for a certain period of time (e.g. a document was not changed during the last two months)	A digital resource has not been changed for a long period after intensive editing
artefacts	level of integration (e.g., all functions in one system, many systems under one GUI, one main system which invokes other systems, many systems exchanging data, many systems with no data exchange)	A digital resource was created in order to increase level of integration (e.g. a presentation was created by using information from two different sources)	A digital resource was created by integrating parts of other digital resources

artefacts	reduced user group	A digital resource was made accessible to a changed user group (e.g. access to a key performance indicator (KPI) was restricted to the department head)	A digital resource was made accessible to a different user group
artefacts	sent to customer	A digital resource was sent to customer (e.g. a presentation was emailed to a customer)	A digital resource was presented to an influential audience
artefacts	type of document or type of portion of document (extracted from content or manually annotated)	A digital resource was changed in type (e.g. a contract was converted from a doc to a pdf file)	*not part of representative study because of results from study with associate partners (see section 8.1.3)*
artefacts			A digital resource is referred to by another resource
artefacts			A digital resource has been the subject of many discussions
people	change in social network, e.g., mentor relationships	A person was faced with a change in social network (e.g. a new contact was added in someone's social network)	*not part of representative study because of results from study with associate partners (see section 8.1.3)*
people	change of roles or responsibilities	A person changed the role or responsibility (e.g. an employee took on the role of a project manager)	A person changed its role or responsibility
people	participation in discussion, e.g., with expert, novice (via mail or in person, …)	A person participated in a discussion (e.g. an employee wrote comments on a bulletin board)	A person has contributed to a discussion
people	participation in project (long term)	A person participated in a project (e.g. an employee was responsible for a certain topic within a large project)	A person has contributed to a project
people	qualification, e.g., training, certificate	A person acquired qualification (e.g. an employee attended a training course)	A person has acquired a qualification or attended a training course
people	time with the current organisation	A person was member of the current organisation for a certain time (e.g. an employee was with a company for three years)	A person has been a member of the organisation for a significant period
people	total time of professional experience	A person had a certain amount of professional experience (e.g. an employee had 10 years work experience in his/her current career)	A person has significant professional experience
people			A digital resource has been used by a person

people			A person is an author of many documents
people			A person has a central role within a social network
people			A person is approached by others for help and advice
process	certified (standardised) process	A process was certified (standardised) (e.g. a process was certified according to ISO 9000 standard)	A process was certified or standardised according to external standards
process	create, check, use of information in process	A process was changed in the pattern of create, check, use of information (e.g. information is now checked during the execution of a process)	A process was changed by adding or deleting steps
process	documented process	A process was documented (e.g. a process was verbally described and depicted in a process model)	A process was documented
process	elapsed time since last change	*Included in "A process was changed in the pattern of create, check, use of information"*	
process	improvement of process (execution time, costs, quality, flexibility)	A process was improved (e.g. execution time or costs were reduced)	A process was improved with respect to time, cost or quality
process	number of cycles within the process	A process was changed according to the number of cycles (loops) (e.g. on average, three call-backs were necessary in order to successfully complete a user request)	A process was changed according to the number of cycles (loops)
process	number of decision within process	A process was changed according to the number of decisions (e.g. on average, three approvals were needed in order to complete an offer before the change)	*not part of representative study because of results from study with associate partners (see section 8.1.3)*
process	number of participants	A process was changed according to the number of participants (e.g. five people had to be involved in order to successfully complete a process before the change)	*not part of representative study because of results from study with associate partners (see section 8.1.3)*

process	number of successful repetitions	A process was repeated successfully a certain number of times (e.g. a process was executed successfully for the fourth time) *Also: included in the people and processes dimension*	A process has been successfully undertaken a number of times
process	time to create	*included in the newly created people and processes dimension*	
process			A process was internally agreed or standardised
artefacts and people	documents changed after process executions (by themselves, by others)	*Included in "a digital resource describing a process was changed"*	
artefacts and people	documents changed after the person has learned something in this context	a digital resource was changed after the person had learned something in this context (e.g. an employee changed a document after return from a training)	A digital resource has been changed after a person had learned something
artefacts and people	enlarged user group	a digital resource was accessed by a changed group of persons (e.g. a document was used by more users than before)	A digital resource has been accessed by a different group of persons
artefacts and people	rating by users	a digital resource was rated by a person (e.g. a document was rated important by a manager)	A digital resource has been assessed by a person
artefacts and people	reputation of role (of person or group) handling document, e.g., creator, sender, signer	a digital resource was created or changed by a person that had a role with a certain reputation (e.g. a document was signed by the department head)	A digital resource has been edited by a highly reputable person
artefacts and process	change in a predefined workflow	a digital resource was changed in a process (e.g. a manual was edited after customer request)	A digital resource has been changed as the result of a process
artefacts and process	change of todo-lists	a digital resource describing a process was changed (e.g. process model of a pre-existing workflow was changed)	A digital resource describing a process has been changed
artefacts and process	used in presentation (customer, team meeting, executive meeting, conference)	a digital resource was used as input for a process (e.g. a document containing Lessons Learnt became part of a training course)	*not part of representative study because of results from study with associate partners (see section 8.1.3)*
artefacts and process	used in training course		

people and process		a person was involved in a process a certain number of times (e.g. an employee took part in a process execution 60 times)	A person has been involved in a process a number of times
people and process		a person was involved in a process for a certain period of time (e.g. an employee took part in the same process for six years)	A person has been involved in a process for a significant period
people and process		a person was the owner of a process for a certain period of time (e.g. an employee was responsible for the process for six years)	A person has been the owner of a process for a significant period

Table 33: Knowledge maturing indicators - further development after ethnographically informed study

8.5 Statistics

8.5.1 Rejection Reasons

Country	Partner	means	contacted	rejects							
				sum	no response	company guideline	no interest	no time	invalid contact data	no reason/ other	No fit to organisation
Austria	TUG/SAP	purposeful sample	10	0	0	0	0	0	0	0	0
Austria	UIBK	purposeful sample	8	3	2	0	0	0	1	0	0
Austria	BOC	purposeful sample	25	15	15	0	0	0	0	0	0
Belgium	FZI	purposeful sample	8	0	0	0	0	0	0	0	0
Belgium	FHNW	purposeful sample	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Eastern Europe	UPB	purposeful sample	12	9	4	0	1	4	0	0	0
Eastern Europe	UIBK	purposeful sample	3	3	3	0	0	0	0	0	0
Slovenia	TUG	purposeful sample	1	0	0	0	0	0	0	0	0
France	FZI	purposeful sample	3	3	2	0	0	1	0	0	0
France	TUG	purposeful sample	1	0	0	0	0	0	0	0	0
France	UIBK	purposeful sample	2	1	1	0	0	0	0	0	0
Germany	FZI	purposeful	66	0	0	0	0	0	0	0	0

		sample									
Germany	UIBK	cold-calling	193	180	70	22	0	20	20	21	27
Germany	UPB	purposeful sample	10	7		2	2	0	3	0	0
Greece	FZI	purposeful sample	9	4	4	0	0	0	0	0	0
Greece	BOC	purposeful sample	15	12	9	0	0	3	0	0	0
Ireland	UWAR										
Ireland	LTRI	purposeful sample	1	0	0	0	0	0	0	0	0
Ireland	SAP	purposeful sample	1	1	1	0	0	0	0	0	0
Italy	UIBK/ISUFI	purposeful sample	14	4	1	0	2	0	1	0	0
Portugal	STRUC	purposeful sample	2	1	0	0	0	1	0	0	0
Portugal	UIBK	purposeful sample	5	0	0	0	0	0	0	0	0
Scandinavia	FZI	purposeful sample	5	5	5	0	0	0	0	0	0
Spain	CIMNE	cold-calling	288	276	9	0	0	264	3	0	0
Spain	STRUC	purposeful sample	18	11	1	8	0	1	1	0	0
Switzerland	FHNW	purposeful sample	10	0	0	0	0	0	0	0	0
Switzerland	UIBK	purposeful sample	1	0	0	0	0	0	0	0	0
UK	LTRI	purposeful sample	3	2	0	0	0	0	0	2	0
UK	SAP	purposeful sample	6	4	4	0	0	0	0	0	0
UK	UWAR	purposeful	229	219	205	2	1	7	0	5	0

		sample/mailing list								
Sum			**939**	**760**	**336**	**34**	**6**	**301**	**29**	**28**	**27**

Table 34: overview rejections

8.5.2 Background Information

8.5.2.1 Coding of job positions and areas

code	code area
executive	chief
executive	chief(deputy)
employee	Employee
head	head(assistant).business_unit
head	head(deputy).business_unit
head.business_unit	head
head.business_unit	head
head.department	head
head.project	project
head.subsidiary	head
head.team	head
manager	head
manager.project	project
responsible	responsible

Table 35: Job positions - mapping of codes to code areas

code	code area
(empty)	not specified
accommodation	business
administration	business
business_development	organisation
communications	business
controlling	business
CRM	business
education	human resources
engineering	business
finance	business
food_and_beverages	business
healthcare	business
HR	human resources
HR_development	human resources
HR_recruitment	human resources
information_systems	information systems/technology
innovation	innovation
knowledge_management	knowledge management
knowledge_management, technology	knowledge management
legal	business
manufacturing	business

marketing	business
operation	business
organisation	organisation
organisational_development	organisation
procurement	business
product	business
quality_management	business
research	research
research&development	research
software_development	information systems/technology
technology	information systems/technology
technology&innovation	information systems/technology

Table 36: Job areas - mapping of codes to code areas

8.5.2.2 Overview Sectors

NACE-code	description	no
10	Manufacture of food products	4
12	Manufacture of tobacco products	1
16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	1
21	Manufacture of basic pharmaceutical products and pharmaceutical preparations	1
22	Manufacture of rubber and plastic products	2
23	Manufacture of other non-metallic mineral products	2
24	Manufacture of basic metals	1
25	Manufacture of fabricated metal products, except machinery and equipment	2
26	Manufacture of computer, electronic and optical products	8
27	Manufacture of electrical equipment	2
28	Manufacture of machinery and equipment n.e.c.	4
29	Manufacture of motor vehicles, trailers and semi-trailers	3
30	Manufacture of other transport equipment	5
31	Manufacture of furniture	1
32	Other manufacturing	4
33	Repair and installation of machinery and equipment	1
Sum industry		**42**

Table 37: Represented industry sectors

NACE-code	description	no
45	Wholesale and retail trade and repair of motor vehicles and motorcycles	1
46	Wholesale trade, except of motor vehicles and motorcycles	2
47	Retail trade, except of motor vehicles and motorcycles	2
49	Land transport and transport via pipelines	3

52	Warehousing and support activities for transportation	1
53	Postal and courier activities	1
55	Accommodation	3
56	Food and beverage service activities	1
58	Publishing activities	1
59	Motion picture, video and television programme production, sound recording and music publishing activities	1
60	Programming and broadcasting activities	1
61	Telecommunications	5
62	Computer programming, consultancy and related activities	17
63	Information service activities	2
64	Financial service activities, except insurance and pension funding	3
68	Real estate activities	3
69	Legal and accounting activities	3
70	Activities of head offices; management consultancy activities	2
71	Architectural and engineering activities; technical testing and analysis	4
72	Scientific research and development	3
77	Rental and leasing activities	1
79	Travel agency, tour operator and other reservation service and related activities	1
84	Public administration and defence; compulsory social security	1
85	Education	7
86	Human health activities	4
87	Residential care activities	1
88	Social work activities without accommodation	1
94	Activities of membership organisations	1
Sum service		**76**

Table 38: Represented service sectors

NACE-code	description	no
35	Electricity, gas, steam and air conditioning supply	2
41	Construction of buildings	4
43	Specialised construction activities	2
Sum not assignable		**8**

Table 39: Represented sectors, not assignable

8.5.2.3   Histograms – Background Information

Years in Current Position

Mean = 4.80
Std. Dev. = 4.633
N = 125

F2_background_duration_years

Mean = 12.13
Std. Dev. = 7.881
N = 124

Years in Current Organisation

Mean = 7.92
Std. Dev. = 6.582
N = 125

Size of Organisation

Size of Represented Part of Organisation
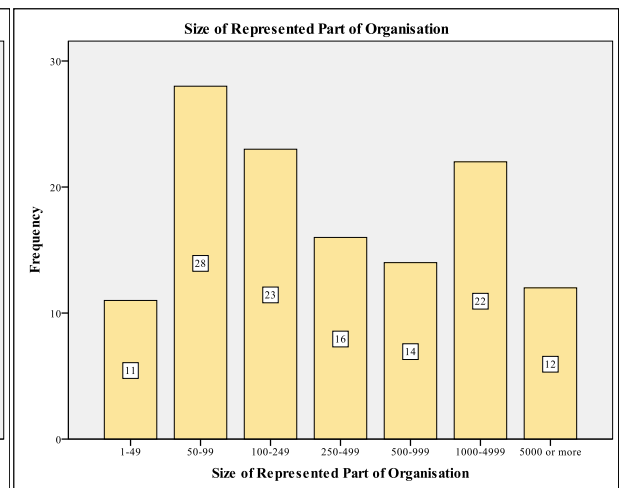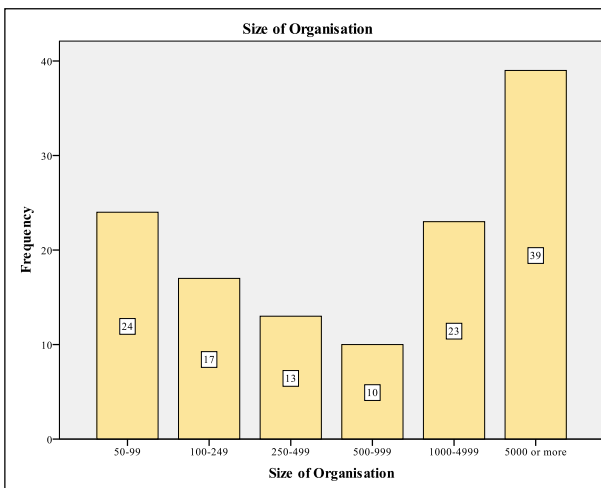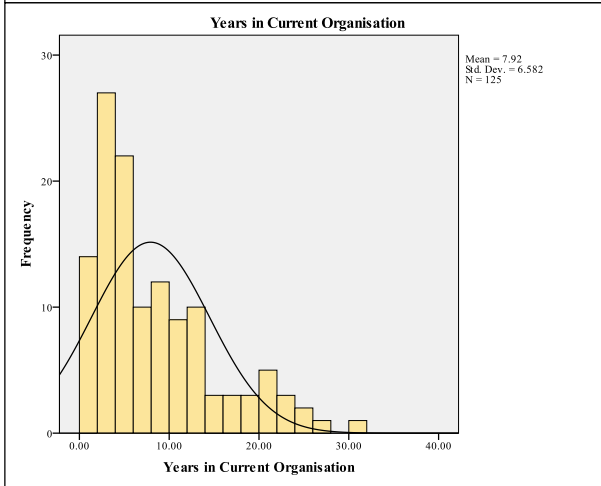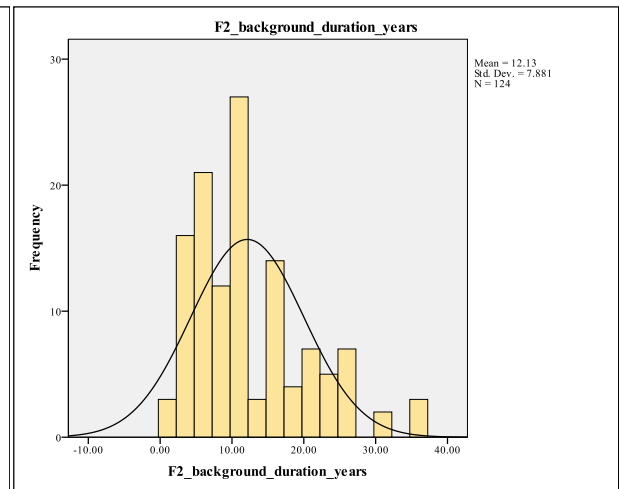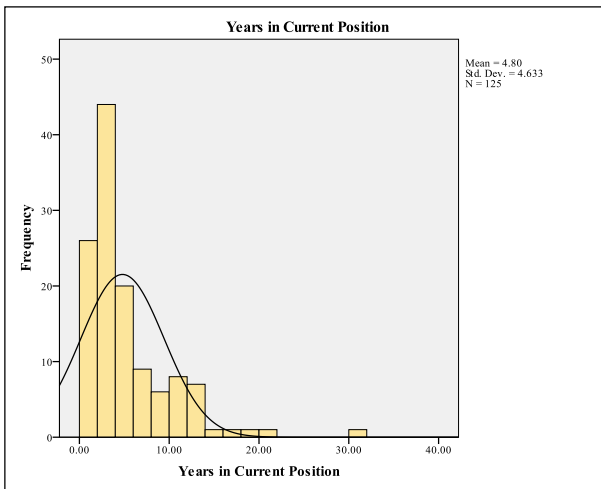
8.5.3 Knowledge Maturing Phases

8.5.3.1 Coding of software

Code	Example	Description
collaboration_tool.conferencing.audio	"audio conferencing"; "Voice over IP"	audio conference call with two or more participants
collaboration_tool.conferencing.desktop	"web meetings", "we use virtual rooms for desktop sharing"; MS Live Meeting	desktop sharing and videoconference tools accessed by employee from own workplace/desktop
collaboration_tool.conferencing.video	"we use videoconferences to transfer knowledge"	dedicated videoconferencing system, sometimes located in special conference rooms
collaboration_tool.generic	clearspace	tool supporting collaboration of team members
collaboration_tool.instantmessenger	Skype; Lotus Sametime	tool for chat video and audio calls used at own workplace
collaboration_tool.peer_to_peer	MS Groove	tool supporting collaboration of team members that is peer to peer based
custom.generic	"adapted systems are used"	adapted or (self)developed software is used and was not specified by interviewee
custom.nonproductive_trainingsystem	"we teach people by using a copy of the productive system"	custom nonproductive system that is a mirror of the productive system and is used to train people
custom.search_engine	"we use a search function that was developed by our IT department"	custom built search engine to find digital artefacts
desktoppublishing.generic	quark express; Adobe INDESIGN	tools to supporting the creation of publication documents
desktoppublishing.pdf	Adobe Acrobat, Adobe Reader, PDF Creator	tools supporting the creation of PDF documents
dms.adapted	We have aligned the functionality of the DMS to our needs	Document management system that was adapted according to organisation's requirements
DMS.generic	"we introduced a DMS"	a not specified document management system
elearning_tool	WBT, e-learning	specific type of tools used for training of employees at their desktops
elearning_tool.custom	"Learning Content Management System (have their own tailored system)"	specific custom type of tools used for training of employees at their desktops
elearning_tool.flash	WBT, elearning based on flash technology	flash-based tools used for training of employees at their desktops
ERP.controlling	SAP R/3 CO	ERP software with focus on supporting controlling

ERP.CRM	SAP CRM; salesforce	ERP software with focus on supporting customer relationship management
ERP.finance	SAP FI; Sage finance software (for smaller organisations)	ERP Software with focus on supporting finance
ERP.finance.custom	financiero	custom made ERP software, focus on finance
ERP.generic	SAP ERP	used to manage internal and external resources of the organisation (not specified by interviewee)
ERP.health_care	SAP IS-H, or hospital management system	ERP software with focus on supporting management of resources in hospitals
ERP.human_resources	SAP HCM	ERP software with focus on supporting human resources
ERP.legal	MILES33	ERP software with focus on supporting legal
ERP.plant_maintenance	SAP PM	ERP software with focus on supporting plant maintenance
ERP.procurement	SAP MM	ERP software with focus on supporting procurement
ERP.prod_planning	SAP APO, SAP PP/DS	ERP software with focus on supporting production planning
extranet.generic	extranet	organisational network based on internet architecture that is extended to users outside the company
filebrowser	Windows Explorer, "Filesystem"	tool used to navigate through file systems on own desktop or on network share
graphic_editing_programm.generic	photoshop	tool for creating and manipulating images
ide.software_development	eclipse	integrated development environment for creating (platform dependent) software
ide.web_publishing	macromedia dreamweaver	integrated development environment for creating comprehensive web pages
informally.all_allowed	"no restrictions at all via central IT"	use this code to show that everything is allowed and therefore no software is really 'informal'
informally.not_allowed	"informally software is not allowed" or "users have not the rights to install"	use this code to show that informally software is not allowed
informally.not_allowed.but_used	"informally software is not allowed but used on private laptop brought to organisation"	code to show that informally software is not allowed but used nevertheless
informally.not_existent	_	use this if no codes or comments made by interviewer
internet.generic	internet, Internet Explorer, portal	generic service or website in the internet, accessed via specific client (browser)

internet.RSS_feeds	RSS feed	software based on a standard for accessing news on webpages
internet.social_software	people search in internet forums; linkedIn; Xing	software (platform) aimed at managing contacts and networking with people
internet.WCMS	RedDot, Typo3	web content management system to maintain internet web pages
internet.WCMS.wiki	MediaWiki, Confluence	Type of CMS for collaborative editing of contents
intranet.form	intranet forms	Specific form which is accessible via intranet of the organisation
intranet.generic	intranet, Internet Explorer, sharepoint, portal	organisational network, based on internet architecture; accessed via client (browser)
intranet.social_software	"we have introduced a knowledge forum"; blog, tagging environment	software (platform) aimed at managing contacts and networking with people within the intranet of the company
intranet.wcms	web content management system to maintain intranet web pages; wiki published on intranet; wordpress	web content management system to maintain digital contents web pages in the intranet
intranet.wcms.wiki	wiki on the intranet	Type of CMS for collaborative editing of contents in the intranet
ITSM_tool	tool to support IT service management	tool for supporting management tasks aligned to IT service management
kms.generic	Centra Knowledge Center	systems who's primary focus in on improving the handling of knowledge
kms.skill_management	skill management system	system for managing and skills of employees
media.video	video files, flash films	multimedia contents (for training purposes)
MIS.generic	Management Information System	System supporting managers and keeping them up to date
modeling_tool.CAM.CNC	CNC	Computer aided manufacturing using CNC code to drive numerically controlled machine tools
modeling_tool.CAM.generic	CAM	Computer aided manufacturing
modeling_tool.design_and_engineering	CAD, 3D Drawing SW	tools for designing and modeling mechanical/electronical parts
modeling_tool.enterprise	ARIS toolset	tools for modeling processes, organisational structure, etc
modeling_tool.generic	Visio	modelling tool for multiple purposes
modeling_tool.mind_maps	MindManager, FreeMind	tools for modeling mindmaps
modeling_tool.simulation	we use a simulation software to show process performance	used to simulate
office.database	Microsoft Access	database application with a primary focus on desktop use

office.generic	Microsoft Office	office application usually containing software for word processing, spreadsheets and presentations
office.generic.web_based	Google Docs	office software which is based on web technology rather than being platform dependant
office.notes	MS One Note	software for storing notes
office.presentation	Microsoft Powerpoint	application for creating electronic presentations
office.spreadsheet	Microsoft Excel	application for managing table-based data
office.spreadsheet.adapted	Macros developed with Microsoft Excel	parts of code using a programming language within a spreadsheet application
office.word_processing	Microsoft Word	primarily used for creating and editing text-based documents
office.word_processing.forms	Forms used in Microsoft Word	forms which are created using a word processing software
open.source.generic	"different open source software"	Software which is available in source code
PIM.adapted	Lotus Noted specifically adapted in order to use it for collaborative management of ideas and proposals	use this code if a personal information managment tool was adapted for specific use
PIM.add_on	Xobni	add on to a PIM
PIM.generic	Microsoft Outlook, Lotus Notes	personal information management tool
PIM.mail	mailsystem, Microsoft Outlook for mail	personal information management tool (used mail)
PIM.newsreader	usenet	software for reading nntp based messages
PIM.sms	sms	personal information management tool (used short message service)
project_management_tool.adapted	"we use Redmine which is originally a project managment tool for idea management"	use this code if a project management tool was adapted to a specific use
project_management_tool.generic	MS Project; backlog (scrum --> mostly excel based)	use this code for a project management tool
simulation.generic	simulation tool	tool for modeling and running simulations of real world processes
suggestion_system.custom	"we have developed our own suggestion system"	software used for collecting and managing ideas and suggestions of employees which was customized
suggestion_system.generic	suggestion system; idea management system	software used for collecting and managing ideas and suggestions of employees

trouble_ticket_system	trouble ticket solutions; "if there are ideas for optimization, that we open a change request - you can do it via a ticket system, which we also have, you can give requirements to our helpdesk and ask questions"	software used to track trouble tickets

Table 40: List of software codes

8.5.3.2 *Statistics for KM phases*

	Ia - expressing ideas	Ib - appropriating ideas	II - distributing in communities	III - formalising	IV - ad-hoc training	V - standardising
N	124	125	126	125	122	124
Mean	5.84	5.72	5.57	5.74	5.60	5.60
Std. Deviation	1.376	1.255	1.382	1.177	1.244	1.384

Table 41: KM phases: Mean values and std. deviation for fostering (questions 8)

Ranks

	Mean Rank
Ia - expressing ideas	3.89
Ib - appropriating ideas	3.55
II - distributing in communities	3.32
III - formalising	3.45
IV - ad-hoc training	3.34
V - standardising	3.45

Table 42: KM phases: Mean rank of questions 8 for Friedman test

Test Statistics[a]

N	119
Chi-square	11.423
df	5
Asymp. Sig.	.044

a. Friedman Test

Table 43: KM phases: Friedman test for question 8

Test Statistics[a]

		Ia - expressing ideas	Ib - appropriating ideas	II - distributing in communities	III - formalising	IV - ad-hoc training	V - standardising
Most Extreme Differences	Absolute	.150	.176	.190	.037	.058	.138
	Positive	.150	.176	.190	.037	.024	.076
	Negative	-.025	.000	.000	-.008	-.058	-.138
Kolmogorov-Smirnov Z		.788	.930	1.008	.194	.300	.720
Asymp. Sig. (2-tailed)		.563	.352	.262	1.000	1.000	.677

a. Grouping Variable: Size

Table 44: KM phases: K-S-test for fostering (questions 8) by size

		Ia - expressing ideas	Ib - appropriating ideas	II - distributing in communities	III - formalising	IV - ad-hoc training	V - standardising
Most Extreme Differences	Absolute	.098	.167	.183	.068	.117	.086
	Positive	.000	.013	.013	.013	.117	.086
	Negative	-.098	-.167	-.183	-.068	-.076	-.069
Kolmogorov-Smirnov Z		.495	.845	.937	.346	.590	.433
Asymp. Sig. (2-tailed)		.967	.472	.344	1.000	.878	.992

a. Grouping Variable: Knowedge Intensity

Table 45: KM phases: K-S-test for fostering (questions 8) by knowledge intensity

Test Statistics[a]

		Ia - expressing ideas	Ib - appropriating ideas	II - distributing in communities	III - formalising	IV - ad-hoc training	V - standardising
Most Extreme Differences	Absolute	.107	.096	.215	.156	.028	.134
	Positive	.107	.013	.013	.156	.014	.134
	Negative	-.045	-.096	-.215	.000	-.028	-.010
Kolmogorov-Smirnov Z		.546	.497	1.118	.810	.147	.696
Asymp. Sig. (2-tailed)		.927	.966	.164	.527	1.000	.718

a. Grouping Variable: Sector

Table 46: KM phases: K-S-test for fostering (questions 8) by sector

Question 10

	Ia - expressing ideas	Ib - appropriating ideas	II - distributing in communities	III - formalising	IV - ad-hoc training	V - standardising
N	124	126	126	126	121	122
Mean	5.23	5.13	4.98	5.20	4.83	5.24
Std. Deviation	1.447	1.391	1.536	1.351	1.546	1.461

Table 47: KM phases: Mean values and std. deviation for successful performance (questions 10)

Ranks

	Mean Rank
Ia - expressing ideas	3.58
Ib - appropriating ideas	3.48
II - distributing in communities	3.39
III - formalising	3.61
IV - ad-hoc training	3.20
V - standardising	3.74

Table 48: KM phases: Mean rank of questions 10 for Friedman test

Test Statistics[a]

N	118
Chi-square	8.663
df	5
Asymp. Sig.	.123

a. Friedman Test

Table 49: KM phases: Friedman test for question 10

Test Statistics[b]

			Ia - expressing ideas	Ib - appropriating ideas	II - distributing in communities	III - formalising	IV - ad-hoc training	V - standardising
Most Extreme Differences	Absolute		.148	.119	.214	.048	.108	.095
	Positive		.148	.119	.214	.012	.108	.083
	Negative		.000	.000	.000	-.048	-.048	-.095
Kolmogorov-Smirnov Z			.776	.630	1.134	.252	.557	.493
Asymp. Sig. (2-tailed)			.584	.822	.153	1.000	.915	.968
Monte Carlo Sig. (2-tailed)	Sig.		.231[a]	.424[a]	.043[a]	.938[a]	.494[a]	.609[a]
	99% Confidence Interval	Lower Bound	.220	.411	.038	.932	.481	.596
		Upper Bound	.242	.436	.048	.944	.507	.621

a. Based on 10000 sampled tables with starting seed 957002199.

b. Grouping Variable: Size

Table 50: KM phases: K-S-test for success (questions 10) by size

Test Statistics[b]

			Ia - expressing ideas	Ib - appropriating ideas	II - distributing in communities	III - formalising	IV - ad-hoc training	V - standardising
Most Extreme Differences	Absolute		.118	.122	.247	.071	.212	.145
	Positive		.118	.024	.000	.071	.028	.145
	Negative		-.009	-.122	-.247	-.059	-.212	-.011
Kolmogorov-Smirnov Z			.608	.635	1.284	.372	1.093	.743
Asymp. Sig. (2-tailed)			.854	.814	.074	.999	.183	.639
Monte Carlo Sig. (2-tailed)	Sig.		.434[a]	.331[a]	.011[a]	.830[a]	.056[a]	.258[a]
	99% Confidence Interval	Lower Bound	.421	.318	.008	.820	.050	.247
		Upper Bound	.446	.343	.013	.840	.062	.269

a. Based on 10000 sampled tables with starting seed 79654295.

b. Grouping Variable: Sector

Table 51: KM phases: K-S-test for success (questions 10) by sector

Test Statistics[b]

			Ia - expressing ideas	Ib - appropriating ideas	II - distributing in communities	III - formalising	IV - ad-hoc training	V - standardising
Most Extreme Differences	Absolute		.147	.249	.130	.096	.079	.213
	Positive		.013	.013	.000	.096	.066	.213
	Negative		-.147	-.249	-.130	-.040	-.079	.000
Kolmogorov-Smirnov Z			.744	1.272	.662	.491	.397	1.081
Asymp. Sig. (2-tailed)			.638	.079	.774	.969	.997	.193
Monte Carlo Sig. (2-tailed)	Sig.		.223[a]	.020[a]	.331[a]	.564[a]	.832[a]	.065[a]
	99% Confidence Interval	Lower Bound	.212	.017	.319	.552	.822	.058
		Upper Bound	.234	.024	.344	.577	.841	.071

a. Based on 10000 sampled tables with starting seed 2048628469.

b. Grouping Variable: Knowedge Intensity

Table 52: KM phases: K-S-test for success (questions 10) by knowledge/technology-intensity

		N	Mean	Std. Deviation
Sector	industry	42	5.38	1.035
	na	8	5.00	1.069
	service	76	5.36	1.208
	Total	126	5.34	1.140

Table 53: Mean values and std. deviation, perceived KM success by sector (questions 17)

		N	Mean	Std. Deviation
Knowledge Intensity	high	79	5.49	1.085
	low	39	5.10	1.231
	na	8	5.00	1.069
	Total	126	5.34	1.140

Table 54: Mean values and std. deviation, perceived KM success by knowledge intensity (questions 17)

		N	Mean	Std. Deviation
Size	large	84	5.27	1.155
	medium	42	5.48	1.110
	Total	126	5.34	1.140

Table 55: Mean values and std. deviation, perceived KM success by size (questions 17)
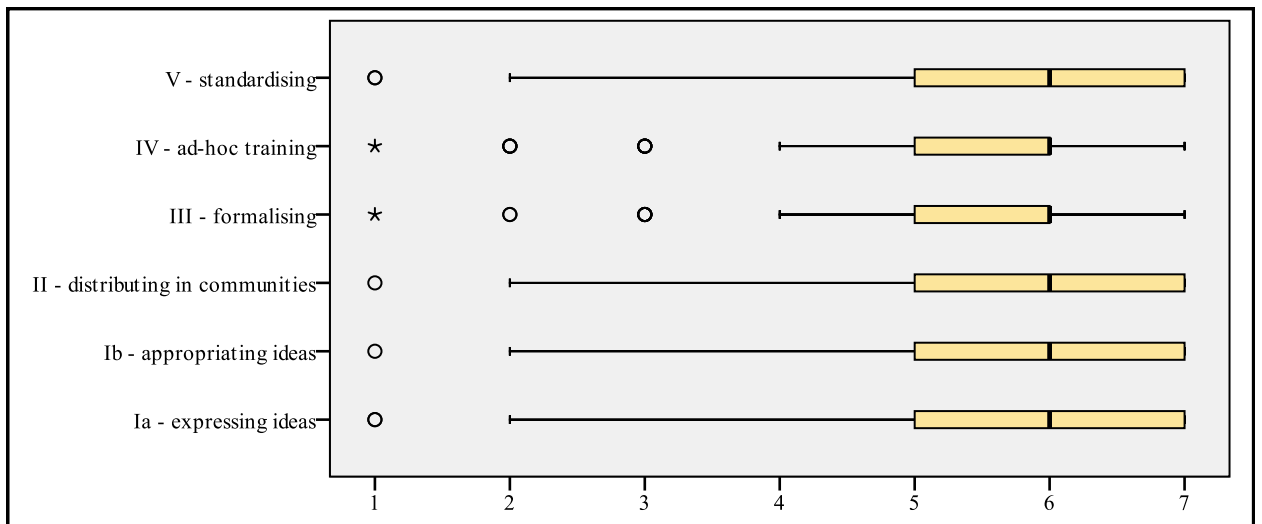
Figure 71: KM phases: Boxplots fostering phases (question 8)

8.5.3.3   Histograms – KM phases (fostering)

Ia - expressing ideas

Mean =5.84
Std. Dev. =1.376
N =124

Ib - appropriating ideas

Mean =5.72
Std. Dev. =1.255
N =125

II - distributing in communities

Mean =5.57
Std. Dev. =1.382
N =126

III - formalising

Mean =5.74
Std. Dev. =1.177
N =125

IV - ad-hoc training

Mean =5.6
Std. Dev. =1.244
N =122

V - standardising

Mean =5.6
Std. Dev. =1.384
N =124
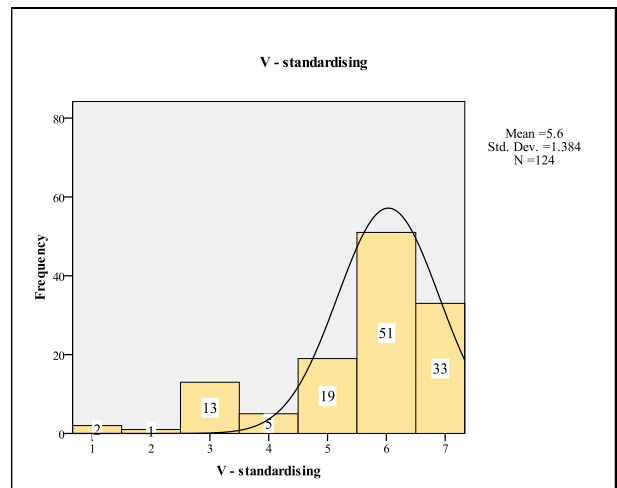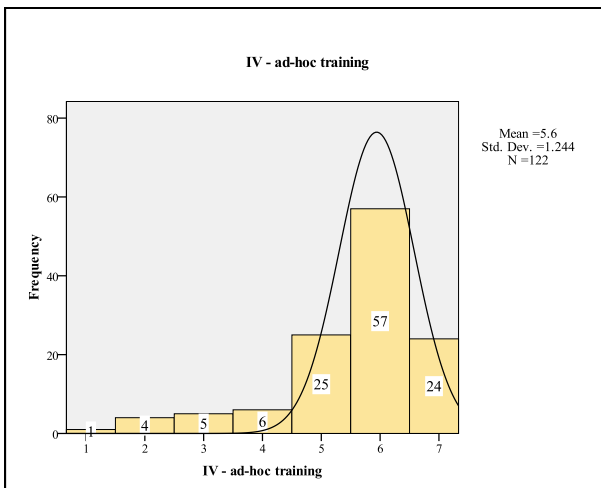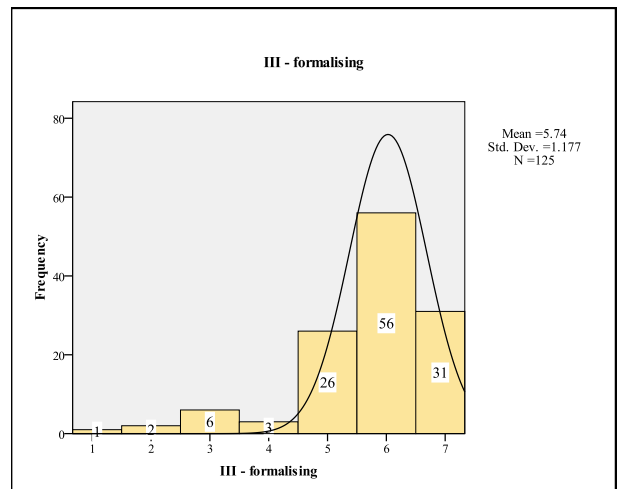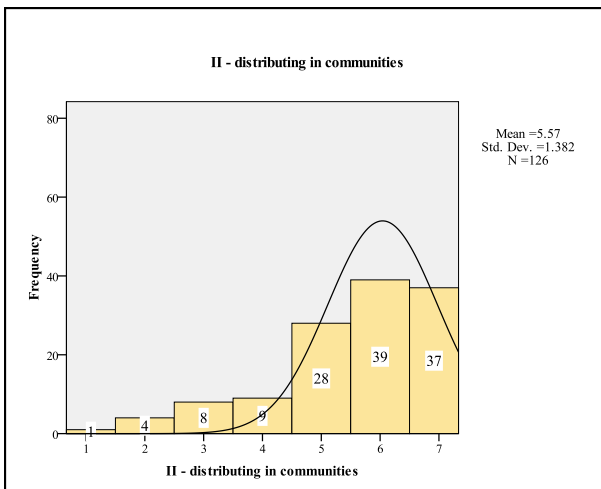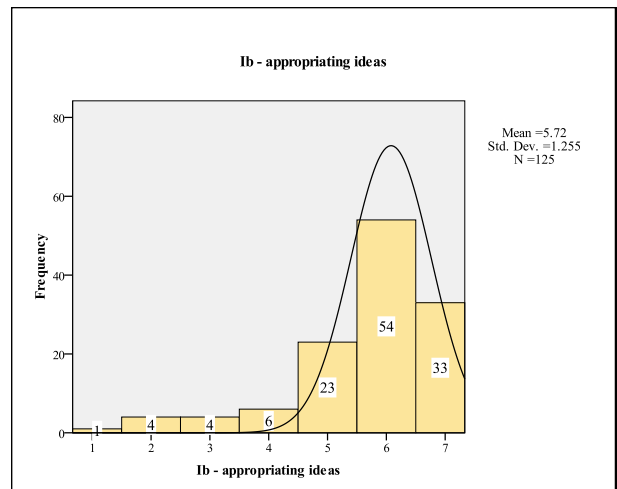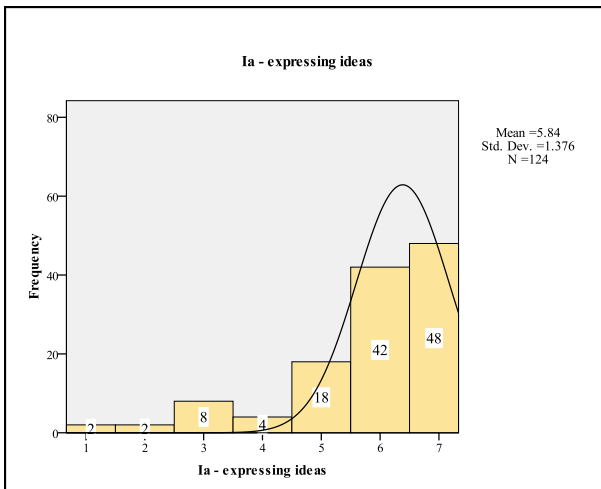
8.5.3.4   Histograms – KM phases (successful performance)

Ia - expressing ideas

Mean =5.23
Std. Dev. =1.447
N =124

Frequency values: 1, 6, 13, 9, 34, 37, 24

Ib - appropriating ideas

Mean =5.13
Std. Dev. =1.391
N =126

Frequency values: 1, 7, 12, 11, 34, 46, 15

II - distributing in communities

Mean =4.98
Std. Dev. =1.536
N =126

Frequency values: 5, 7, 10, 14, 31, 46, 13

III - formalising

Mean =5.2
Std. Dev. =1.351
N =126

Frequency values: 1, 4, 15, 10, 30, 51, 15

IV - ad-hoc training

Mean =4.83
Std. Dev. =1.546
N =121

Frequency values: 2, 8, 21, 11, 27, 39, 13

V - standardising

Mean =5.24
Std. Dev. =1.461
N =122

Frequency values: 2, 6, 11, 9, 28, 46, 20

8.5.3.5 Descriptive Statistics – KM Success
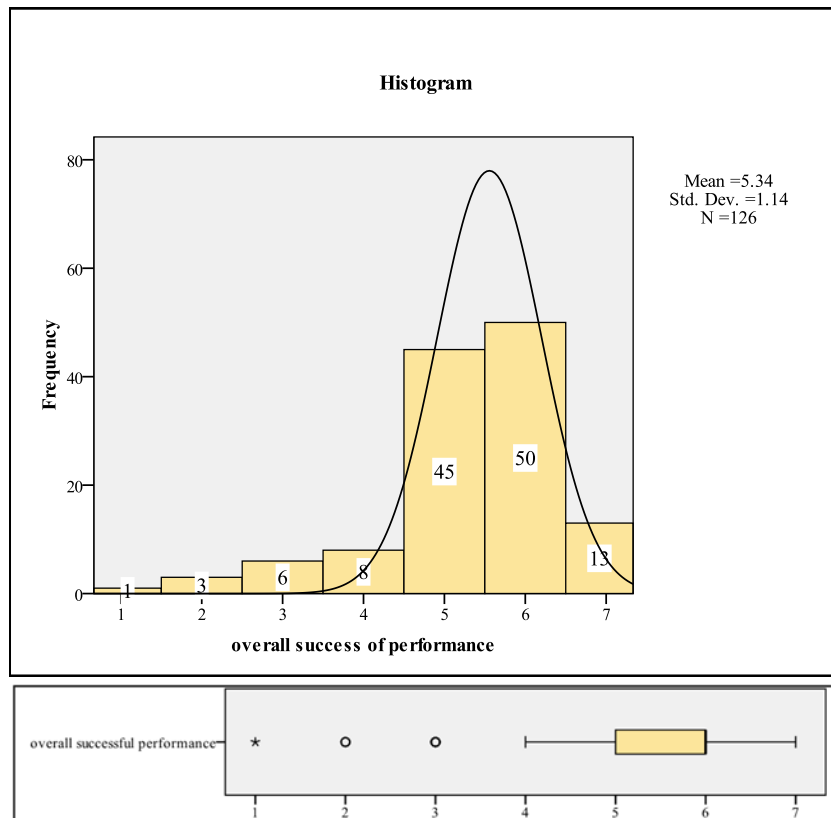
Figure 72: KM success: Histogram and boxplot (question 17)

Test Statistics[b]

			overall success of performance
Most Extreme Differences	Absolute		.142
	Positive		.013
	Negative		-.142
Kolmogorov-Smirnov Z			.726
Asymp. Sig. (2-tailed)			.667
Monte Carlo Sig. (2-tailed)	Sig.		.208[a]
	99% Confidence Interval	Lower Bound	.198
		Upper Bound	.219

a. Based on 10000 sampled tables with starting seed 754262874.

b. Grouping Variable: Knowedge Intensity

Table 56: K-S-test for question 17 after knowledge intensity

Test Statistics[b]

		overall success of performance
Most Extreme Differences	Absolute	.071
	Positive	.071
	Negative	-.024
Kolmogorov-Smirnov Z		.378
Asymp. Sig. (2-tailed)		.999
Monte Carlo Sig. (2-tailed)	Sig.	.798[a]
	99% Confidence Interval — Lower Bound	.787
	Upper Bound	.808

a. Based on 10000 sampled tables with starting seed 1066061003.

b. Grouping Variable: Size

Table 57: K-S-test for question 17 after size

Test Statistics[b]

		overall success of performance
Most Extreme Differences	Absolute	.087
	Positive	.044
	Negative	-.087
Kolmogorov-Smirnov Z		.453
Asymp. Sig. (2-tailed)		.986
Monte Carlo Sig. (2-tailed)	Sig.	.635[a]
	99% Confidence Interval — Lower Bound	.622
	Upper Bound	.647

a. Based on 10000 sampled tables with starting seed 1507486128.

b. Grouping Variable: Sector

Table 58: K-S-test for question 17 after sector

8.5.4 Knowledge Maturing Activities

8.5.4.1   Descriptive Statistics

Knowledge Maturing Activity	Question 12 mean values (perceived importance)	Question 13 mean values (perceived support)	Question 14 mean values (perceived successful performance)
Find relevant digital resources	6.056	5.248	4.960
Embed information at individual or organisational level	6.198	5.571	5.278
Keep up-to-date with organisation-related knowledge	6.222	5.540	5.151
Familiarise oneself with new information	6.280	5.648	5.352
Reorganise information at individual or organisational level	5.656	4.928	4.696
Reflect on and refine work practices or processes	6.192	5.296	4.920
Create and co-develop digital resources	5.645	5.137	4.789

Share and release digital resources	5.718	5.358	5.065
Restrict access and protect digital resources	4.699	5.252	5.309
Find people with particular knowledge or expertise	6.365	5.357	5.056
Communicate with people	6.603	5.897	5.540
Assess, verify and rate information	6.000	5.228	4.967
lower quartile (0.25 quantile)	5.702	5.243	4.950
median	6.124	5.327	5.060
upper quartile (0.75 quantile)	6.237	5.548	5.286

Table 59: KM activities: Mean values for questions 12, 13 and 14

	N	Mean	Std. Deviation	Variance
Find relevant digital resources (perceived importance)	125	6.06	1.405	1.973
Embed information at individual or organisational level (perceived importance)	126	6.20	.955	.912
Keep up-to-date with organisation related knowledge (perceived importance)	126	6.22	.962	.926
Familiarise oneself with new information (perceived importance)	125	6.28	.809	.655
Reorganise information at individual or organisational level (perceived importance)	125	5.66	1.333	1.776
Reflect on and refine work practices or processes (perceived importance)	125	6.19	1.134	1.285
Create and co-develop digital resources (perceived importance)	124	5.65	1.432	2.052
Share and release digital resources (perceived importance)	124	5.72	1.606	2.578
Restrict access and protect digital resources (perceived importance)	123	4.70	2.150	4.622
Find people with particular knowledge or expertise (perceived importance)	126	6.37	.917	.842
Communicate with people (perceived importance)	126	6.60	.821	.673
Assess, verify and rate information (perceived importance)	125	6.00	1.008	1.016
Valid N (listwise)	120			

Table 60: KM activities: Descriptive statistics (perceived importance)

	N	Mean	Std. Deviation	Variance
Find relevant digital resources (perceived support)	125	5.25	1.554	2.414
Embed information at individual or organisational level (perceived support)	126	5.57	1.155	1.335
Keep up-to-date with organisation related knowledge (perceived support)	126	5.54	1.269	1.610
Familiarise oneself with new information (perceived support)	125	5.65	1.131	1.278
Reorganise information at individual or organisational level (perceived support)	125	4.93	1.504	2.261
Reflect on and refine work practices or processes (perceived support)	125	5.30	1.503	2.258
Create and co-develop digital resources (perceived support)	124	5.14	1.574	2.477

	N	Mean	Std. Deviation	Variance
Share and release digital resources (perceived support)	123	5.36	1.620	2.625
Restrict access and protect digital resources (perceived support)	123	5.25	1.809	3.272
Find people with particular knowledge or expertise (perceived support)	126	5.36	1.546	2.391
Communicate with people (perceived support)	126	5.90	1.332	1.773
Assess, verify and rate information (perceived support)	123	5.23	1.530	2.341
Valid N (listwise)	117			

Table 61: KM activities: Descriptive statistics (perceived support)

	N	Mean	Std. Deviation	Variance
Find relevant digital resources (perceived success of performance)	125	4.96	1.588	2.523
Embed information at individual or organisational level (perceived success of performance)	126	5.28	1.237	1.530
Keep up-to-date with organisation related knowledge (perceived success of performance)	126	5.15	1.437	2.065
Familiarise oneself with new information (perceived success of performance)	125	5.35	1.240	1.536
Reorganise information at individual or organisational level (perceived success of performance)	125	4.70	1.509	2.278
Reflect on and refine work practices or processes (perceived success of performance)	125	4.92	1.473	2.171
Create and co-develop digital resources (perceived success of performance)	123	4.79	1.595	2.545
Share and release digital resources (perceived success of performance)	123	5.07	1.673	2.799
Restrict access and protect digital resources (perceived success of performance)	123	5.31	1.630	2.658
Find people with particular knowledge or expertise (perceived success of performance)	126	5.06	1.581	2.501
Communicate with people (perceived success of performance)	126	5.54	1.446	2.090
Assess, verify and rate information (perceived success of performance)	123	4.97	1.443	2.081
Valid N (listwise)	117			

Table 62: KM activities: Descriptive statistics (perceived success of performance)

Knowledge maturing activities:

1. Find relevant digital resources
2. Embed information at individual or organisational level
3. Keep up-to-date with organisation-related knowledge
4. Familiarise oneself with new information
5. Reorganise information at individual or organisational level
6. Reflect on and refine work practices or processes
7. Create and co-develop digital resources
8. Share and release digital resources
9. Restrict access and protect digital resources
10. Find people with particular knowledge or expertise
11. Communicate with people
12. Assess, verify and rate information

Legend:

----- median

············ upper and lower quartile

See table 59 (appendix) for data used to create this figure.

Figure 73: KM activities portfolio support – success

8.5.4.2 Boxplots
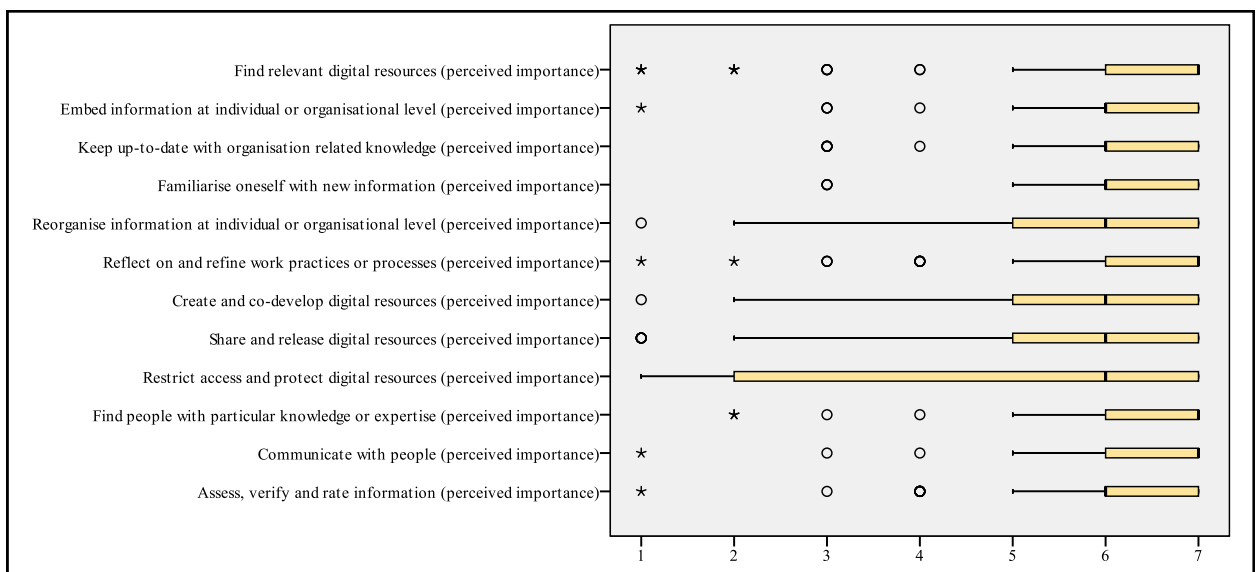
Figure 74: KM activities: Boxplots perceived importance
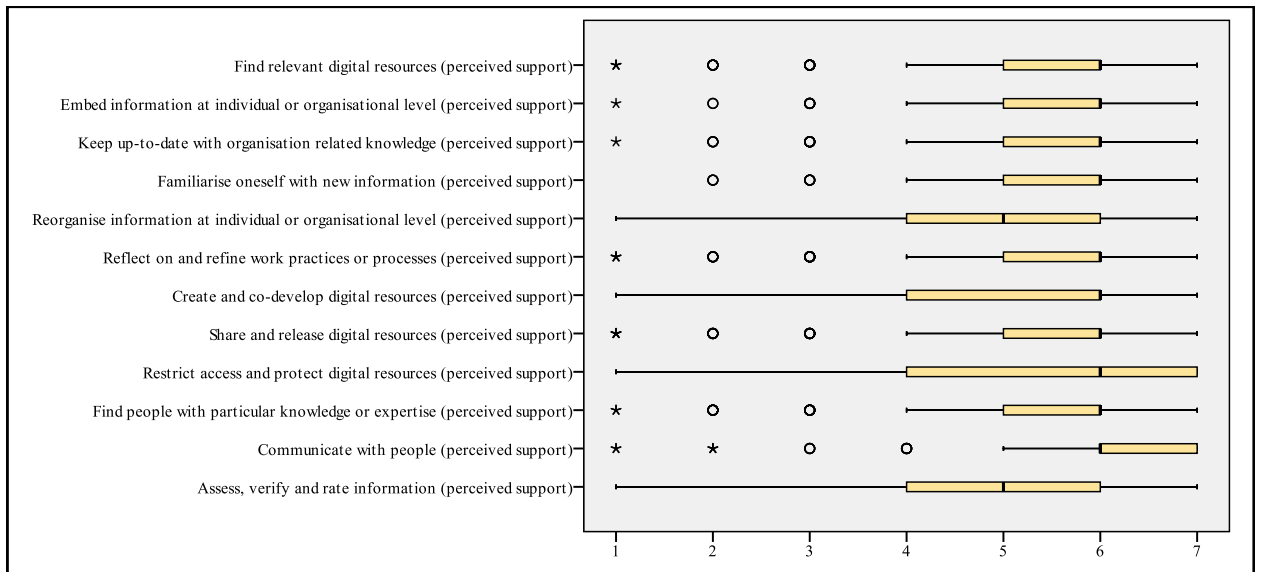
Figure 75: KM activities: Boxplots perceived support

Figure 76: KM activities: Boxplots perceived success of performance

8.5.4.3 Histograms

Find relevant digital resources (perceived importance)

Mean =6.06
Std. Dev. =1.405
N =125

Find relevant digital resources (perceived support)

Mean =5.25
Std. Dev. =1.554
N =125

Find relevant digital resources (perceived success of performance)

Mean =4.96
Std. Dev. =1.588
N =125

Embed information at individual or organisational level (perceived importance)

Mean =6.2
Std. Dev. =0.955
N =126

Embed information at individual or organisational level (perceived support)

Mean =5.57
Std. Dev. =1.155
N =126

Embed information at individual or organisational level (perceived success of performance)

Mean =5.28
Std. Dev. =1.237
N =126

Keep up-to-date with organisation related knowledge (perceived importance)

Mean =6.22
Std. Dev. =0.962
N =126

Keep up-to-date with organisation related knowledge (perceived support)

Mean =5.54
Std. Dev. =1.269
N =126

Keep up-to-date with organisation related knowledge (perceived success of performance)

Mean =5.15
Std. Dev. =1.437
N =126

Familiarise oneself with new information (perceived importance)

Mean =6.28
Std. Dev. =0.809
N =125

Familiarise oneself with new information (perceived support)

Mean =5.65
Std. Dev. =1.131
N =125

Familiarise oneself with new information (perceived success of performance)

Mean =5.35
Std. Dev. =1.24
N =125

Reorganise information at individual or organisational level (perceived importance)

Mean =5.66
Std. Dev. =1.333
N =125

Reorganise information at individual or organisational level (perceived support)

Mean =4.93
Std. Dev. =1.504
N =125

Reorganise information at individual or organisational level (perceived success of performance)

Mean =4.7
Std. Dev. =1.509
N =125

Reflect on and refine work practices or processes (perceived importance)

Mean =6.19
Std. Dev. =1.134
N =125

Reflect on and refine work practices or processes (perceived support)

Mean =5.3
Std. Dev. =1.503
N =125

Reflect on and refine work practices or processes (perceived success of performance)

Mean =4.92
Std. Dev. =1.473
N =125

Create and co-develop digital resources (perceived importance)

Mean =5.65
Std. Dev. =1.432
N =124

Create and co-develop digital resources (perceived support)

Mean =5.14
Std. Dev. =1.574
N =124

Create and co-develop digital resources (perceived success of performance)

Mean =4.79
Std. Dev. =1.595
N =123

Share and release digital resources (perceived importance)

Mean =5.72
Std. Dev. =1.606
N =124

Share and release digital resources (perceived support)

Mean =5.36
Std. Dev. =1.62
N =123

Share and release digital resources (perceived success of performance)

Mean =5.07
Std. Dev. =1.673
N =123

Restrict access and protect digital resources (perceived importance)

Mean =4.7
Std. Dev. =2.15
N =123

Restrict access and protect digital resources (perceived support)

Mean =5.25
Std. Dev. =1.809
N =123

Restrict access and protect digital resources (perceived success of performance)

Mean =5.31
Std. Dev. =1.63
N =123

Find people with particular knowledge or expertise (perceived importance)

Mean =6.37
Std. Dev. =0.917
N =126

Find people with particular knowledge or expertise (perceived support)

Mean =5.36
Std. Dev. =1.546
N =126

Find people with particular knowledge or expertise (perceived success of performance)

Mean =5.06
Std. Dev. =1.581
N =126

Communicate with people (perceived importance)

Mean =6.6
Std. Dev. =0.821
N =126

Communicate with people (perceived support)

Mean =5.9
Std. Dev. =1.332
N =126

Communicate with people (perceived success of performance)

Mean =5.54
Std. Dev. =1.446
N =126

Assess, verify and rate information (perceived importance)

Mean =6
Std. Dev. =1.008
N =125

Assess, verify and rate information (perceived support)

Mean =5.23
Std. Dev. =1.53
N =123

Assess, verify and rate information (perceived success of performance)

Mean =4.97
Std. Dev. =1.443
N =123

8.5.4.4 Test Statistics

Test Statistics[c]

	Z	Asymp. Sig. (2-tailed)
Find relevant digital resources (perceived support) - Find relevant digital resources (perceived importance)	-5.524[a]	.000
Embed information at individual or organisational level (perceived support) - Embed information at individual or organisational level (perceived importance)	-5.070[a]	.000
Keep up-to-date with organisation related knowledge (perceived support) - Keep up-to-date with organisation related knowledge (perceived importance)	-5.664[a]	.000
Familiarise oneself with new information (perceived support) - Familiarise oneself with new information (perceived importance)	-5.423[a]	.000
Reorganise information at individual or organisational level (perceived support) - Reorganise information at individual or organisational level (perceived importance)	-4.915[a]	.000
Reflect on and refine work practices or processes (perceived support) - Reflect on and refine work practices or processes (perceived importance)	-5.728[a]	.000
Create and co-develop digital resources (perceived support) - Create and co-develop digital resources (perceived importance)	-4.077[a]	.000
Share and release digital resources (perceived support) - Share and release digital resources (perceived importance)	-2.639[a]	.008
Restrict access and protect digital resources (perceived support) - Restrict access and protect digital resources (perceived importance)	-3.276[b]	.001
Find people with particular knowledge or expertise (perceived support) - Find people with particular knowledge or expertise (perceived importance)	-6.194[a]	.000
Communicate with people (perceived support) - Communicate with people (perceived importance)	-5.625[a]	.000
Assess, verify and rate information (perceived support) - Assess, verify and rate information (perceived importance)	-5.239[a]	.000

a. Based on positive ranks.

b. Based on negative ranks.

c. Wilcoxon Signed Ranks Test

Table 63: KM activities: Wilcoxon signed ranks tests for perceived importance and support (questions 12 and 13)

Test Statistics[c]

	Z	Asymp. Sig. (2-tailed)
Find relevant digital resources (perceived success of performance) - Find relevant digital resources (perceived importance)	-6.134[a]	.000
Embed information at individual or organisational level (perceived success of performance) - Embed information at individual or organisational level (perceived importance)	-6.920[a]	.000
Keep up-to-date with organisation related knowledge (perceived success of performance) - Keep up-to-date with organisation related knowledge (perceived importance)	-7.174[a]	.000
Familiarise oneself with new information (perceived success of performance) - Familiarise oneself with new information (perceived importance)	-6.601[a]	.000
Reorganise information at individual or organisational level (perceived success of performance) - Reorganise information at individual or organisational level (perceived importance)	-5.596[a]	.000
Reflect on and refine work practices or processes (perceived success of performance) - Reflect on and refine work practices or processes (perceived importance)	-7.173[a]	.000
Create and co-develop digital resources (perceived success of performance) - Create and co-develop digital resources (perceived importance)	-5.633[a]	.000
Share and release digital resources (perceived success of performance) - Share and release digital resources (perceived importance)	-3.927[a]	.000
Restrict access and protect digital resources (perceived success of performance) - Restrict access and protect digital resources (perceived importance)	-3.152[b]	.002
Find people with particular knowledge or expertise (perceived success of performance) - Find people with particular knowledge or expertise (perceived importance)	-7.119[a]	.000
Communicate with people (perceived success of performance) - Communicate with people (perceived importance)	-6.943[a]	.000
Assess, verify and rate information (perceived success of performance) - Assess, verify and rate information (perceived importance)	-6.575[a]	.000

a. Based on positive ranks.

b. Based on negative ranks.

c. Wilcoxon Signed Ranks Test

Table 64: KM activities: Wilcoxon signed ranks tests for perceived importance and success of performance (questions 12 and 14)

	Z	Asymp. Sig. (2-tailed)
Find relevant digital resources (perceived success of performance) - Find relevant digital resources (perceived support)	-3.094[a]	.002
Embed information at individual or organisational level (perceived success of performance) - Embed information at individual or organisational level (perceived support)	-3.721[a]	.000
Keep up-to-date with organisation related knowledge (perceived success of performance) - Keep up-to-date with organisation related knowledge (perceived support)	-4.834[a]	.000
Familiarise oneself with new information (perceived success of performance) - Familiarise oneself with new information (perceived support)	-3.600[a]	.000
Reorganise information at individual or organisational level (perceived success of performance) - Reorganise information at individual or organisational level (perceived support)	-2.423[a]	.015
Reflect on and refine work practices or processes (perceived success of performance) - Reflect on and refine work practices or processes (perceived support)	-4.317[a]	.000
Create and co-develop digital resources (perceived success of performance) - Create and co-develop digital resources (perceived support)	-4.012[a]	.000
Share and release digital resources (perceived success of performance) - Share and release digital resources (perceived support)	-3.342[a]	.001
Restrict access and protect digital resources (perceived success of performance) - Restrict access and protect digital resources (perceived support)	-.556[b]	.578
Find people with particular knowledge or expertise (perceived success of performance) - Find people with particular knowledge or expertise (perceived support)	-2.576[a]	.010
Communicate with people (perceived success of performance) - Communicate with people (perceived support)	-4.089[a]	.000
Assess, verify and rate information (perceived success of performance) - Assess, verify and rate information (perceived support)	-3.113[a]	.002

a. Based on positive ranks.

b. Based on negative ranks.

c. Wilcoxon Signed Ranks Test

Table 65: KM activities: Wilcoxon signed ranks tests for perceived support and success of performance (questions 13 and 14)

8.5.5 Knowledge Maturing Indicators

8.5.5.1 Descriptive Statistics

Descriptive Statistics

	N	Mean	Std. Deviation	Variance
has been accepted into a restricted domain	119	4.78	1.688	2.850
has become part of a guideline or has become standard	121	6.10	1.052	1.107
has not been changed for a long period after intensive editing	119	3.98	1.761	3.101
was selected from a range of digital resources	118	4.90	1.361	1.853
became part of a collection of similar information	121	4.93	1.453	2.112
was created/refined in a meeting	121	5.49	1.266	1.602
was prepared for a meeting	120	4.78	1.452	2.109
was created by integrating parts of other digital resources	120	5.15	1.358	1.843
was made accessible to a different user group	118	5.18	1.418	2.011
was presented to an influential audience	121	5.31	1.658	2.751
is referred to by another digital resource	120	5.13	1.441	2.077
has been the subject of many discussions	120	5.51	1.402	1.966
Valid N (listwise)	115			

Table 66: KM indicators: Descriptive statistics (digital resources)

Descriptive Statistics

	N	Mean	Std. Deviation	Variance
has acquired a qualification or attended a training course	120	5.10	1.525	2.326
has a central role within a social network	121	5.21	1.460	2.132
changed its role or responsibility	120	4.66	1.569	2.462
has contributed to a project	121	5.47	1.245	1.551
has contributed to a discussion	122	5.14	1.344	1.807
has been a member of the organisation for a significant period	121	4.81	1.675	2.805
has significant professional experience	121	5.75	1.164	1.355
is an author of many documents	122	5.06	1.392	1.939
is approached by others for help and advice	122	5.98	1.098	1.206
Valid N (listwise)	115			

Table 67: KM indicators: Descriptive statistics (person)

Descriptive Statistics

	N	Mean	Std. Deviation	Variance
was certified or standardised according to external standards	121	5.41	1.701	2.894
was internally agreed or standardised	122	5.93	1.111	1.235
was changed by adding or deleting steps	120	5.44	1.106	1.223
was documented	122	5.56	1.206	1.455
was improved with respect to time, cost or quality	121	6.19	1.011	1.022
was changed according to the number of cycles (loops)	117	4.98	1.364	1.862
has been successfully undertaken a number of times	122	5.88	1.103	1.216
Valid N (listwise)	117			

Table 68: KM indicators: Descriptive statistics (process)

Descriptive Statistics

	N	Mean	Std. Deviation	Variance
A digital resource has been changed after a person had learned something	120	5.72	1.139	1.297
A digital resource has been accessed by a different group of persons	119	5.49	1.234	1.523
A digital resource has been assessed by a person	120	4.58	1.447	2.095
A digital resource has been edited by a highly reputable person	120	5.36	1.395	1.946
A digital resource has been used by a person	119	4.23	1.470	2.160
A digital resource describing a process has been changed	119	5.05	1.192	1.421
A digital resource has been changed as the result of a process	120	5.63	1.115	1.243
A person has been involved in a process a number of times	121	5.16	1.118	1.250
A person has been involved in a process for a significant period	121	5.01	1.320	1.742
A person has been the owner of a process for a significant period	121	5.13	1.628	2.649
Valid N (listwise)	117			

Table 69: KM indicators: Descriptive statistics (combinations)
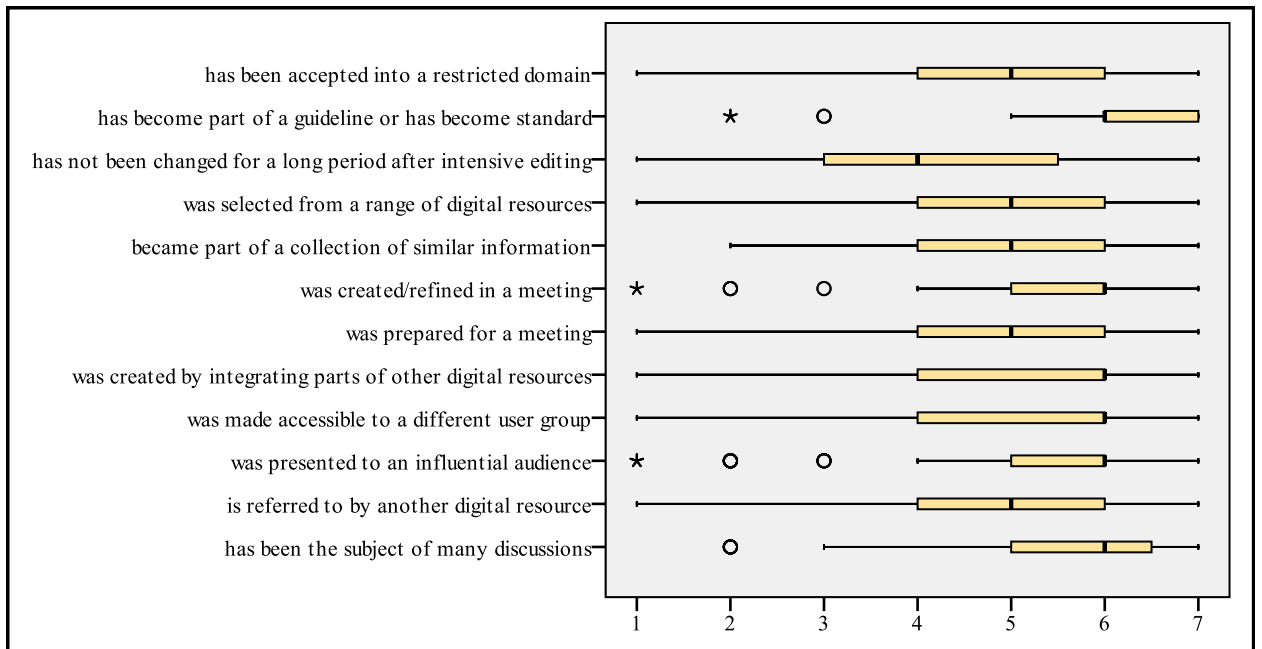
Figure 77: KM indicators: Boxplots (digital resources)
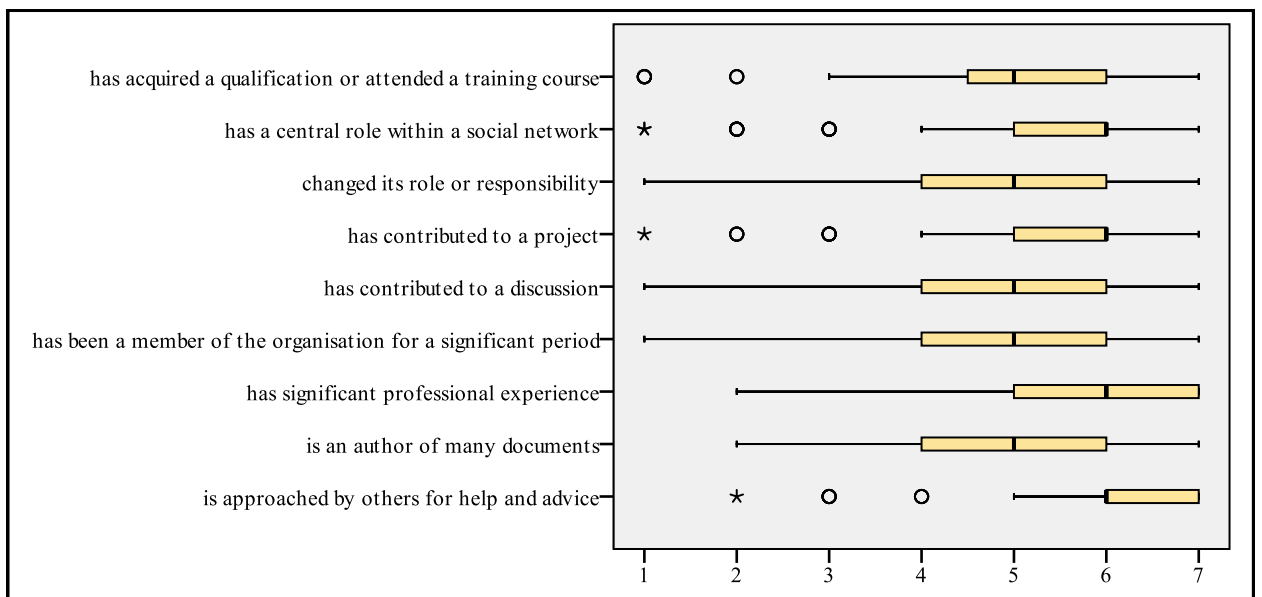
Figure 78: KM indicators: Boxplots (person)
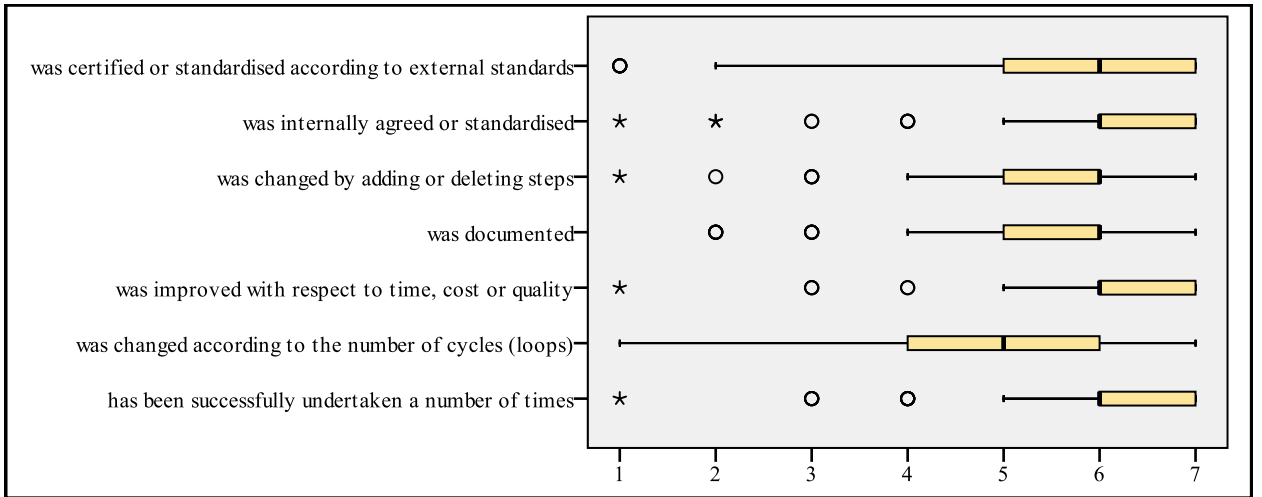
Figure 79: KM indicators: Boxplots (process)
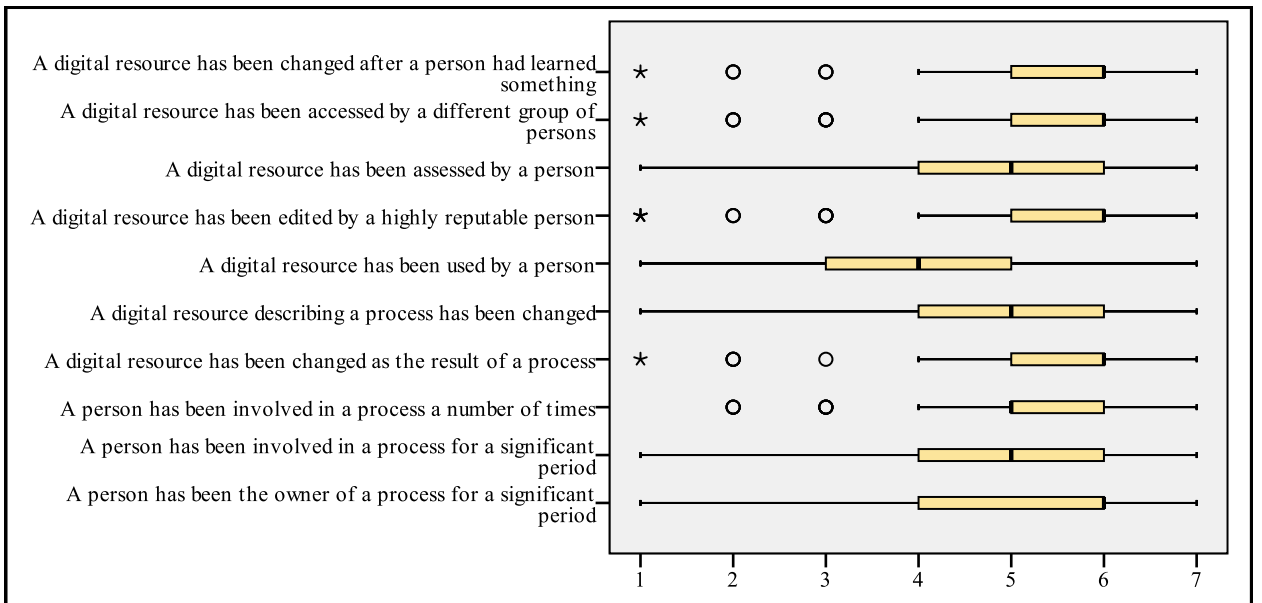
Figure 80: KM indicators: Boxplots (combinations)

8.5.5.3 Statistics KMI: Overview

One-Sample Kolmogorov-Smirnov Test

		Digital Resources	Persons	Processes	Combinations
N		121	122	122	121
Normal Parameters[a,b]	Mean	5.1106	5.2358	5.6319	5.1313
	Std. Deviation	.66876	.71754	.66955	.66898
Most Extreme Differences	Absolute	.069	.082	.099	.081
	Positive	.069	.058	.054	.062
	Negative	-.035	-.082	-.099	-.081
Kolmogorov-Smirnov Z		.756	.905	1.093	.892
Asymp. Sig. (2-tailed)		.617	.386	.183	.403

a. Test distribution is Normal.

b. Calculated from data.

Table 70: Kolmogorov-Smirnov-test for normal distribution of KM indicator means

8.5.5.4 Histograms – KMI: Digital Resources

became part of a collection of similar information

Mean =4.93
Std. Dev. =1.453
N =121

was created/refined in a meeting

Mean =5.49
Std. Dev. =1.266
N =121

was prepared for a meeting

Mean =4.78
Std. Dev. =1.452
N =120

was created by integrating parts of other digital resources

Mean =5.15
Std. Dev. =1.358
N =120

was made accessible to a different user group

Mean =5.18
Std. Dev. =1.418
N =118

was presented to an influential audience

Mean =5.31
Std. Dev. =1.658
N =121

is referred to by another digital resource

Mean =5.13
Std. Dev. =1.441
N =120

has been the subject of many discussions

Mean =5.51
Std. Dev. =1.402
N =120

8.5.5.5   Histograms – KMI: Person

has acquired a qualification or attended a training course

Mean =5.1
Std. Dev. =1.525
N =120

has a central role within a social network

Mean =5.21
Std. Dev. =1.46
N =121

changed its role or responsibility

Mean =4.66
Std. Dev. =1.569
N =120

has contributed to a project

Mean =5.47
Std. Dev. =1.245
N =121

has contributed to a discussion

Mean =5.14
Std. Dev. =1.344
N =122

Frequency

has contributed to a discussion

2 4 8 20 29 45 14

has been a member of the organisation for a significant period

Mean =4.81
Std. Dev. =1.675
N =121

Frequency

has been a member of the organisation for a significant period

7 10 8 14 31 37 14

has significant professional experience

Mean =5.75
Std. Dev. =1.164
N =121

Frequency

has significant professional experience

3 5 5 25 51 32

is an author of many documents

Mean =5.06
Std. Dev. =1.392
N =122

Frequency

is an author of many documents

8 12 15 32 40 15

is approached by others for help and advice

Mean =5.98
Std. Dev. =1.098
N =122

Frequency

is approached by others for help and advice

1 6 4 16 51 44

232

was certified or standardised according to external standards

Mean =5.41
Std. Dev. =1.701
N =121

was internally agreed or standardised

Mean =5.93
Std. Dev. =1.111
N =122

was changed by adding or deleting steps

Mean =5.44
Std. Dev. =1.106
N =120

was documented

Mean =5.56
Std. Dev. =1.206
N =122

was improved with respect to time, cost or quality

Mean =6.19
Std. Dev. =1.011
N =121

was changed according to the number of cycles (loops)

Mean =4.98
Std. Dev. =1.364
N =117

has been successfully undertaken a number of times

Mean =5.88
Std. Dev. =1.103
N =122

8.5.5.7   Histograms – KMI: combinations

A digital resource has been changed after a person had learned something

Mean =5.72
Std. Dev. =1.139
N =120

A digital resource has been accessed by a different group of persons

Mean =5.49
Std. Dev. =1.234
N =119

A digital resource has been assessed by a person

Mean =4.57
Std. Dev. =1.447
N =120

A digital resource has been edited by a highly reputable person

Mean =5.36
Std. Dev. =1.395
N =120

A digital resource has been used by a person

Mean =4.23
Std. Dev. =1.47
N =119

A digital resource describing a process has been changed

Mean =5.05
Std. Dev. =1.192
N =119

A digital resource has been changed as the result of a process

Mean =5.63
Std. Dev. =1.115
N =120

A person has been involved in a process a number of times

Mean =5.16
Std. Dev. =1.118
N =121

A person has been involved in a process for a significant period

Mean =5.01
Std. Dev. =1.32
N =121

A person has been the owner of a process for a significant period

Mean =5.13
Std. Dev. =1.628
N =121

8.5.5.8   *Statistics factor analysis*

change in a digital resource's context of application

Crosstab

Count

		Size		Total
		large	medium	
change in a digital resource's context of application	very low	17	11	28
	low	21	7	28
	high	21	7	28
	very high	18	10	28
Total		77	35	112

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	2.119[a]	3	.548
Likelihood Ratio	2.123	3	.547
N of Valid Cases	112		

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 8.75.

Crosstab

Count

		Sector			Total
		industry	na	service	
change in a digital resource's context of application	very low	8	2	18	28
	low	9	4	15	28
	high	12	1	15	28
	very high	7	0	21	28
Total		36	7	69	112

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	7.990[a]	6	.239
Likelihood Ratio	8.938	6	.177
N of Valid Cases	112		

a. 4 cells (33.3%) have expected count less than 5. The minimum expected count is 1.75.

Crosstab

Count

		Knowledge Intensity			Total
		high	low	na	
change in a digital resource's context of application	very low	17	9	2	28
	low	16	8	4	28
	high	16	11	1	28
	very high	25	3	0	28
Total		74	31	7	112

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	12.565[a]	6	.050
Likelihood Ratio	14.126	6	.028
N of Valid Cases	112		

a. 4 cells (33.3%) have expected count less than 5. The minimum expected count is 1.75.

state change due to creation of a digital resource

Crosstab

Count

		Size		Total
		large	medium	
state change due to creation of a digital resource	very low	21	7	28
	low	23	5	28
	high	14	14	28
	very high	19	9	28
Total		77	35	112

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	7.439[a]	3	.059
Likelihood Ratio	7.375	3	.061
N of Valid Cases	112		

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 8.75.

Crosstab

Count

		Sector			Total
		industry	na	service	
state change due to creation of a digital resource	very low	9	1	18	28
	low	10	3	15	28
	high	9	1	18	28
	very high	8	2	18	28
Total		36	7	69	112

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	2.185[a]	6	.902
Likelihood Ratio	2.156	6	.905
N of Valid Cases	112		

a. 4 cells (33.3%) have expected count less than 5. The minimum expected count is 1.75.

Crosstab

Count

		Knowledge Intensity			Total
		high	low	na	
state change due to creation of a digital resource	very low	22	5	1	28
	low	16	9	3	28
	high	17	10	1	28
	very high	19	7	2	28
Total		74	31	7	112

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	4.610[a]	6	.595
Likelihood Ratio	4.628	6	.592
N of Valid Cases	112		

a. 4 cells (33.3%) have expected count less than 5. The minimum expected count is 1.75.

state change due to a digital resource being handled by influential person

Crosstab

Count

		Size		Total
		large	medium	
state change due to a digital resource being handled by influential person	very low	20	8	28
	low	18	10	28
	high	20	8	28
	very high	19	9	28
Total		77	35	112

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	.457[a]	3	.928
Likelihood Ratio	.454	3	.929
N of Valid Cases	112		

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 8.75.

Crosstab

Count

		Sector			Total
		industry	na	service	
state change due to a digital resource being handled by influential person	very low	10	1	17	28
	low	6	1	21	28
	high	9	3	16	28
	very high	11	2	15	28
Total		36	7	69	112

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	4.330[a]	6	.632
Likelihood Ratio	4.351	6	.629
N of Valid Cases	112		

a. 4 cells (33.3%) have expected count less than 5. The minimum expected count is 1.75.

Crosstab

Count

		Knowledge Intensity			Total
		high	low	na	
state change due to a digital resource being handled by influential person	very low	19	8	1	28
	low	23	4	1	28
	high	17	8	3	28
	very high	15	11	2	28
Total		74	31	7	112

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	6.657[a]	6	.354
Likelihood Ratio	6.821	6	.338
N of Valid Cases	112		

a. 4 cells (33.3%) have expected count less than 5. The minimum expected count is 1.75.

change due to the selection of a digital resource

Crosstab

Count

		Size		Total
		large	medium	
change due to the selection of a digital resource	very low	20	8	28
	low	18	10	28
	high	22	6	28
	very high	17	11	28
Total		77	35	112

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	2.452[a]	3	.484
Likelihood Ratio	2.505	3	.474
N of Valid Cases	112		

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 8.75.

Crosstab

Count

		Sector			Total
		industry	na	service	
change due to the selection of a digital resource	very low	9	3	16	28
	low	6	1	21	28
	high	12	2	14	28
	very high	9	1	18	28
Total		36	7	69	112

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	5.122[a]	6	.528
Likelihood Ratio	5.110	6	.530
N of Valid Cases	112		

a. 4 cells (33.3%) have expected count less than 5. The minimum expected count is 1.75.

Crosstab

Count

		Knowledge Intensity			Total
		high	low	na	
change due to the selection of a digital resource	very low	17	8	3	28
	low	21	6	1	28
	high	16	10	2	28
	very high	20	7	1	28
Total		74	31	7	112

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	3.619[a]	6	.728
Likelihood Ratio	3.561	6	.736
N of Valid Cases	112		

a. 4 cells (33.3%) have expected count less than 5. The minimum expected count is 1.75.

state of stability after editing a digital resource

Crosstab

Count

		Size		Total
		large	medium	
state of stability after editing a digital resource	very low	19	9	28
	low	21	7	28
	high	18	10	28
	very high	19	9	28
Total		77	35	112

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	.790[a]	3	.852
Likelihood Ratio	.805	3	.848
N of Valid Cases	112		

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 8.75.

Crosstab

Count

		Sector			Total
		industry	na	service	
state of stability after editing a digital resource	very low	7	1	20	28
	low	10	1	17	28
	high	9	4	15	28
	very high	10	1	17	28
Total		36	7	69	112

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	5.263[a]	6	.511
Likelihood Ratio	4.683	6	.585
N of Valid Cases	112		

a. 4 cells (33.3%) have expected count less than 5. The minimum expected count is 1.75.

Crosstab

Count

		Knowledge Intensity			Total
		high	low	na	
state of stability after editing a digital resource	very low	20	7	1	28
	low	19	8	1	28
	high	17	7	4	28
	very high	18	9	1	28
Total		74	31	7	112

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	4.482[a]	6	.612
Likelihood Ratio	3.876	6	.693
N of Valid Cases	112		

a. 4 cells (33.3%) have expected count less than 5. The minimum expected count is 1.75.

state change due to individual learning, handling a digital resource or a state of network positioning

Crosstab

Count

		Size		Total
		large	medium	
state change due to individual learning, handling a digital resource or a state of network positioning	very low	17	10	27
	low	22	6	28
	high	19	9	28
	very high	17	11	28
Total		75	36	111

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	2.410[a]	3	.492
Likelihood Ratio	2.503	3	.475
N of Valid Cases	111		

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 8.76.

Crosstab

Count

		Sector			Total
		industry	na	service	
state change due to individual learning, handling a digital resource or a state of network positioning	very low	9	2	16	27
	low	13	2	13	28
	high	7	1	20	28
	very high	10	1	17	28
Total		39	6	66	111

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	4.050[a]	6	.670
Likelihood Ratio	4.085	6	.665
N of Valid Cases	111		

a. 4 cells (33.3%) have expected count less than 5. The minimum expected count is 1.46.

Crosstab

Count

		Knowledge Intensity			Total
		high	low	na	
state change due to individual learning, handling a digital resource or a state of network positioning	very low	13	12	2	27
	low	19	7	2	28
	high	22	5	1	28
	very high	16	11	1	28
Total		70	35	6	111

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	6.984[a]	6	.322
Likelihood Ratio	7.145	6	.308
N of Valid Cases	111		

a. 4 cells (33.3%) have expected count less than 5. The minimum expected count is 1.46.

state of perceived expertise

Crosstab

Count

		Size		Total
		large	medium	
state of perceived expertise	very low	19	8	27
	low	21	7	28
	high	17	11	28
	very high	18	10	28
Total		75	36	111

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	1.540[a]	3	.673
Likelihood Ratio	1.554	3	.670
N of Valid Cases	111		

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 8.76.

Crosstab

Count

		Sector			Total
		industry	na	service	
state of perceived expertise	very low	11	0	16	27
	low	9	3	16	28
	high	9	1	18	28
	very high	10	2	16	28
Total		39	6	66	111

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	3.797[a]	6	.704
Likelihood Ratio	4.928	6	.553
N of Valid Cases	111		

a. 4 cells (33.3%) have expected count less than 5. The minimum expected count is 1.46.

Crosstab

Count

		Knowledge Intensity			Total
		high	low	na	
state of perceived expertise	very low	19	8	0	27
	low	14	11	3	28
	high	19	8	1	28
	very high	18	8	2	28
Total		70	35	6	111

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	5.065[a]	6	.535
Likelihood Ratio	6.221	6	.399
N of Valid Cases	111		

a. 4 cells (33.3%) have expected count less than 5. The minimum expected count is 1.46.

state change of a person's role

Crosstab

Count

		Size		Total
		large	medium	
state change of a person's role	very low	20	7	27
	low	24	4	28
	high	15	13	28
	very high	16	12	28
Total		75	36	111

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	8.621[a]	3	.035
Likelihood Ratio	9.093	3	.028
N of Valid Cases	111		

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 8.76.

Crosstab

Count

		Sector			Total
		industry	na	service	
state change of a person's role	very low	9	3	15	27
	low	12	1	15	28
	high	11	2	15	28
	very high	7	0	21	28
Total		39	6	66	111

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	6.459[a]	6	.374
Likelihood Ratio	7.580	6	.271
N of Valid Cases	111		

a. 4 cells (33.3%) have expected count less than 5. The minimum expected count is 1.46.

Crosstab

Count

		Knowledge Intensity			Total
		high	low	na	
state change of a person's role	very low	17	7	3	27
	low	20	7	1	28
	high	15	11	2	28
	very high	18	10	0	28
Total		70	35	6	111

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	5.525[a]	6	.478
Likelihood Ratio	6.674	6	.352
N of Valid Cases	111		

a. 4 cells (33.3%) have expected count less than 5. The minimum expected count is 1.46.

state of experience of a person

Crosstab

Count

		Size		Total
		large	medium	
state of experience of a person	very low	21	6	27
	low	18	10	28
	high	19	9	28
	very high	17	11	28
Total		75	36	111

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	2.023[a]	3	.568
Likelihood Ratio	2.091	3	.554
N of Valid Cases	111		

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 8.76.

Crosstab

Count

		Sector			Total
		industry	na	service	
state of experience of a person	very low	4	3	20	27
	low	10	2	16	28
	high	12	1	15	28
	very high	13	0	15	28
Total		39	6	66	111

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	9.459[a]	6	.149
Likelihood Ratio	11.305	6	.079
N of Valid Cases	111		

a. 4 cells (33.3%) have expected count less than 5. The minimum expected count is 1.46.

Crosstab

Count

		Knowledge Intensity			Total
		high	low	na	
state of experience of a person	very low	15	9	3	27
	low	17	9	2	28
	high	16	11	1	28
	very high	22	6	0	28
Total		70	35	6	111

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	6.431[a]	6	.377
Likelihood Ratio	7.584	6	.270
N of Valid Cases	111		

a. 4 cells (33.3%) have expected count less than 5. The minimum expected count is 1.46.

state of person involved in a process

Crosstab

Count

		Size		Total
		large	medium	
state of person involved in a process	very low	16	11	27
	low	21	7	28
	high	18	10	28
	very high	20	8	28
Total		75	36	111

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	1.884[a]	3	.597
Likelihood Ratio	1.888	3	.596
N of Valid Cases	111		

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 8.76.

Crosstab

Count

		Sector			Total
		industry	na	service	
state of person involved in a process	very low	10	1	16	27
	low	12	1	15	28
	high	8	3	17	28
	very high	9	1	18	28
Total		39	6	66	111

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	3.151[a]	6	.790
Likelihood Ratio	2.886	6	.823
N of Valid Cases	111		

a. 4 cells (33.3%) have expected count less than 5. The minimum expected count is 1.46.

Crosstab

Count

		Knowledge Intensity			Total
		high	low	na	
state of person involved in a process	very low	17	9	1	27
	low	18	9	1	28
	high	15	10	3	28
	very high	20	7	1	28
Total		70	35	6	111

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	3.236[a]	6	.779
Likelihood Ratio	3.005	6	.808
N of Valid Cases	111		

a. 4 cells (33.3%) have expected count less than 5. The minimum expected count is 1.46.

state change concerning success or standardization of a process

Crosstab

Count

		Size		Total
		large	medium	
state change concerning success or standardization of a process	very low	19	9	28
	low	21	8	29
	high	19	10	29
	very high	19	10	29
Total		78	37	115

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	.421[a]	3	.936
Likelihood Ratio	.427	3	.935
N of Valid Cases	115		

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 9.01.

Crosstab

Count

		Sector			Total
		industry	na	service	
state change concerning success or standardization of a process	very low	8	1	19	28
	low	9	2	18	29
	high	8	3	18	29
	very high	13	0	16	29
Total		38	6	71	115

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	5.335[a]	6	.502
Likelihood Ratio	6.427	6	.377
N of Valid Cases	115		

a. 4 cells (33.3%) have expected count less than 5. The minimum expected count is 1.46.

Crosstab

Count

		Knowledge Intensity			Total
		high	low	na	
state change concerning success or standardization of a process	very low	17	10	1	28
	low	21	6	2	29
	high	17	9	3	29
	very high	20	9	0	29
Total		75	34	6	115

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	5.023[a]	6	.541
Likelihood Ratio	6.280	6	.393
N of Valid Cases	115		

a. 4 cells (33.3%) have expected count less than 5. The minimum expected count is 1.46.

state change of description of a process I

Crosstab

Count

		Size		Total
		large	medium	
state change of description of a process I	very low	21	7	28
	low	22	7	29
	high	17	12	29
	very high	18	11	29
Total		78	37	115

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	3.085[a]	3	.379
Likelihood Ratio	3.102	3	.376
N of Valid Cases	115		

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 9.01.

Crosstab

Count

		Sector			Total
		industry	na	service	
state change of description of a process I	very low	9	3	16	28
	low	12	1	16	29
	high	10	2	17	29
	very high	7	0	22	29
Total		38	6	71	115

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	6.077[a]	6	.415
Likelihood Ratio	7.191	6	.304
N of Valid Cases	115		

a. 4 cells (33.3%) have expected count less than 5. The minimum expected count is 1.46.

Crosstab

Count

		Knowledge Intensity			Total
		high	low	na	
state change of description of a process I	very low	15	10	3	28
	low	21	7	1	29
	high	17	10	2	29
	very high	22	7	0	29
Total		75	34	6	115

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	6.148[a]	6	.407
Likelihood Ratio	7.304	6	.294
N of Valid Cases	115		

a. 4 cells (33.3%) have expected count less than 5. The minimum expected count is 1.46.

state change of description of a process II

Crosstab

Count

		Size		Total
		large	medium	
state change of description of a process II	very low	17	11	28
	low	19	10	29
	high	19	10	29
	very high	23	6	29
Total		78	37	115

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	2.543[a]	3	.468
Likelihood Ratio	2.665	3	.446
N of Valid Cases	115		

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 9.01.

Crosstab

Count

		Sector			Total
		industry	na	service	
state change of description of a process II	very low	5	2	21	28
	low	10	1	18	29
	high	9	3	17	29
	very high	14	0	15	29
Total		38	6	71	115

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	8.706[a]	6	.191
Likelihood Ratio	10.011	6	.124
N of Valid Cases	115		

a. 4 cells (33.3%) have expected count less than 5. The minimum expected count is 1.46.

Crosstab

Count

		Knowledge Intensity			Total
		high	low	na	
state change of description of a process II	very low	22	4	2	28
	low	19	9	1	29
	high	17	9	3	29
	very high	17	12	0	29
Total		75	34	6	115

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	8.123[a]	6	.229
Likelihood Ratio	9.650	6	.140
N of Valid Cases	115		

a. 4 cells (33.3%) have expected count less than 5. The minimum expected count is 1.46.

8.5.5.9 Qualitative analysis of indicators (Question 15) – results of coding process

has been accepted into a restricted domain	Disagreement	8	
	organisational environment	6	
	general interdependency with context	5	
	definition of digital resource	2	
	lack of comprehension	2	
	personal interdependency	1	
	quality interdependency	1	
	undecided	1	
	unit interdependency	1	
	usage interdependency	1	
	wrong comprehension	1	29
has not been changed for a long period after intensive editing	quality interdependency	11	
	definition of digital resource	6	
	disagreement	6	
	usage interdependency	5	
	undecided	4	
	lack of comprehension	2	
	organisational culture	2	
	organisational environment	2	
	external context	1	39
was selected from a range of digital resources	lack of comprehension	4	
	personal interdependency	4	

	quality interdependency	4	
	disagreement	3	
	general interdependency with context	2	
	interdependency of method	2	
	undecided	2	
	definition of digital resource	1	
	usage interdependency	1	23
was prepared for a meeting	disagreement	5	
	personal interdependency	5	
	general interdependency with context	3	
	quality interdependency	2	
	general interdependency	1	
	organisational culture	1	
	organisational environment	1	
	undecided	1	19
was created by integrating parts of other digital resources	quality interdependency	5	
	disagreement	4	
	general interdependency with context	2	
	lack of comprehension	1	
	personal interdependency	1	
	undecided	1	14
was presented to an influential audience	disagreement	3	
	organisational environment	2	
	experiencing competency	1	
	lack of comprehension	1	
	undecided	1	
	wrong comprehension	1	9
has been the subject of many discussions	general interdependency with context	3	
	disagreement	2	
	quality interdependency	2	
	lack of comprehension	1	
	organisational environment	1	
	personal interdependency	1	10
has acquired a qualification or attended a training course	personal interdependency	6	
	quality interdependency	3	
	disagreement	2	
	undecided	2	
	usage interdependency	2	
	experiencing competency	1	
	lack of comprehension	1	17
has a central role within a social network	general interdependency with context	4	
	personal interdependency	4	
	undecided	2	
	disagreement	1	
	lack of comprehension	1	
	social relatedness	1	13

changed its role or responsibility	disagreement	6	
	general interdependency with context	5	
	undecided	2	
	personal interdependency	1	14
has contributed to a discussion	disagreement	3	
	general interdependency with context	3	
	quality interdependency	3	
	undecided	3	
	personal interdependency	1	
	wrong comprehension	1	14
has been a member of the organisation for a significant period	personal interdependency	8	
	disagreement	5	
	undecided	2	
	general interdependency with context	1	
	quality interdependency	1	17
is an author of many documents	quality interdependency	9	
	disagreement	6	
	organisational environment	2	
	definition of digital resource	1	
	lack of comprehension	1	
	Undecided	1	
	work processes	1	21
was certified or standardised according to external standards	usage interdependency	4	
	disagreement	2	
	Undecided	2	
	general interdependency with context	1	
	organisational goal	1	10
was internally agreed or standardised	usage interdependency	3	
	disagreement	2	5
was changed by adding or deleting steps	interdependency of method	3	
	disagreement	2	
	improvement priority	2	
	organisational environment	2	
	lack of comprehension	1	
	Undecided	1	
	usage interdependency	1	12
was documented	disagreement	3	
	usage interdependency	2	
	organisational environment	1	
	personal interdependency	1	
	quality interdependency	1	8
was changed according to the number of cycles (loops)	lack of comprehension	5	
	quality interdependency	3	
	work processes	3	
	interdependency of method	1	
	organisational environment	1	

	undecided	1	
	usage interdependency	1	15
A digital resource has been assessed by a person	personal interdependency	4	
	general interdependency with context	2	
	undecided	2	
	disagreement	1	
	improvement priority	1	
	lack of comprehension	1	
	organisational culture	1	12
A digital resource has been edited by a highly reputable person	personal interdependency	6	
	disagreement	2	
	organisational culture	1	
	organisational environment	1	
	undecided	1	11
A digital resource has been used by a person	personal interdependency	4	
	disagreement	2	
	usage interdependency	2	
	definition of digital resource	1	
	lack of comprehension	1	
	undecided	1	11
A digital resource describing a process has been changed	undecided	5	
	disagreement	2	
	usage interdependency	2	
	general interdependency with context	1	
	quality interdependency	1	11
A person has been involved in a process for a significant period	disagreement	5	
	undecided	4	
	lack of comprehension	2	
	personal interdependency	2	
	organisational environment	1	
	process perfomance	1	
	work processes	1	16
A person has been the owner of a process for a significant period	disagreement	6	
	undecided	4	
	lack of comprehension	2	
	organisational environment	2	
	personal interdependency	2	
	usage interdependency	2	
	general interdependency	1	19
			427

8.5.5.10 Summary of codes for Question 15

Code	Sum
disagreement	101

254

personal interdependency	68
quality interdependency	54
undecided	52
general interdependency with context	40
lack of comprehension	38
usage interdependency	33
organisational environment	25
definition of digital resource	12
organisational culture	9
improvement priority	7
work processes	7
interdependency of method	6
wrong comprehension	5
process perfomance	2
general interdependency	2
experiencing competency	2
organisational goal	1
lack of resources	1
social relatedness	1
unit interdependency	1
external context	1
notion of standard	1
	469

8.5.5.11 Sample of in-depth analysis of comments

A digital resource has been accepted into a restricted domain

definition of digital resource (2)

maybe that type of documents must als be improved in future discussions, but because it is stored to arestricted area it might be important

Yes, but not in the sense as you mentioned it as an example, but in the moment where sth is absorbed, in the sense there is a document made of out of it, the document was filed, and this document is accessible. Then I assume that a document can be used without questioning it. Inside the company

disagreement (8)

communication in this company is not restricted, so this category doesn_t say anything about maturity level of digital resource

In our company, no, => 2

Now I understand "restricted domain". That is what I mean by "context". Ich habe access credentials when I do sth in this area. [examples read] Yes, I have understood. Now when I include it in a restricted domain, then this doesn_t say much.

You can assume that matured knowledge is in the document, but if that contributes to maturing? Writing it down is supporting maturing, yes. These are two aspects. I think it helps yourself to write things down, it matures, but if others profit from it - there is too much information. Is there a rating? 1-7? => 5, more 4

Do not agree at all - if I understood it correctly. If has been accepted to a restricted domain, this is no indicator that knowledge has matured.

I don_t think that publishing it on the intranet contributes to knowledge maturing

general interdependency with context (5)

Depends

Again 1 to 7. Conditionally yes, would say => 3

depends on the type of the restricted domain (in case of portal I would agree)

If that tells me if that leads to knowledge maturing? Slightly agree - you would have to look more closely at it.

This is definitely more mature than if it was not placed there, is definitely less mature than having become a guideline/standard

lack of comprehension (2)

If I understood it, I would answer

Do not understand the question. What is a "restricted area"? Not sure whether I can follow! (see other remarks)

organisational environment (6)

because of co-operative working styles there are nearly any restricted areas, somtimes we use flip-charts also these resources, paers are relevant

 | No, it depends on the person - there also political decisions in the company, and there was before "was selected from a range of resources, there I said rather not, yes because of political decisions this is especially in these large groups in organizations, there it does not matter if this was a good document or not, or partially, and I have seen this political influence as well here - belongs to the company |

Yes, but not in the sense as you mentioned it as an example, but in the moment where sth is absorbed, in the sense there is a document made of out of it, the document was filed, and this document is accessible. Then I assume that a document can be used without questioning it. Inside the company

Whether I think or the organizations thinks so? I personally think yes, but it does not apply in our organization

In our company, as soon as it is on the file system, it is mature

8.5.6 *Types of Organizations with Respect to Knowledge Maturing*
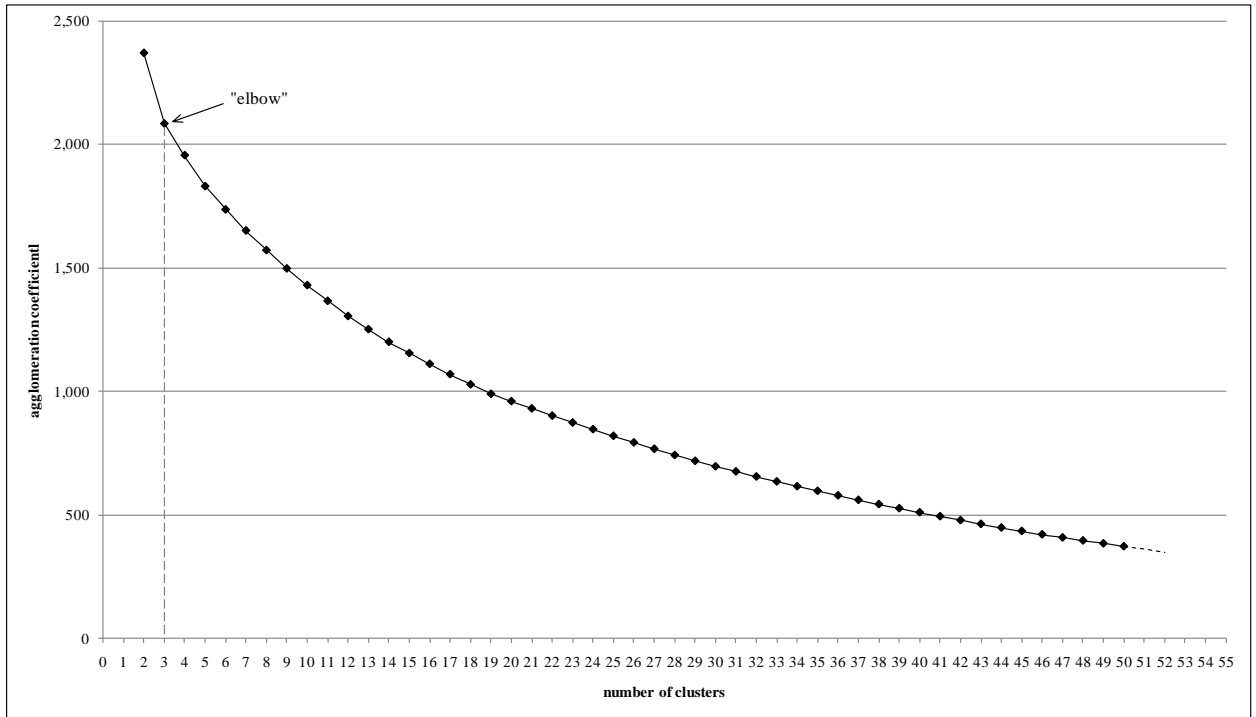
Figure 81: Cluster analysis – elbow criterion

Size * Clustering by success of KM activities (Ward's method, squared Euclidean distance) Crosstabulation

			Clustering by success of KM activities (Ward's method, squared Euclidean distance)			Total
			1	2	3	
Size	large	Count	27	28	24	79
		Expected Count	29.7	29.7	19.6	79.0
		% within Clustering by success of KM activities (Ward's method, squared Euclidean distance)	61.4%	63.6%	82.8%	67.5%
	medium	Count	17	16	5	38
		Expected Count	14.3	14.3	9.4	38.0
		% within Clustering by success of KM activities (Ward's method, squared Euclidean distance)	38.6%	36.4%	17.2%	32.5%
Total		Count	44	44	29	117
		Expected Count	44.0	44.0	29.0	117.0
		% within Clustering by success of KM activities (Ward's method, squared Euclidean distance)	100.0%	100.0%	100.0%	100.0%

Table 71: Cross table (clusters and strata size)

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	4.134[a]	2	.127
Likelihood Ratio	4.471	2	.107
Linear-by-Linear Association	3.232	1	.072
N of Valid Cases	117		

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 9.42.

Table 72: Chi-squared test (clusters and strata size)

Knowedge Intensity * Clustering by success of KM activities (Ward's method, squared Euclidean distance) Crosstabulation

			Clustering by success of KM activities (Ward's method, squared Euclidean distance)			Total
			1	2	3	
Knowedge Intensity	high	Count	31	25	17	73
		Expected Count	29.5	26.8	16.7	73.0
		% within Clustering by success of KM activities (Ward's method, squared Euclidean distance)	70.5%	62.5%	68.0%	67.0%
	low	Count	13	15	8	36
		Expected Count	14.5	13.2	8.3	36.0
		% within Clustering by success of KM activities (Ward's method, squared Euclidean distance)	29.5%	37.5%	32.0%	33.0%
Total		Count	44	40	25	109
		Expected Count	44.0	40.0	25.0	109.0
		% within Clustering by success of KM activities (Ward's method, squared Euclidean distance)	100.0%	100.0%	100.0%	100.0%

Table 73: Cross table (clusters and strata knowledge intensity)

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	.615[a]	2	.735
Likelihood Ratio	.612	2	.736
Linear-by-Linear Association	.111	1	.739
N of Valid Cases	109		

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 8.26.

Table 74: Chi-squared test (clusters and strata knowledge intensity)

Sector * Clustering by success of KM activities (Ward's method, squared Euclidean distance) Crosstabulation

			Clustering by success of KM activities (Ward's method, squared Euclidean distance)			Total
			1	2	3	Total
Sector	industry	Count	17	13	8	38
		Expected Count	15.3	13.9	8.7	38.0
		% within Clustering by success of KM activities (Ward's method, squared Euclidean distance)	38.6%	32.5%	32.0%	34.9%
	service	Count	27	27	17	71
		Expected Count	28.7	26.1	16.3	71.0
		% within Clustering by success of KM activities (Ward's method, squared Euclidean distance)	61.4%	67.5%	68.0%	65.1%
Total		Count	44	40	25	109
		Expected Count	44.0	40.0	25.0	109.0
		% within Clustering by success of KM activities (Ward's method, squared Euclidean distance)	100.0%	100.0%	100.0%	100.0%

Table 75: Cross table (clusters and strata sector)

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	.464[a]	2	.793
Likelihood Ratio	.463	2	.794
N of Valid Cases	109		

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 8.72.

Table 76: Chi-squared test (clusters and strata sector)

Case Summaries (Question 8)									
KM activity	cluster I (n)	cluster I (mean values)	cluster II (n)	cluster II (mean values)	cluster III (n)	cluster III (mean values)	cluster I (mean values) - cluster II (mean values)	cluster II (mean values) - cluster III (mean values)	total (n)	total (mean)
Ia - expressing ideas	43	6.30	43	5.88	29	4.97	.42	.92	115	5.81
Ib - appropriating ideas	44	6.11	44	5.77	28	4.82	.34	.95	116	5.67
II - distributing in communities	44	6.14	44	5.45	29	4.83	.68	.63	117	5.56
III - formalising	44	6.30	43	5.60	29	5.03	.69	.57	116	5.72
IV - ad-hoc training	44	6.18	41	5.56	29	4.76	.62	.80	114	5.60
V - standardising	44	6.18	42	5.48	29	4.79	.71	.68	115	5.57

Table 77: Fostering KM (question 8) grouped by clusters

Case Summaries (Question 10)									
KM activity	cluster I (n)	cluster I (mean values)	cluster II (n)	cluster II (mean values)	cluster III (n)	cluster III (mean values)	cluster I (mean values) - cluster II (mean values)	cluster II (mean values) - cluster III (mean values)	total (n)	total (mean)
Ia - expressing ideas	44	5.77	43	5.12	29	4.31	.66	.81	116	5.16
Ib - appropriating ideas	44	5.80	44	5.05	29	3.97	.75	1.08	117	5.06
II - distributing in communities	44	5.91	44	4.75	29	3.86	1.16	.89	117	4.97
III - formalising	44	5.93	44	4.93	29	4.52	1.00	.41	117	5.21
IV - ad-hoc training	43	5.65	42	4.83	29	3.59	.82	1.25	114	4.82
V - standardising	43	5.98	43	5.16	29	4.21	.81	.96	115	5.23

Table 78: Success of KM per phase (question 10) grouped by clusters

Case Summaries (question 17)				
	cluster I	cluster II	cluster III	total
N	44	44	29	117
Mean	6.11	5.20	4.34	5.33
Std. Deviation	.618	.878	1.203	1.122

Table 79: Success of KM (question 17)

Case Summaries (KM activities - perceived importance)									
KM activity	cluster I (n)	cluster I (mean values)	cluster II (n)	cluster II (mean values)	cluster III (n)	cluster III (mean values)	cluster I (mean values) - cluster II (mean values)	cluster II (mean values) - cluster III (mean values)	total (n)	total (mean)
Find relevant digital resources	44	6.61	44	5.61	29	5.76	1.00	-.14	117	6.03
Embed information at individual or organisational level	44	6.50	44	6.09	29	5.79	.41	.30	117	6.17
Keep up-to-date with organisation related knowledge	44	6.61	44	6.14	29	5.66	.48	.48	117	6.20
Familiarise oneself with new information	44	6.61	44	5.91	29	6.24	.70	-.33	117	6.26
Reorganise information at individual or organisational level	44	6.11	44	5.57	29	5.17	.55	.40	117	5.68
Reflect on and refine work practices or processes	44	6.57	44	6.00	29	6.00	.57	.00	117	6.21
Create and co-develop digital resources	44	5.98	44	5.34	29	5.38	.64	-.04	117	5.59
Share and release digital resources	44	6.05	44	5.68	29	5.10	.36	.58	117	5.68
Restrict access and protect digital resources	44	5.05	44	4.45	29	4.21	.59	.25	117	4.62
Find people with particular knowledge or expertise	44	6.52	44	6.18	29	6.31	.34	-.13	117	6.34
Communicate with people	44	6.77	44	6.36	29	6.66	.41	-.29	117	6.59
Assess, verify and rate information	44	6.41	44	5.70	29	5.72	.70	-.02	117	5.97

Table 80: Perceived importance of KM activities (question 12) grouped by clusters

Case Summaries (KM activities - perceived support)									
KM activity	cluster I (n)	cluster I (mean values)	cluster II (n)	cluster II (mean values)	cluster III (n)	cluster III (mean values)	cluster I (mean values) - cluster II (mean values)	cluster II (mean values) - cluster III (mean values)	total (n)	total (mean)
Find relevant digital resources	44	6.36	44	4.86	29	3.97	1.50	.90	117	5.21
Embed information at individual or organisational level	44	6.11	44	5.57	29	4.69	.55	.88	117	5.56
Keep up-to-date with organisation related knowledge	44	5.93	44	5.86	29	4.31	.07	1.55	117	5.50
Familiarise oneself with new information	44	6.25	44	5.52	29	4.90	.73	.63	117	5.64
Reorganise information at individual or organisational level	44	5.77	44	4.86	29	3.59	.91	1.28	117	4.89
Reflect on and refine work practices or processes	44	6.18	44	5.00	29	4.21	1.18	.79	117	5.25
Create and co-develop digital resources	44	5.91	44	4.84	29	4.17	1.07	.67	117	5.08
Share and release digital resources	44	6.23	44	5.25	29	3.97	.98	1.28	117	5.30
Restrict access and protect digital resources	44	5.70	44	4.93	29	4.79	.77	.14	117	5.19
Find people with particular knowledge or expertise	44	6.00	44	5.50	29	4.14	.50	1.36	117	5.35
Communicate with people	44	6.57	44	5.82	29	4.79	.75	1.03	117	5.85
Assess, verify and rate information	44	5.91	44	5.39	29	3.86	.52	1.52	117	5.21

Table 81: Perceived support of KM activities (question 13) grouped by clusters

Case Summaries (KM activities - perceived success of performance)									
KM activity	cluster I (n)	cluster I (mean values)	cluster II (n)	cluster II (mean values)	cluster III (n)	cluster III (mean values)	cluster I (mean values) - cluster II (mean values)	cluster II (mean values) - cluster III (mean values)	total (n)	total (mean)
Find relevant digital resources	44	6.20	44	4.66	29	3.45	1.55	1.21	117	4.94
Embed information at individual or organisational level	44	6.14	44	5.09	29	4.14	1.05	.95	117	5.25
Keep up-to-date with organisation related knowledge	44	5.73	44	5.55	29	3.69	.18	1.86	117	5.15
Familiarise oneself with new information	44	6.09	44	5.23	29	4.34	.86	.88	117	5.33
Reorganise information at individual or organisational level	44	5.70	44	4.50	29	3.38	1.20	1.12	117	4.68
Reflect on and refine work practices or processes	44	5.89	44	4.80	29	3.41	1.09	1.38	117	4.86
Create and co-develop digital resources	44	5.68	44	4.59	29	3.62	1.09	.97	117	4.76
Share and release digital resources	44	6.32	44	4.82	29	3.31	1.50	1.51	117	5.01
Restrict access and protect digital resources	44	5.84	44	5.14	29	4.55	.70	.58	117	5.26
Find people with particular knowledge or expertise	44	5.93	44	5.02	29	3.62	.91	1.40	117	5.02
Communicate with people	44	6.43	44	5.48	29	4.00	.95	1.48	117	5.47
Assess, verify and rate information	44	5.68	44	5.02	29	3.72	.66	1.30	117	4.95

Table 82: Perceived success of performance of KM activities (question 14) grouped by clusters

Case Summaries (KM indicators - digital resources)									
KM activity	cluster I (n)	cluster I (mean values)	cluster II (n)	cluster II (mean values)	cluster III (n)	cluster III (mean values)	cluster I (mean values) - cluster II (mean values)	cluster II (mean values) - cluster III (mean values)	total (n)	total (mean)
has been accepted into a restricted domain	42	5.19	43	4.37	28	4.82	.82	-.45	113	4.79
has become part of a guideline or has become standard	43	6.35	43	6.14	28	6.04	.21	.10	114	6.19
has not been changed for a long period after intensive editing	43	3.93	43	4.00	28	4.07	-.07	-.07	114	3.99
was selected from a range of digital resources	43	5.00	42	4.74	28	4.93	.26	-.19	113	4.88
became part of a collection of similar information	43	5.23	43	4.53	28	4.86	.70	-.32	114	4.88
was created/refined in a meeting	43	5.51	43	5.51	28	5.43	.00	.08	114	5.49
was prepared for a meeting	42	5.07	43	4.84	28	4.46	.23	.37	113	4.83
was created by integrating parts of other digital resources	42	5.55	43	4.91	28	4.96	.64	-.06	113	5.16
was made accessible to a different user group	42	5.50	43	5.05	28	4.93	.45	.12	113	5.19
was presented to an influential audience	43	5.47	43	4.95	28	5.71	.51	-.76	114	5.33
is referred to by another digital resource	43	5.58	43	4.86	28	4.93	.72	-.07	114	5.15
has been the subject of many discussions	42	5.24	43	5.86	28	5.50	-.62	.36	113	5.54

Table 83: KM indicators – digital resources (question 15) grouped by clusters

Case Summaries (KM indicators - person)									
KM activity	cluster I (n)	cluster I (mean values)	cluster II (n)	cluster II (mean values)	cluster III (n)	cluster III (mean values)	cluster I (mean values) - cluster II (mean values)	cluster II (mean values) - cluster III (mean values)	total (n)	total (mean)
has acquired a qualification or attended a training course	42	5.48	43	4.88	27	4.70	.59	.18	112	5.06
has a central role within a social network	43	5.53	42	4.74	28	5.36	.80	-.62	113	5.19
changed its role or responsibility	43	4.70	42	4.76	28	4.57	-.06	.19	113	4.69
has contributed to a project	43	5.53	42	5.79	28	4.96	-.25	.82	113	5.49
has contributed to a discussion	43	5.14	43	4.98	28	5.14	.16	-.17	114	5.08
has been a member of the organisation for a significant period	43	5.09	43	4.49	28	4.89	.60	-.40	114	4.82
has significant professional experience	43	5.86	43	5.58	28	5.86	.28	-.28	114	5.75
is an author of many documents	43	5.44	43	4.74	28	5.04	.70	-.29	114	5.08
is approached by others for help and advice	43	6.19	43	6.07	28	5.79	.12	.28	114	6.04

Table 84: KM indicators – person (question 15) grouped by clusters

Case Summaries (KM indicators - process)									
KM activity	cluster I (n)	cluster I (mean values)	cluster II (n)	cluster II (mean values)	cluster III (n)	cluster III (mean values)	cluster I (mean values) - cluster II (mean values)	cluster II (mean values) - cluster III (mean values)	total (n)	total (mean)
was certified or standardised according to external standards	42	5.90	43	5.42	28	5.14	.49	.28	113	5.53
was internally agreed or standardised	43	6.21	43	5.98	28	5.68	.23	.30	114	5.99
was changed by adding or deleting steps	42	5.76	43	5.16	28	5.43	.60	-.27	113	5.45
was documented	43	5.81	43	5.60	28	5.11	.21	.50	114	5.56
was improved with respect to time, cost or quality	42	6.31	43	5.93	28	6.39	.38	-.46	113	6.19
was changed according to the number of cycles (loops)	42	5.17	42	4.98	27	4.63	.19	.35	111	4.96
has been successfully undertaken a number of times	43	5.93	43	5.84	28	5.75	.09	.09	114	5.85

Table 85: KM indicators – process (question 15) grouped by clusters

Case Summaries (KM indicators - combinations)									
KM activity	cluster I (n)	cluster I (mean values)	cluster II (n)	cluster II (mean values)	cluster III (n)	cluster III (mean values)	cluster I (mean values) - cluster II (mean values)	cluster II (mean values) - cluster III (mean values)	total (n)	total (mean)
A digital resource has been changed after a person had learned something	42	5.83	43	5.42	28	5.96	.41	-.55	113	5.71
A digital resource has been accessed by a different group of persons	42	5.67	42	5.31	28	5.36	.36	-.05	112	5.46
A digital resource has been assessed by a person	42	4.90	43	4.70	28	4.18	.21	.52	113	4.65
A digital resource has been edited by a highly reputable person	42	5.31	43	5.44	28	5.61	-.13	-.17	113	5.43
A digital resource has been used by a person	42	4.40	42	4.29	28	4.04	.12	.25	112	4.27
A digital resource describing a process has been changed	41	5.15	43	5.12	28	4.79	.03	.33	112	5.04
A digital resource has been changed as the result of a process	42	5.83	43	5.58	28	5.50	.25	.08	113	5.65
A person has been involved in a process a number of times	42	5.40	43	5.12	28	5.11	.29	.01	113	5.22
A person has been involved in a process for a significant period	42	5.00	43	5.07	28	5.11	-.07	-.04	113	5.05
A person has been the owner of a process for a significant period	42	5.31	43	5.19	28	5.21	.12	-.03	113	5.24

Table 86: KM indicators – combinations (question 15) grouped by clusters
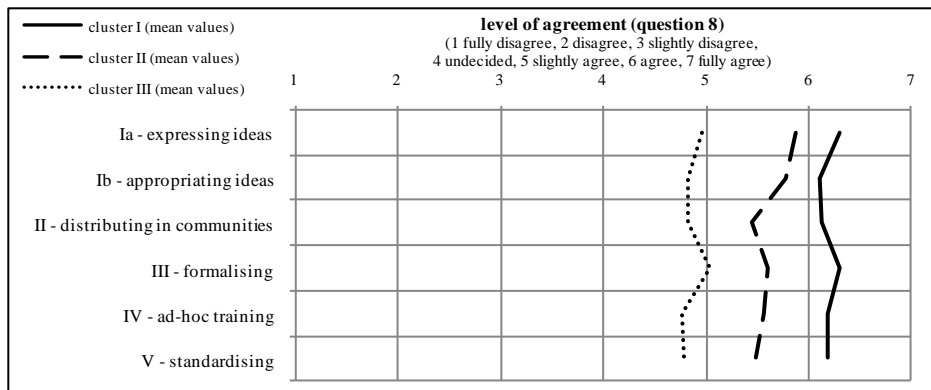
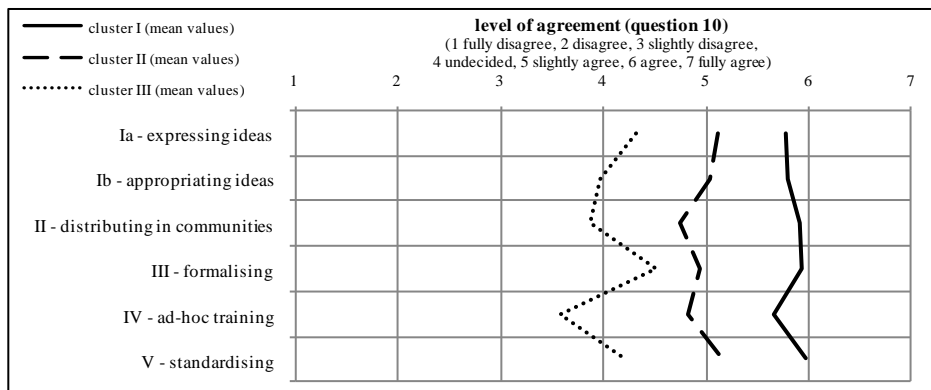**Figure 82: Fostering KM per phase (question 8) grouped by clusters**

Figure 83: Success of KM per phase (question 10) grouped by clusters
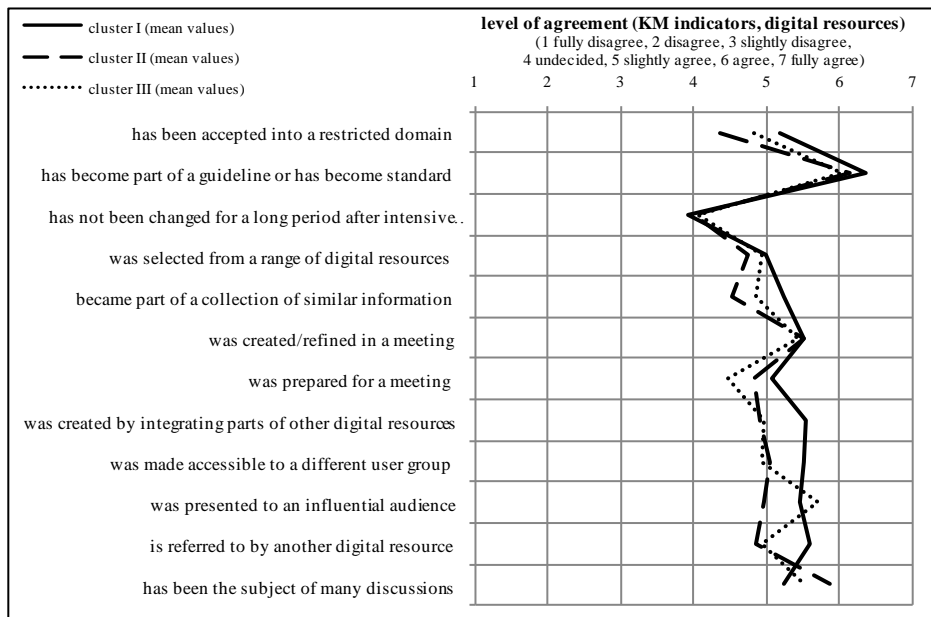

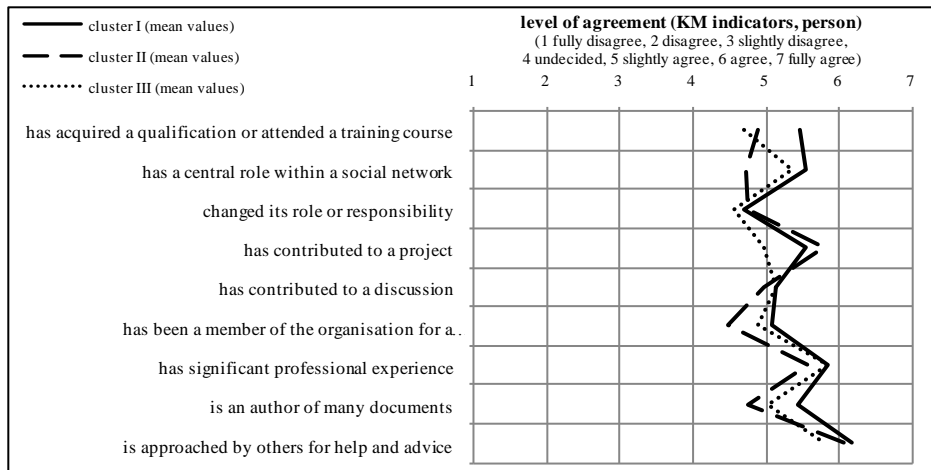**Figure 84: KM indicators – digital resources (question 15) grouped by clusters**

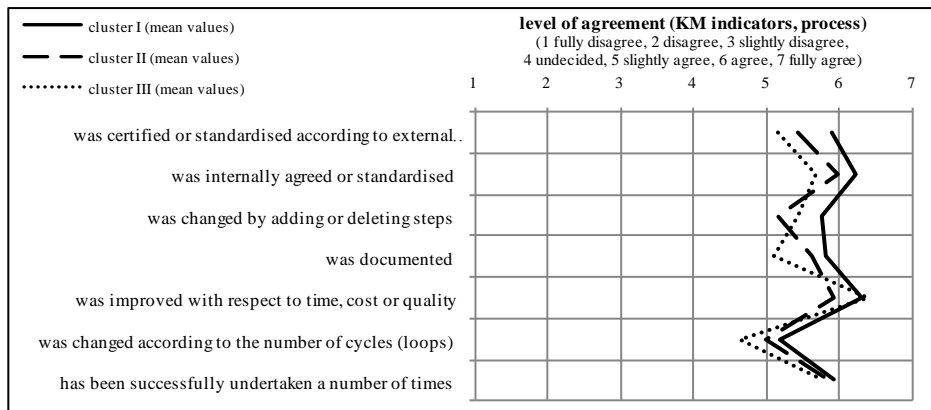**Figure 85: KM indicators – person (question 15) grouped by clusters**

Figure 86: KM indicators – process (question 15) grouped by clusters
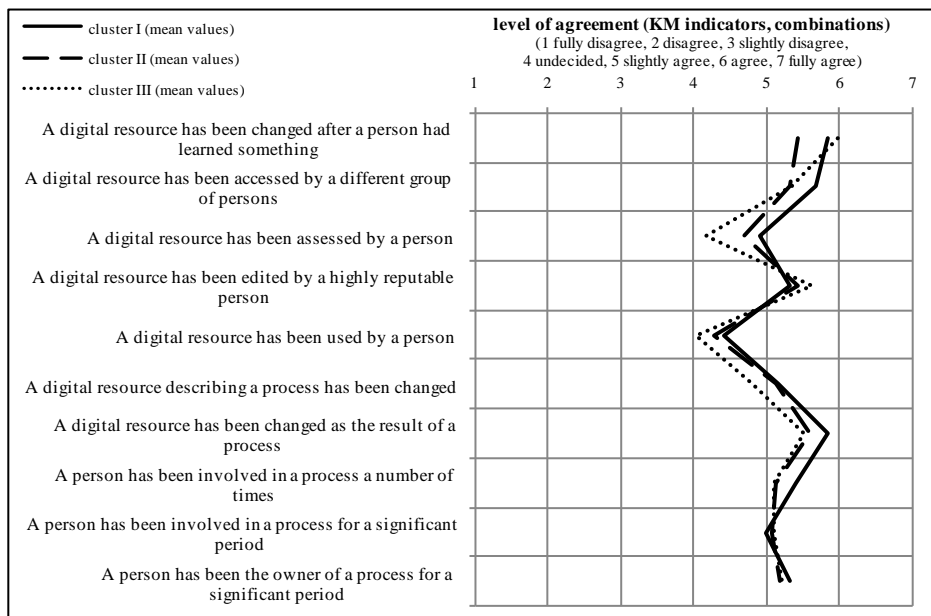

Figure 87: KM indicators – combinations (question 15) grouped by clusters

8.6 EUROSTAT on classification with regard to technology and knowledge intensity

Dear User,

We have the following response from the Author Service for you:

"The classification referred to is for classifying the Manufacturing sector and Service sector into high-tech intensity resp knowledge intensity classes. That is the reason why the codes you mention, and some more, are not included.

So to answer your question then: No, there is not a way of classifying these codes into the existing classes as the codes you mention are neither manufacturing nor services.

This leaves two options:
1. Leave them out.
2. Create more strata.

I would personally create a fifth strata for these codes, which all belong to the major NACE Rev. 2 classes D, E and F. Alternatively you could separate into three (D, E and F) but the number of organisations might then be too small, especially if you are thinking about conducting a survey. If you are looking at the whole economy it could be an idea to separate A and B from D, E and F.

Hope this helps."

We trust this answer is of assistance and if you require further guidance please feel free to re-contact us.

Thank you for your communication and your interest in Eurostat data and related services.

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