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Rationale and Design of a Knowledge Maturing Environment for Workplace Integrated Learning

Dissertation

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Abstract

Organisations have to react fast on changing circumstances on their markets in order to stay competitive. To the same extent, knowledge workers have to adapt to fast changing requirements and need to gain new knowledge in the context of their work. Neither traditional approaches to knowledge management nor formal approaches to advanced training have completely convinced with sustainable support strategies. Top down approaches initiated by the management have to be combined with new bottom up approaches in order to appropriately embed individual knowledge creation into the workplace and to make the most out of knowledge workers' competences and creativity for achieving organisational goals.

The Knowledge Maturing Phase Model (Schmidt, 2005) describes a theory of goal oriented learning on a collective level. Based on this model, this thesis tackles the problem of the design of a software concept, so that its implementation supports knowledge maturing in particular scenarios. That is to say, how may a Learning and Maturing Environment support individuals in designing effective and continuous learning processes, communities in collaborative and purposeful knowledge development and organisations in encouraging, motivating and guiding their employees to achieve their business goals efficiently.

This thesis examines the Knowledge Maturing Phase Model and puts several theories of individual and social learning in relation to it in order to shape the understanding of knowledge maturing in the different phases. Furthermore, it examines the results of three different empirical studies and derives concrete software requirements from it. Based on these results, a general concept for a Learning and Maturing Environment is developed. An instance of this concept was developed in a participatory design process and

evaluated in three different contexts in order to gain insights to which degree it might support knowledge maturing.

The implemented prototype indeed seems to support learning and knowledge maturing in the observed scenarios. The users' feedback about the evaluated instantiation clearly reflects its potential for knowledge maturing support. However, it became very clear that the software prototype is not applicable in different contexts without particular adaptations. The reason is mainly the difference in the very context dependent work requirements, which result in different priorities of Knowledge Maturing Activities that have to be supported.

Based on the theoretic and empirical insights and the evaluation results, it can be concluded that the presented software concept can be applied for developing a Learning and Maturing Environment. However, the concrete manifestation depends on the application context and it should be designed with a focus on its most relevant Knowledge Maturing Activities. Moreover, it has to be flexible enough for a seamless integration into individual work processes.

Zusammenfassung

Unternehmen müssen schnell auf ändernde Bedingungen auf ihren Märkten reagieren, um konkurrenzfähig zu bleiben. In gleichem Maße müssen Wissensarbeiter sich an die schnell ändernden Anforderungen anpassen und neues Wissen im Kontext ihrer Arbeit aufbauen. Weder traditionelle Ansätze zum Wissensmanagement, noch formale Ansätze zur beruflichen Weiterbildung konnten dafür mit durchweg erfolgreichen Lösungsstrategien überzeugen. Management geleitete Ansätze zum effizienteren Wissenserwerb müssen mit solchen verknüpft werden, die intrinsisch motiviert von Mitarbeitern initiiert werden. So können individuelle Wissenserwerbsprozesse am Arbeitsplatz verankert und der größtmögliche Gewinn aus der Kompetenz und Kreativität der Wissensarbeiter gezogen werden, um organisationale Ziele zu erreichen.

Das Prozessmodell zur Wissensreifung (Schmidt, 2005) beschreibt eine Theorie des Ziel-orientierten Lernens in einem kollektiven Kontext. Basierend auf diesem Modell wird das Problem bearbeitet, wie eine Softwarearchitektur gestaltet sein muss, um auf dessen Basis Anwendungen zu entwickeln, die Wissensreifung in bestimmten Szenarien unterstützen. Wie muss also eine Lern- und Wissensreifungsplattform gestaltet sein, um Menschen zu untersützen effektive und kontinuierliche Lernprozesse zu gestalten, um eine Gemeinschaft in kollaborativen und zielgerichteten Wissensentwicklungsprozessen zu unterstützen und die Organisation zu unterstützen, ihre Mitarbeiter zu ermutigen, zu motivieren und zu lenken, um die Arbeitsziele effzient zu erreichen.

Diese Arbeit untersucht das Prozessmodell zur Wissenreifung und analysiert die Verknüpfung zu verschiedenen Theorien individuellen und sozialen Lernens, um das allgemein Verständnis von Wissensreifung in den verschiedenen Phasen des Modells klarer auszuprägen. Weiterhin werden die Ergeb-

nisse von drei verschiedenen empirischen Studien analysiert und konkrete Softwareanforderungen davon abgeleitet. Basierend auf diesen Ergebnissen wurde ein allgemeines Konzept für eine Lern- und Wissensreifungsplattform erarbeitet. Softwareprototypen, die als Instanz des Modells betrachtet werden können, wurden mit Hilfe von nutzerpartizipativer Entwicklung implementiert und in drei verschiedenen Kontexten evaluiert, um zu erfahren in welchem Maße Wissensreifung davon tatsächlich unterstützt werden kann.

Der implementierte Prototyp scheint Lernen und Wissensreifung in den beobachteten Szenarien durchaus zu unterstützen. Die Nutzerrückmeldung zu dem evaluierten Prototypen spiegelt ein Potenzial für die Untersützung von Wissensreifung sehr deutlich wider. Es wurde aber auch sehr deutlich, dass durch die unterschiedlichen kontextabhängigen Arbeitsanforderungen und durch die unterschiedlichen Prioritäten von zu unterstützenden Wissensreifungsaktivitäten, der Softwareprototyp nicht ohne entsprechende Anpassungen in verschiedenen Szenarien genutzt werden kann.

Basierend auf den theoretischen und empirischen Erkenntnissen, sowie den Evaluationsergebnissen, kann geschlossen werden, dass das vorgestellte Softwarekonzept durchaus angewendet werden kann, um eine Lern- und Wissensreifungsplattform zu entwickeln. Allerdings hängt die konkrete Ausprägung stark vom Anwendungskontext ab und sie sollte mit einem Fokus auf die kontextuell wichtigsten Wissensreifungsaktivitäten entwickelt werden. Darüber hinaus muss die Anwendung aber flexibel genug sein, um in die individuellen Arbeitsprozesse integriert werden zu können.

Contents

List of Tables

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List of Acronyms

AJAX Asynchronous JavaScript and XML

API Application Programming Interface

APOSDLE Advanced Process-Oriented Self-Directed Learning Environment

AT Activity Theory

BO Boundary Object

CAD Computer-aided Design

CD Cognitive Dissonance

CI Corporate Identity

CK Connexions Kent

CLT Cognitive Load Theory

CMS Content Management System

CoP Communities of Practice

CSCW Computer Supported Collaborative Work

DCog Distributed Cognition

DBR design-based research

DoW Description of Work

DS Design Studies

DWR Direct Web Remoting

EC European Commission

ESB Enterprise Service Bus

FAQ Frequently Asked Questions

GUI Graphical User Interface

HCI Human Computer Interaction

HR Human Resource

HTML Hypertext Markup Language

HTTP Hypertext Transfer Protocol

HTTPS Hypertext Transfer Protocol Secure

ISO International Organization for Standardization

IT Information Technology

IWC Inter-Widget Communication

JMS Java Message Service

KIE Knowledge Indicating Event

KM Knowledge Maturing

KMA Knowledge Maturing Activities

KMI Knowledge Maturing Indicators

KPI Key Performance Indicators

LME Learning and Maturing Environment

LMI Labour Market Information

LMS Learning Management System

MKO More Knowledgeable Other

OLME Organisational Learning and Maturing Environment

OGSA Open Grid Service Architecture

P.A. Personal Adviser

PC Personal Computer

PDF Portable Document Format

PLE Personal Learning Environment

PLME Personal Learning and Maturing Environment

REST Representational State Transfer

RFC Request For Comments

ROLE Responsive Open Learning Environments

RSS Really Simple Syndication

SAML Security Assertion Markup Language

SI Symbolic Interactionism

SIMPLE Social Interactive Mashup PLE

SME small and medium-sized enterprise

SNA Social Network Analysis

SOA Service Oriented Architecture

SOAP former: Simple Object Access Protocol; not an acronym anymore since SOAP version 1.2, 2003

SOBOLEO Social Bookmarking and Lightweight Engineering of Ontologies

SSO Single Sign-On

SUS System Usability Scale

TEBO Technology Enhanced Boundary Object

TEL Technology Enhanced Learning

TM Transactive Memories

UCD User Centered Design

UDDI Universal Description, Discovery and Integration

UI user interface

URI Uniform Resource Identifier

URL Uniform Resource Locator

VLE Virtual Learning Environment

WS Web Service

WP1 Work package 1

WP2 Work package 2

WP3 Work package 3

WP4 Work package 4

WP5 Work package 5

WP6 Work package 6

WSDL Web Services Description Language

XML Extensible Markup Language

XMPP Extensible Messaging and Presence Protocol

ZPD Zone of Proximal Development

Chapter 1

Introduction

1.1 Motivation and Problem Description

Individual (and informal) learning and work is often not sufficiently interconnected, although employees need to continuously develop their competency in their work context and organisations have to adapt to market developments by making use of their employees' creativity and competency to act (Maier & Schmidt, 2007; Ellinger, 2005; Lohman, 2000; Brown & Duguid, 1991). Isolated traditional approaches to learning fail to address the increasing agile business demands, mainly characterised by needs for rapid learning, innovation and a short time-to-market (Dove, 1999; Attwell, 2007b; Schmidt, 2005). Apart from the neglected interconnection between individual learning processes and organisational agility, organisational knowledge sharing between employees is still facing barriers (Lee & Ahn, 2007; Rosen, Furst, & Blackburn, 2007). This includes missing individual willingness and organisational processes, a potential loss of power, a lack of trust among people and also missing awareness with whom and for what purpose knowledge needs to be shared (Rosen et al., 2007). The disconnection of peers in a community who share common objectives, leads to a loss of potential innovation (Camelo-Ordaz, García-Cruz, Sousa-Ginel, & Valle-Cabrera, 2011). Moreover, there is typically missing support for transferring immature knowledge into viable organisational outcome. Rarely, organisations have concepts of how to support the transformation of ideas of employees or externals into a valuable part of a product, which can be an artefact, internal process improvements or externally sold process knowledge (Nonaka, 1994; Nonaka &

Krogh, 2009; Gangi & Wasko, 2009). All this is especially relevant to small and medium-sized enterprises (SMEs) as they probably build the most relevant economic instances in terms of innovation, amount of employed persons and apprenticeship (European Commission, 2005).

For several years now the emergence of a much discussed concept can be observed in the Technology Enhanced Learning (TEL)-community, called *Personal Learning Environment (PLE)*. The notion of PLE can be traced back at least to (1997), though it refers to an on-site setting. Ogata and Yano (1998) first referred to a software environment. However, these approaches were referring to possibilities of adapting the user interface according to individual preferences. At least in the European research community for Technology Enhanced Learning (TEL), the notion of PLE was recognised first in 2004 in a Personal Learning Environment-session at the JISC/CETIS Conference. Subsequently, Scott Wilson published a presentation and well known figure describing his vision of a future Virtual Learning Environment (VLE)[1][2]. Wilson and more specifically Downes (2005) are reflecting about the needs and missing

- support for individuals in situated and work-integrated learning
- focus on individual characteristics of learners
- adaptability of the software according to individual learning processes, contextual interests and work routines.

The discussion emerged from the perceived weaknesses of Virtual Learning Environments (VLEs). Downes refers to the growing need for contextualised learning of knowledge workers as they are confronted more and more with interdisciplinary topics (2005). The organisations' agility has to be improved in order to stay innovative, reduce products' time-to-market and improve customer services (Schmidt, 2005). VLEs were considered too static in representing the approach to digitally copying on-site courses without relations to the context of current tasks (Wilson et al., 2007; Harmelen, 2006). The spirit of easy digital collaboration, (social) networking and knowledge dissemination which emerged with the Web 2.0 movement was harnessed for individual learners in order to overcome these weaknesses of VLEs.

[1] http://zope.cetis.ac.uk/members/scott/blogview?entry=20050125170206, 11.01.2012
[2] http://www.flickr.com/photos/vanishing/sets/370240/, 11.01.2012

The Web 2.0 is often subscribed with buzz words like *Pro-sumer*, *Interaction*, *Collaboration* and more. Although the principle technique behind it is not really new[3], something actually has changed in the heads of internet users in a way that motivates them in contributing to community-oriented knowledge bases through engaging in digitally represented social networks. People started to write weblogs, reflecting and reporting about their own individual experiences or about topics that are interesting to them and thereby connect to other people. It is something like a digital *speakers corner*, which connects them to other interested persons, which in turns provides anchor points for situated and informal learning. They also explicitly connect to other people on social networking platforms like Facebook[4] (rather private) or Linkedin[5] (rather business-oriented). It has become easier to raise awareness for certain topics and to connect to people with similar interests and passions in order to learn about topics, solve particular problems or discuss specific issues. Thus, learning on a social layer e.g. in CoP is addressed. Starting with the idea that everyone can contribute, Wikipedia has emerged to one of the biggest common knowledge bases with a large number of participants. Many people got used to contribute to open accessible knowledge and even more are used to access and retrieve it[6], relying on the community's self-organisation and the common goal of creating a trustworthy and entire encyclopedia. This spirit is aimed to be brought into the specific cultures and framing conditions of organisations with the notion of *Enterprise 2.0*.

The term *Enterprise 2.0* is even more vague and undefined than *Web 2.0* but according to Mcafee (2006) it mainly stands for the implementation of social media in organisations in order to increase

- the motivation to use intra-organisational software for knowledge exchange
- collaboration between employees

[3]The basic technical approach is XMLHttpRequest, an Application Programming Interface (API) for dynamically loading data from a webserver without a page reload. It was developed by Microsoft and first implemented in the Internet Explorer, 1999. Nowadays a W3C standardisation draft exists: http://www.w3.org/TR/XMLHttpRequest/, 06.04.2012

[4]http://www.facebook.com, 11.01.2012

[5]http://www.linkedin.com, 11.01.2012

[6]According to Wikipedia, out of more than 16 million named accounts, ca. 300,000 editors edit Wikipedia every month, and of those, ca. 50,000 more than five times a month, http://en.wikipedia.org/wiki/Wikipedia:Wikipedians

- agility and efficiency of processes
- intra-organisational communication
- the communication between organisations and their customers.

Drivers of the Enterprise 2.0 idea are claiming that classical top-down approaches to knowledge management have largely failed (Mature Consortium, 2007). These approaches were rather technically driven and the requirements for the software used in organisations were mostly defined by the management. The gap to end-users was too large, they actually have not used it (Cook, 2008).

Thus, the organisational level needs to be addressed. Knowledge workers need to be supported in a bottom-up manner of knowledge creation, as individuals but also connected to their communities. Organisations need to be supported in guiding their employees in working- and learning activities that aim for achieving the companies' goals. It needs a holistic approach when it comes to supporting knowledge creation in organisations.

It needs more than software which is only focussing on the user but which rather provides awareness for the organisational context including objectives, partners and processes. Individuals need to be supported differently in particular contexts than communities. Organisations need to lower barriers of collaborative knowledge creation, need to provide space for fostering motivation and an overall situation of trustworthiness. It is the individual, the community and the overall organisation, all parties with their specific roles, sub-goals and characteristics who need to get involved in a collective goal-oriented development of knowledge, in short: *knowledge maturing* (Maier & Schmidt, 2007; Mature Consortium, 2009a).

It is more than an isolated PLE or VLE that is needed to tackle these issues. A rather holistic approach to a Learning and Maturing Environment (LME) has to be designed. An LME is supposed to support individual learning within the constraints of organisational goals. These individual learning processes should be embedded into communities in order to foster communication and social interaction. Furthermore, an LME should allow situated learning in the context of organisational resources or processes. Thus it fosters knowledge workers' ability to react on organisational demands. Organisations might also have an anchor point with the LME to guide their employees to improve goal-oriented learning. The software might provide the users with particular contents, certain experts or formal training courses. It supports bottom-up knowledge creation and workplace learning with a focus on organisations' business goals.

1.2 Objectives

Based on the considerations described above, this work tackles three objectives:

1. **What is knowledge maturing and how do related theories of social learning contribute to our understanding of knowledge maturing processes?** This work analyses different well established theories of individual and social learning. It will be examined, if and to which degree a guideline can be provided that helps to implement organisational processes and software tools in order to support knowledge maturing activities.

2. **How does the design of a technical framework which supports knowledge maturing look like?** It will be examined how knowledge workers have to be supported in organisational processes and in the process of establishing social networks, in creating and sharing resources, in collaboration with colleagues or in the retrieval of contextually relevant knowledge. Based on insights from theoretic and empirical analyses and a literature review, a concept for an LME will be described.

3. **What can we say about the applicability of an instantiated LME in real world settings?** By means of empirical evaluation activities, it will be examined what we can learn about the LME concept in real world settings. This includes a critical reflection about motivational and organisational barriers and the overall process of user centered design.

1.3 Methodology

Computer science is a highly interdisciplinary research field, which is not build on a coherent theory. It rather lends from other fields of science as mathematics, psychology or sociology. Especially in the course of software and interface design, prospective guidelines for designing a software product are missing. The problem is that the findings of other theories can not be easily used to build a software system. Firstly, the research fields are doing research for their own area and thus findings are hardly transferrable to computer science. Secondly, guidelines which were developed by means of other theories are of retrospective nature and can not consider the specific context of the software implementation. Moreover, a software design process underlies continuously changing requirements. It iteratively changes user expectations, which in turn changes, adapts, or concretises the software requirements. Hence, the methodology applied in this thesis is following a hypothesis-guided design approach (Keil-Slawik, 2001). Based on theoretic consideration, gained from different research areas as sociology or psychology, a model is developed which addresses the basic problem. This model should allow to derive hypotheses for the concrete system design. Based on these hypotheses the concrete software is developed, i.e. design decisions are made in the context of the problem area. Afterwards, the software is evaluated, i.e. it is observed whether the hypotheses could be applied successfully. This is typically a problem as especially the isolation of variables is hardly realised in such complex settings (Keil-Slawik, 2001). However, the evaluation can lead to two principle results: Firstly, some of the hypotheses might turn out to be verified and can then be seen as generally applicable characteristics. Secondly, the results lead to a necessary change either of the model, the hypotheses or of the software (design decision were wrong).

This is exactly the approach followed in the MATURE project and in this thesis. The different aspects of the hypothesis-guided design approach are implemented in this thesis as depicted in figure 1.1. Based on a discussion of the underlying Knowledge Maturing Model and its positioning to other theories of learning and knowledge creation, abstract requirements are derived. These implicitly provide the first set of hypotheses for a system design. In addition, empirically gained insights by means of different studies refine and extend the abstract requirements. Concrete services are identified there, which might support knowledge maturing and learning. Both strands influence the architecture design. Moreover, in ongoing and participative iterations, the software was tested with end users, which led to further improvements in the software design and hence the concrete system instantiation. The project's concluding summative evaluation allowed some

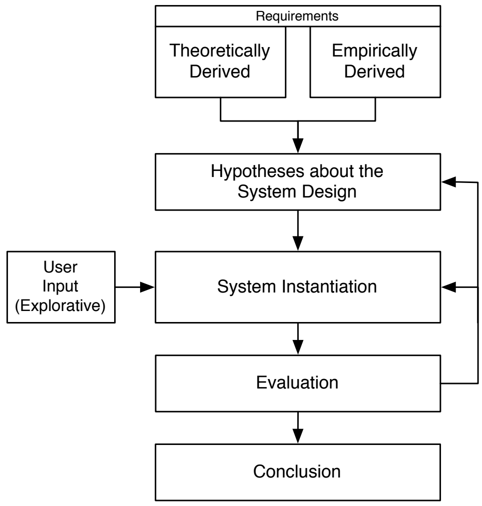

Figure 1.1: *The research methodology is following a hypothesis-guided design approach.*

statements about the model, the hypotheses and general design characteristics. However, it will become obvious that such conclusions from evaluation activities have to be considered cautiously. We will see that it is hardly possible to implement one LME instantiation without significant changes in different contexts. This is due to the fact that people have different prior knowledge about certain software approaches and that organisational processes and working tasks are typically very different in different scenarios. Thus, we can scaffold our knowledge about possible knowledge maturing support of different LME instantiations but have to address particular contextual aspects for each new implementation scenario.

1.4 Contributions

This work came into being in relation with the MATURE project. To a certain degree, theoretic concepts, and also technical approaches, which are described in this work, were developed and instantiated in the course of the project. This section clarifies the relation between the project activities, this thesis makes use of and the author's personal contributions, which eventually justify this thesis. Thus, first it will be described, which goals the project defined, how these were tackled in the different work packages, and how the author was involved in it. Afterwards, the unique steps of this thesis will be delimited to these project tasks.

1.4.1 MATURE Overview

According to the official *Description of Work*, the main objectives of the MATURE project are (Mature Consortium, 2007):

1. An analysis of real-world maturing practices, and a general conceptual model of the knowledge maturing process and specializations for the different types of knowledge assets (content, process, semantics), its current state-of-practice, how it should take place and how to overcome barriers (particularly motivational and social barriers)

2. The development of a Personal Learning and Maturing Environment (PLME), embedded into the working environment, enabling and encouraging the individual to engage in maturing activities (comprising content, process and semantic aspects) within communities and beyond

3. The development of an Organisational Learning and Maturing Environment (OLME), enabling to analyze and to take up community activities (comprising content, process, and semantic aspects), to reseed innovation processes and to apply guiding strategies

4. The development of reusable Maturing Services for seeding and reseeding, creating awareness of maturing-relevant individual and community activities, helping in combination and consensus building (comprising content, process, and semantic aspects)

The MATURE project contained six main work packages for research and development with the following responsibilities:

1. **Work package 1 (WP1)** was responsible for the theoretic analysis and state of the art of Knowledge Maturing (KM), the implementation of the three empirical studies, and the development of the knowledge maturing landscape, as well as refinements and suggestions regarding the KM model.

2. **Work package 2 (WP2)** was responsible for the design and development of the Personal Learning and Maturing Environment.

3. **Work package 3 (WP3)** was responsible for the design and development of the Organisational Learning and Maturing Environment[7].

4. **Work package 4 (WP4)** was responsible for the design and development of Maturing Services.

5. **Work package 5 (WP5)** was responsible for the design and development of the backend architecture.

6. **Work package 6 (WP6)** was responsible for the design and implementation of the requirements analysis, as well as the formative and the summative evaluation.

The author of this thesis is assistant researcher of the working group *Computer Science Education* at University of Paderborn. This working group was formally leading Work package 2 (WP2), thus the author was co-responsible for the design and development of the PLME. Moreover, the author's involvement in project activities were significantly beyond solely WP2 tasks. Figure 1.2 shows briefly and simplified the activities of different work packages in the different years.

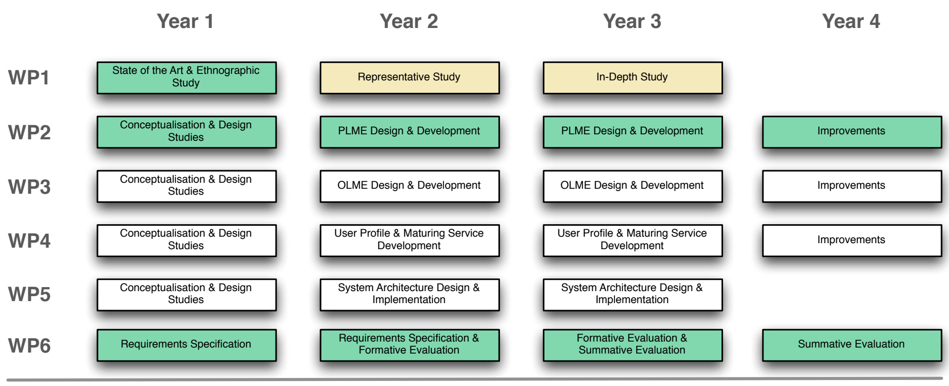

Figure 1.2: *The author of this thesis was actively involved in and partly operatively leading the Work package 2 activities marked green and due to working group activities also associated to those marked in yellow.*

The author was actively involved in those activities which are marked green. They comprise:

[7] A discussion regarding the differentiation between PLME and OLME can be found in section 4.4.2

- **Theory shaping:** Differentiation of KM model and introduction of the three different knowledge instantiations *cognifacts*, *sociofacts* and *artifacts*, which became a major part of the Knowledge Maturing model.

- **Ethnographic Study:** An ethnographically-informed study, during which ethnographers visited an organisation for a period of two weeks in order to document knowledge maturing activities and processes (cf. 3.1).

- **WP2 - Design Study:** Experimental technological developments in year 1 aiming at giving researchers the possibility to develop an idea of the design of an LME.

- **Design and Development of a PLME:** Actual design, prototypical development and implementation at application partners. This comprised regular design meetings as part of the User Centered Design (UCD) process, actual software development, and enrollment and training of application partners.

- **Integration Activities:** Initiative formally led by WP5 with the objective to integrate different MATURE-related software components, including the overall connection to an appropriate backend architecture.

- **Requirements Analysis Process:** Processes led by WP6 including especially the design and description of expert-defined software use cases relevant for an LME implementation.

- **Formative and summative Evaluation:** The formative evaluation enclosed a software rollout of one instantiation and initial findings that were adopted in the software design. The summative evaluation comprised the software deployment at two different application partners.

Apart from these activities, the CSE working group was also involved in the *Representative Study* (cf. 3.3) and the *In-depth study* (cf. 3.4) associated to WP1. Hence, due to the common project work and regular communication a good understanding of the author about these studies and the related theoretical work persists.

1.4.2 Delimitation to this Work

The delimitation or better the add-on to the MATURE work is described subsequently:

- **Positioning of the Knowledge Maturing Phase Model**: Although the Knowledge Maturing model landscape was refined and extended in the course of the project, a thorough and in-depth analysis about the relation of the KM model to other established theories of learning was missing. In (Mature Consortium, 2009a) the relation to Communities of Practice (CoP) was depicted. However, such an activity was never enlarged. Thus, it was caught up in this thesis.

- **Derivation of requirements from results of empirical studies**: Due to the parallel activities of the rather empirically working WP1 to the rather technically working WP2 (and actually also WP3), it was hard to take up the empirical findings in the technical development process. Thus, neither the persona analysis, nor the Knowledge Maturing Activities (KMA) definition, nor the Knowledge Maturing Indicators (KMI) definition was explicitly used during the design process. However, the latter was at least partly implemented and tested in the prototypical instantiation. Hence, this thesis directly uses the empirical results in order to shape the system design.

- **Description and discussion of conceptual system architecture**: Different approaches to a system design were discussed during the project but there was never a concrete analysis with respect to theoretical and application partner needs. A lot of discussions were led for particular problems like a unified data model or a Single Sign-On (SSO) concept. However, there was no description and rationale of a conceptually idealised architecture which is able to satisfy the contextual needs. It was probably also a weakness in the project that the different development teams have worked to much side by side regarding this issue. However, this issue was tackled again in this thesis.

- **Additional case study for investigating the prototype in an additional scenario**: Apart from the project's evaluation activities, the deployment of a prototype could be observed in an additional third scenario. This completely different scenario took place in an university seminar and is also presented.

1.4.3 Overview of Concepts and their Relationship

Figure 1.3 presents a landscape of concepts, which are relevant for the understanding of Knowledge Maturing and for the design of a Learning and Maturing Environment. Hence, these concepts are relevant for the design and rationale of the LME and are of major importance for this thesis. The figure mainly depicts the relationship between these concepts on a high level of abstraction. Those elements, which are colored dark orange, are activities not theoretical concepts. They were the origin for many theoretical and practical insights and developments. The figure shows six clusters. The up-

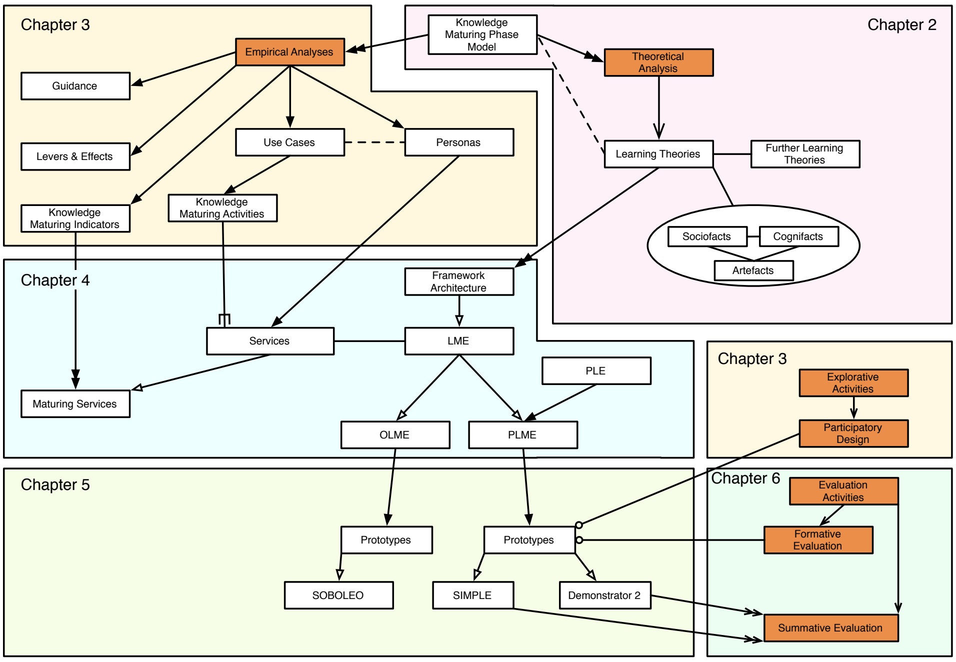

Figure 1.3: A landscape of concepts relevant for Knowledge Maturing and the Design of an LME.

per left depicts the outcomes of the empirical analyses. These analyses are important for the development of the related concepts. The arrows which leave this activity represent the fact that the destinations were developed based on the outcomes of the analyses. Furthermore, a weak relation exists between Use Cases and Personas. The outgoing line from Knowledge

Maturing Activities indicates a clustering of the services by means of the activities.

In the upper right cluster, the relationship between theoretical considerations is depicted. The Knowledge Maturing Phase Model is the main theoretic starting point for the examination of Knowledge Maturing. This phase model influences the particular implementation of the empirical analyses and the theoretical analysis. As part of the theoretical investigation, different learning theories are considered and examined in relation to the phase model.

The results of the theoretical and empirical analyses will mainly influences the definition and development of the Learning and Maturing Environment architecture, depicted in the middle blue box. The Knowledge Maturing Indicators are used in the Maturing Services which are inherited from all services. This set of all services is developed in the empirical part of the work and mainly based on the Personas and clustered by the Knowledge Maturing Activities (KMA). The general framework is furthermore influenced by theoretical considerations.

Based on the LME definition, prototypes were developed (bottom left box). This development was embedded in participatory design activities (middle right box) and formative evaluation activities (bottom-right cluster). Finally, these prototypes were investigated in summative evaluations in order to gain insights to which degree the prototypes may support knowledge maturing.

1.5 Structure of the Thesis

Subsequently to this instruction, chapter 2 introduces first the Knowledge Maturing Model, which is the fundamental theoretical model this thesis is based on. Afterwards, a literature study is presented, which relates known theories of individual and social learning to the Knowledge Maturing Phase Model. It shows how different aspects of learning in the phases can be explained. Additionally, first abstract requirements for an LME will be derived from this analysis.

Chapter 3 presents the results of three different empirical studies that were conducted as part of the project and revealed a lot about current knowledge maturing practices. These results were used to derive concrete requirements in terms of a service landscape. Furthermore, it will be examined the role and relevance of Knowledge Maturing Activities and Knowledge Maturing Indicators for the support of Knowledge Maturing processes.

Based on these findings, in chapter 4 the requirements to and design of a system architecture is discussed on which base a Learning and Maturing Environment can be implemented. The system design is followed by the according instantiation description in chapter 5.

Chapter 6 describes three case studies in which the software was deployed to different user groups in different contexts, before chapter 7 presents and discusses related work.

The thesis closes in chapter 8 with a concise summary of the essential outcomes and discusses the conclusions and implications for future work.

Chapter 2

Theoretical Findings and State of the Art

2.1 Objective

This chapter provides the theoretical introduction of this thesis. The basic theoretical model is the knowledge maturing phase model, initially presented by Schmidt (2005). In short, the main idea of this model is to describe the transition from bottom-up individual learning initiatives over collaborative social learning to organisational learning as a kind of a not necessarily linear evolutionary process yielding an overall improved individual and organisational performance. Around this model, the idea of the MATURE project was developed. From this EC co-funded project a lot of input was gathered, this work directly or indirectly uses, albeit from a very particular perspective. After introducing the general knowledge maturing model and the MATURE project, particular theories of individual, social and organisational learning are discussed and their relationship to the knowledge maturing model presented. Based on these theoretic concepts, anchor points can be identified, which help to derive requirements for a software that supports knowledge maturing. A conclusion summarises the findings and leads over to the next chapter.

2.2 Knowledge Maturing

2.2.1 Knowledge

This section aims at providing a working definition for "knowledge" in order to develop an understanding of knowledge maturing. Knowledge itself is hardly well defined. The challenge is to separate knowledge from information by simultaneously staying concrete (Roehl, 1999) and also keeping a distinction to the understanding of *intelligence*. Many approaches to a definition of knowledge exist. Depending on the context and background of the author, some tend to be more generic, some more specific, for example regarding an economic value of gained knowledge. In order to come to an approximation and finally to a working definition, some aspects of knowledge shall be shortly introduced.

Polanyi introduced the dichotomy of a tacit dimension of knowledge and an explicit one in literature (Polanyi, 1958, 1966). He investigated the well known phenomenon of being able to perform an action but not being able to explain this action. Polanyi distinguished between explicit knowledge and referred to it by the german word "Können" (being able to do something) and tacit knowledge by referring to "Wissen" (knowing) (Polanyi, 1985).

Nonaka and Takeuchi performed a series of studies in Japanese organisations in order to explain their success and developed the SECI model, which became a driver in the research on organisational knowledge management (Nonaka & Takeuchi, 1995) (cf. 2.4.7). A key assumption of this model is that employees have to make their tacit knowledge explicitly available to the organisation. The authors referred to Polanyi but used the construct of tacit knowledge differently (M. Li & Gao, 2003). Nonaka and Takeuchi introduced another dimension of non-explicit knowledge, *implicit knowledge*. Implicit knowledge includes the fact that people are sometimes able to express knowledge but are not willing to do this. Thus, according to M. Li and Gao (2003), explicit and tacit knowledge (according to Polanyi) span two pols of codifiability of knowledge where implicit knowledge lies between both and the *explicit*-pol represents higher codifiability as shown in figure 2.1. **Meyer and Sugiyama** continued the discussion of viability of knowledge as a key aspect (Meyer & Sugiyama, 2007). They state, knowledge needs to be viable in order to distinguish it from fallacy. Moreover, knowledge is reflected in any actions or operations of actors. Meyer and Sugiyama defined

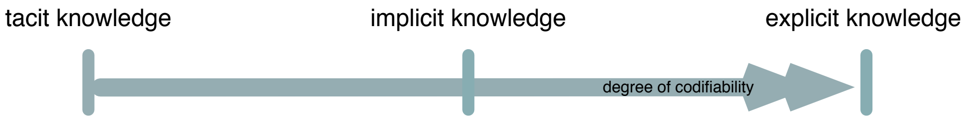

Figure 2.1: *Codifiability of different knowledge dimensions. Own figure, adapted from (Meyer & Sugiyama, 2007)*

knowledge as follows: "Knowledge is defined as a set of structural connectivity patterns. Its contents have proven to be viable for the achievement of goals." (Meyer & Sugiyama, 2007) Following Güldenberg (1999), *structural connectivity patterns* reflect the inclusion of different forms of collectivity of knowledge, which might be individual or forms e.g. organisational knowledge. Moreover, they argue that this formulation reflects the constructivist viewpoint of a non-existing reality.

However, Meyer also discussed the distinction between explicit and non-explicit knowledge, which should be included in the definition as well[1]. Thus, the working definition of knowledge for this thesis is:

> "Knowledge is defined as a set of structural connectivity patterns. Its contents with varying codifiability have proven to be viable for the achievements of goals."

Although the diffuseness of knowledge is considered in this definition, it is rather pragmatically motivated and anchored in natural science, regarding knowledge as something object-like. Thus, it is rather something rationalised that can be derived from data and information, which is different from the philosophical approach (going back to Platon), always including a certain degree of subjective conviction regarding facts.

The following sections will show the appropriateness and feasibility of the definition given above with respect to the given thesis context and goal. The next section introduces the concept Knowledge Maturing.

2.2.2 Knowledge Maturing

Today, humans are required to engage and participate in learning over lifetime (Fischer, 2000; Attwell, 2007a). After the industrial revolution had its zenith, a class of workers has raised, Drucker called *Knowledge Worker*

[1] Actually, Meyer included this in a white paper, which was not published, cf. (Meyer, 2005).

(1959). As part of an economic process towards a more efficient and customer-oriented production, the needed knowledge became broader and its application more and more interdisciplinary. Moreover, the new knowledge worker generation had to deal with fast changing technologies and shorter product life-cycles (Attwell, 2007b). The demand for continuous learning within and beyond the domain of the workers' formal education raised steadily. With the implementation of computers and later the fast developing internet techniques, an information overload emerged, knowledge worker hardly learn to deal with during their formal education (Delen & Al-Hawamdeh, 2009; Pauleen, 2009; Jefferson, 2006). Lifelong learning requires a shift from an exclusive formal education to work-integrated learning (Fischer, 2000). It is characterised by the following points:

- Context dependent learning: Knowledge workers need to learn within the context of their work. They hardly benefit from ill-defined formal courses, which do not relate to their work tasks. The solutions are required on demand. This facilitates the incorporation of new knowledge with known things. The worker can draw on her/his experience in combination with an explorative way of learning.

- Learning on demand: Problems occur while working on tasks. Hence, demands for learning occur spontaneously. Knowledge workers need context-specific information and are required to be able to find a proper solution in time.

- Self-reflection: After experiencing a breakdown in some activity, people need to reflect about missing knowledge or wrong assumptions regarding expected outcomes. Schön (1983) calls that reflection-in-action. Knowledge workers should be supported in identifying such breakdowns and should be provided with context-relevant information for reflection.

- Reciprocal learning within a community: Knowledge workers need to engage in joint activities of informal learning in order to achieve an explorative or reciprocal way of learning in communities (Fischer, 1999). Colleagues can be contact persons for communication or task specific experts.

- Knowledge is constructed: In collaborative work activities, different stakeholders may work on the same task. The participants are aware that everyone posses relevant knowledge but none of them possesses all necessary knowledge. Rittel (1984) refers to that as an "asymmetry of knowledge". Furthermore, the stakeholders may belong to different work cultures, with different norms, representations or speech (Fischer, 1999). In such situations, knowledge is jointly constructed not transferred or delivered.

Context dependent learning and on demand learning is a big challenge for knowledge workers. The demand on learning can not be coped only by means of traditional learning systems, e.g. (regular) face-to-face trainings or learning management systems, although they may be based on profound pedagogic concepts (Schmidt, 2005; Attwell, 2007b). These systems are typically not flexible enough and do not provide contents and materials workers actually need on demand. Furthermore, a classical knowledge management approach is tackling mainly the delivery of materials and does not cope individual needs and approaches to learn. Thus, there is a gap of continuity and holism of knowledge development. Schmidt (2005) proposed the knowledge maturing phase model, presented in figure 2.2. It represents phases of increasing levels of knowledge maturity, starting from scratch and yielding well-formed standardised organisational documents.

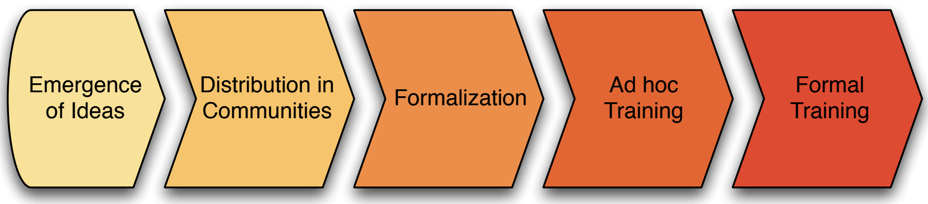

Figure 2.2: *The initial Knowledge Maturing Phase Model. Adapted from (Schmidt, 2005)*

- **Emergence of ideas:** In this phase, ideas are generated very informally through discussions or other factors. The ideas are not even necessarily generated within a concrete work context but also externally. Discussion partners have (almost) no common and shared terminology, they agreed on before.

- **Community formation:** In this phase a common and shared terminology is (collaboratively) developed. The relevant knowledge is specifically related to the work context and published on (internal) communication platforms. People are starting to work together on different artefacts around the related topic, e.g. wiki pages or documents.

- **Formalization:** Within the formalization phase, knowledge around certain topics is transformed from unstructured media into more formalised artefacts. Due to a clear need of the related knowledge, this is done for a specific purpose (e.g. internal presentation) but without any pedagogical considerations.

- **Ad hoc training:** In this phase, pedagogically sound artefacts are being created. These can be disseminated as learning material. However, learner need to be well grounded in the topic related to the artefacts.

- **Formal Training:** Individual learning objects are aggregated to a set of learning material, probably also a whole training course. This set covers a broader subject area than the single artefacts considered before and can be used to teach novices.

Each phase represents an evolutionary process of knowledge in people's mind, which becomes manifest and observable in artefacts. This can be regarded similar to the *Seeding - Evolutionary Growth - Reseeding* model proposed by Fischer (1996). At the beginning of each phase, an idea or an initial artefact is seeding the phase with certain contextual knowledge (cf. figure 2.3). During the *evolutionary growth*, this knowledge is then used to develop and enhance a particular topic. This is probably resulting in some kind of new or changed artefacts. New information is added and the representation changes. Moreover, the amount and group of people that are coming in touch with it might change or increases. Finally, at some point in time, the work and its results need to be assessed and reseeded. In terms of the maturing model, either a certain maturity has been reached or the phase needs to be passed again or the maturing process even stops. Taking for example the transition from phase 2 - *Distribution in community* to 3 - *Formalization*, the assessment could lead to re-seeding, which itself might mean that the topic is interesting and important for the organisation but more details need to be discussed before changing to a more formal style of

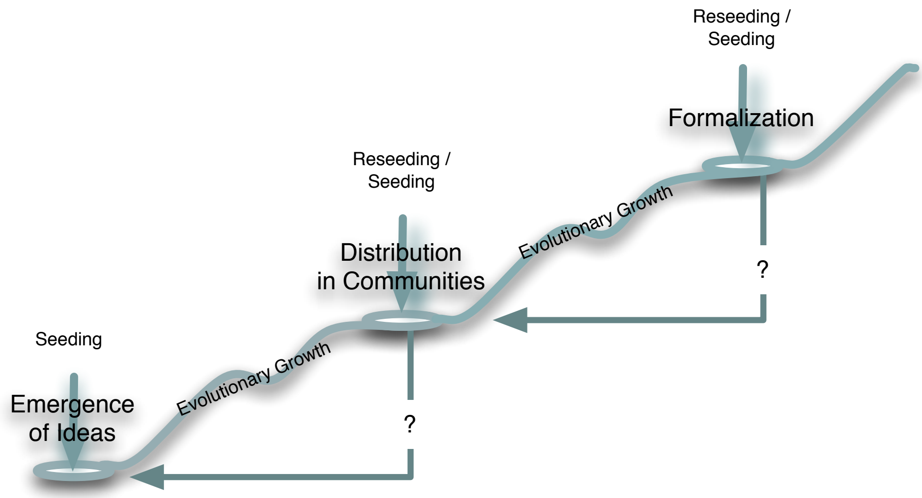

Figure 2.3: *Using Fischer's SER model to explain the steps between Knowledge Maturing phases.*

the artefact and to a more influencing audience. It could even lead to the insight that the topic should be dropped and not further investigated as it has not enough relevance. At best, the next phase is approached, which is initiated with a new seeding phase, by adding new important, phase specific information.

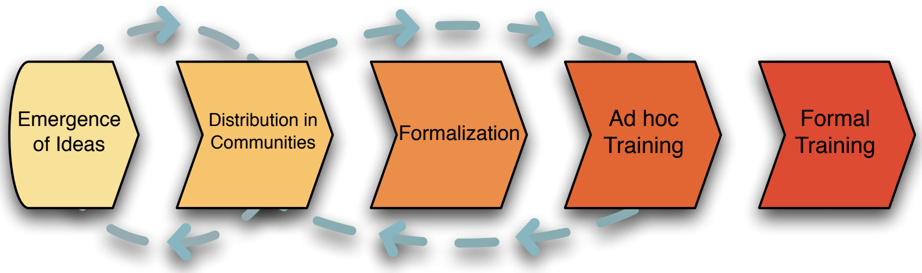

Figure 2.4: *The non-linearity of the Knowledge Maturing phase model.*

Although the previous descriptions might convey the impression that the knowledge maturing process is highly linear, this is not the case. As figure 2.4 shows, phases can be passed twice or more or the overall process can start again or maturing disrupts. In reality, the different strands are interwoven and closely linked, artefacts of different maturity are split into new, others are combined or (partly) even dropped. Knowledge worker might engage in

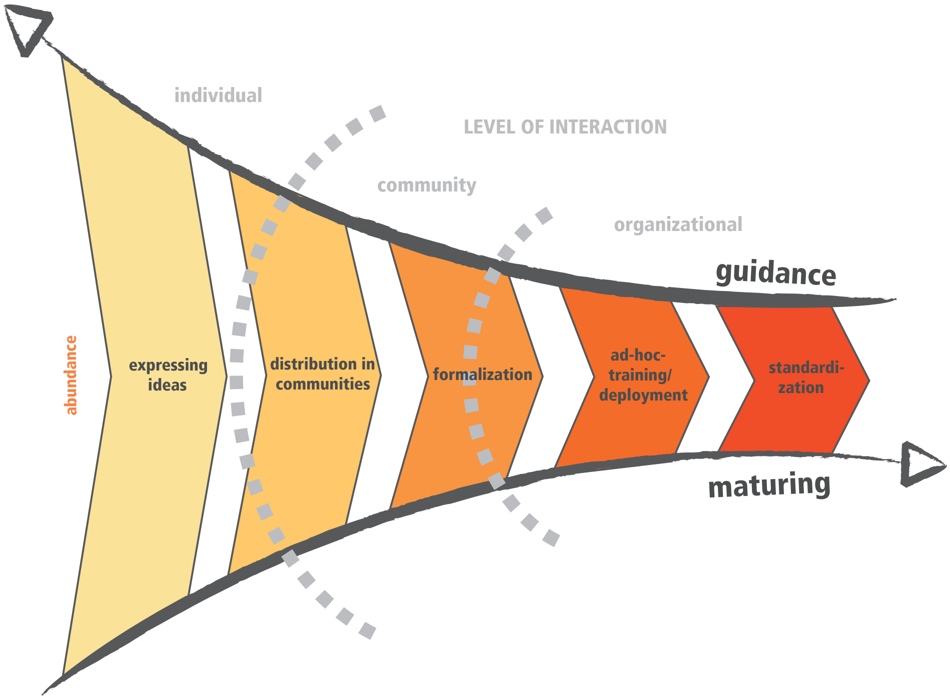

Figure 2.5: The main figure (and logo) of the Mature project describing the most relevant aspects of knowledge maturing including the different phases, their relation to the individual, community and organisation, and the role of guidance activities.

a growth process regarding one artefact and in a reseeding process regarding another (Mature Consortium, 2009a).

Apart from the relevance of the different knowledge maturing phases, figure 2.5 picks up the relevance of the different social entities with different levels of interaction: individual, community and organisation. Moreover the need for organisational guidance along the knowledge maturing process is depicted. At the beginning of a knowledge maturing process, during the emergence of ideas, the individual knowledge worker and her/his ideas are focused. The necessary common terminology for discussions and negotiations is build when distributing ideas into the community. Here also artefacts are shared, collaboratively further developed and discussed. When working on a common objective, the degree of interconnection and communication has to be supported. Here, an economic value is trying to be achieved and therefore, efficient work processes are much more important than in communities of interest. Guidance reflects the need for influence of the organisation on work activities of individuals and communities. It typically decreases when maturity increases as in more formal and standardised settings the need for guiding activities is less than in informal settings in order to achieve a certain organisational goal. This is also reflected in the type and form of knowledge assets used, produced and shared. As indicated in figure 2.5, the abundance is decreasing when knowledge reaches a higher level of maturity. This is quite natural as at the beginning many informal artefacts or externalised discussions emerge. In the higher maturing phases, fewer but more formalised and standardised artefacts exist.

The three social entities and their different levels of interaction (individuals, community, organisation) also reflect different perspectives on learning. Furthermore, the knowledge maturing phase model represents a direction of maturing. Although phases of maturing can be repetitive or even disruptive, knowledge maturing still has a direction towards the final knowledge maturing phase. Hence, knowledge maturing is defined as **goal-oriented learning on a collective level** (Mature Consortium, 2009a). "Goal-oriented" refers to the direction of maturing and includes individual goals (e.g. obtain more knowledge about a particular topic), team or community goals (e.g. working on a common FAQ database) and organisational goals (e.g. refining work processes according to a certain strategy). They may change over time and are refined in social processes. The "collective level" should be understood as communities of different granularity, which can be a team, a department or even an organisation. Knowledge maturing is typically not an individual activity but "an interconnected series of activities of interacting individuals, frequently also within different collectives" (Mature Consortium, 2009a, p.50). However, knowledge is understood to be bound to individuals' mind that is manifested in their behaviour. Hence, the theory of knowledge maturing refers to individual learning processes but also to collective learning processes. Individuals may learn about different topics informally or even by means of a formal (e-learning) course. Furthermore, in social interaction, a common understanding, a common terminology, norms and rules might be constructed and informal or formal processes established. Thus, knowledge maturing is not only about the creation of artefacts. It is also about the individual creation of knowledge and about the social construction of a common (work) culture.

The knowledge maturing model distinguishes between three different kinds of knowledge assets: contents, semantics and processes. Contents represent static results of externalisation activities such as documents, images or videos. Although, these static artefacts play a huge role, processes need to be considered as they are closely related to the actual organisational work producing viable output. Such processes do not necessarily need to be formally modeled like business processes. They can be also more informal and historically grown processes in SMEs. Semantics are important to interlink the different assets. This can happen on different levels of abstraction and is not reduced to links between documents or (on a meta level) the creation of an ontology but refers also to the negotiation of a common terminology and meaning. Figure 2.6 shows the increasing differentiation of and into knowl-

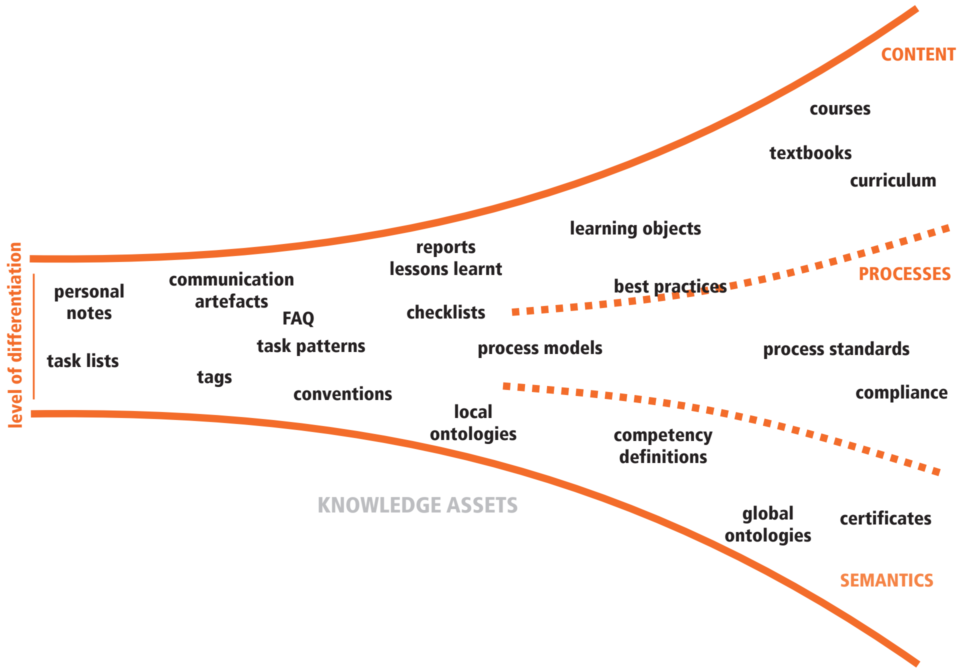

Figure 2.6: *Depicts the increasing differentiation of and into the different knowledge assets with increasing levels of maturity.*

edge assets in increasing phases of maturity and with the changing levels of interaction. In the beginning, more informal and not yet very differentiated assets are developed and shared. When approaching the later phases of maturity, knowledge assets are very structured and organisationally standardised.

These assets are constructed in maturing processes by individuals and by communities in social interaction. As mentioned before, knowledge workers construct knowledge in formal or informal processes. They acquire new knowledge about a certain topic and construct a common understanding. Furthermore, they might also (implicitly) negotiate a common terminology, norms and rules. In sum, the maturing of artefacts, the maturing of community activities and individual learning needs to be supported.

These aspects and underlying theoretical considerations will be further examined in detail in the following sections.

2.3 Knowledge Maturing on Different Dimensions

The last section introduced the notion of knowledge maturing and the knowledge maturing phase model. Especially, the mutual relationship between individual learning processes and social interaction in communities is an important aspect for that concept. Furthermore, it was indicated that artefact maturing may enhance maturing processes.

In order to get a clearer picture of the interrelation between individuals and communities in knowledge maturing processes, we first examined the theory of Symbolic Interactionism (SI). It states that the development of individual consciousness happens in social interaction by means of symbols. Symbols are codified externalisations of knowledge. They might comprise spoken language, gestures or persistent artefacts. Based on this theory, we identified three different dimensions of knowledge, which will be described subsequently: cognifacts, sociofacts and artefacts.

2.3.1 Symbolic Interactionism

The Symbolic Interactionism (SI) provides a core theoretical concept for understanding knowledge maturing processes. It spots on learning on different levels of abstraction by focussing on communication between people. The main idea is that individuals act or work with *things*. *Things* can be real objects or social concepts (like friends, love, etc.). The linkage between *things* and the particular meaning is developed within social interaction, through negotiation, dialogues, etc. Thus, social interaction leads to a creation of meaning by means of a common language, a symbolic medium. Basically, it contributes to explaining

- an ontogenetic development
- a phylogenetic development through social interactions

Individuals learn through exchanging ideas and information with fellow humans in social interaction (ontogenetic development). Furthermore, this social interaction is contributing to the development of the society or parts of it, i.e. communities (phylogenetic development). Thus, a mutual dependency exists between an actor and her/his social context she/he is living and communicating in. According to the SI, communication and social interaction are the basic activities for developing an individual identity and consciousness in society or communities, especially regarding the evolution of rules and norms in it. The (sometime competitive) personal as well as the social identities are mainly relevant for negotiating norms and rules, which represents the phylogenetic development of consciousness of a community or society (Blumer, 1969). These negotiations of meaning take place on different social and contextual levels.

During their socialisation, individuals develop a personality and are integrated into society. As part of society, individuals develop their social identity in social groups or communities. Within this social context, persons are typically strongly influenced by a *significant other*, someone with a highly emotional or power-based linkage to the person that can change and influence attitudes and behaviour. These persons are important for the individual creation of norms and rules, including the ability to reflect about them. These influences shape the personal but also social identities. Especially the social identity might change and maybe adapted often during lifetime, e.g. when changing the job or a department, or when becoming parents.

The SI describes three different forms of a personal identity for individuals. The *I* represents very personal aspects as needs, creativity, wishes or spontaneity. It determines the (spontaneous) reactions to other persons' actions in an interaction. The *Me* represents rather social aspects, especially the awareness of the perception of an individual by others. This includes the awareness about expectations of a generalised other towards that individual, including norms and rules. The *Self* represents the self-reflection of persons and leads to pondering between the *I* and the *Me*, ending in the actual re-action to other people's activities in social interaction. These (personal) decisions might also be against the norm. In order to foster knowledge maturing, it is important to support all three personal identities. People should be provided with awareness of existing social norms and rules and possible consequences of activities and decisions.

During the genesis of identity, people may take three different social roles. *Play* includes imitating a role of a person. A person has two identities then. The one of an (imaginary) other and the own. People learn to take the role of a counterpart, and may learn to predict probable reactions in social interaction. During the *Game*, people take social roles linked to the current action context. This can mean to take several roles at a time, which leads to considering different norms, rules and other expectations. *Universal co-operation and communication* focuses on the perspective of the *generalised other*, who is representing the aggregated expectations, norms and rules of society in a particular situation. These need to be created within the society as part of a co-operative process. They help to get a particular view on a specific context, which can be assessed from a rather general perspective. However, all three roles show the importance of awareness of context in knowledge maturing processes. It is important to know the stakeholders and their intentions, barriers that are results of certain (social) group constellations, power structures and driving or limiting rules in order to support single knowledge maturing phases but also the transition between these phases. Individuals interacting with each other should be aware of the different social roles including their relevance and attitudes with respect to decision making.

As described, the SI spots on the micro-sociological processes of individual knowledge achievement in social interaction, and in turn on its relevance for developing a society's consciousness. However, knowledge is not only achieved during face-2-face communication but also by means of exchanging artefacts (Nelkner, Magenheim, & Reinhardt, 2009). This is another relevant strand of knowledge creation. Due to its replicability and its high degree of dissemination, which can not be achieved by direct communication, it is a basis for sustainable knowledge emergence (Nelkner et al., 2009). Artefacts are persistent and reproducible digital or non-digital outcomes of externalisation activities. This includes for example videos, tools, books, etc., they represent an external memory (Keil-Slawik, 1992). However, by creating artefacts a certain degree of de-contextualisation is accepted and needed. The author usually abstracts from the subject domain, hence she/he de-contextualises the content. This might be of lower degree when describing something experienced (e.g. circumstances of an accident) and of higher degree when summing up something that is already objectified (e.g. quarterly figures of a company). When an author writes an article for example, she/he can not describe each contextual detail. She/he generalises from reality in order to achieve an adequate and concise description or reflection in a more abstract form. Assuming, this article is disseminated and someone else reads it, the reader automatically re-contextualises the content into her/his individual context and domain. As the reader probably does not exactly know the original context, a blur of the precise meaning of the article might go along with the re-contextualisation process. The receiver of the artefact needs to take a certain role in order to interpret and re-contextualise the artefact, thereby potentially creating new knowledge, depending on earlier experience and knowledge (Blumer, 1973). It may lead to new knowledge if people experience a difference between their current knowledge and expectations to what they actually incorporate (cf. 2.4.2).

Figure 2.7 presents an incorporated picture, showing the aspects of the SI extended by the role of artefacts for knowledge creation. Two individuals have their own personal identity. Without a socially interactive context, this is dominated by the *I* and is represented by particular knowledge, needs, wishes, attitudes and preferences. We will later refer to it as **cognifact**. Both take a certain social role, each represents a social identity. Social identities may even overlap. Individuals take different formal or informal roles in specific social contexts or within communities. Depending on the context people are differently influenced by that role, which is partly determining their behaviour or reactions. When they communicate, they take into consideration the perspective of the communication partner (identity of *Me* in the social role *Game*). That is to say, each socially interactive context is influenced by the individuals' knowledge, norms or attitudes and the specific values and expectations according to their particular social roles. Bounded by the influence of the *generalised other*, the personal identity may adapt to different norms or values, new knowledge might be constructed and the consciousness of the community is shaped. This process shall be subsumed by the notion of **sociofact**. Artefacts as an external memory may drive and support the development of the personal identity and the community. Due to the process of reduction and de-contextualisation on the one hand,

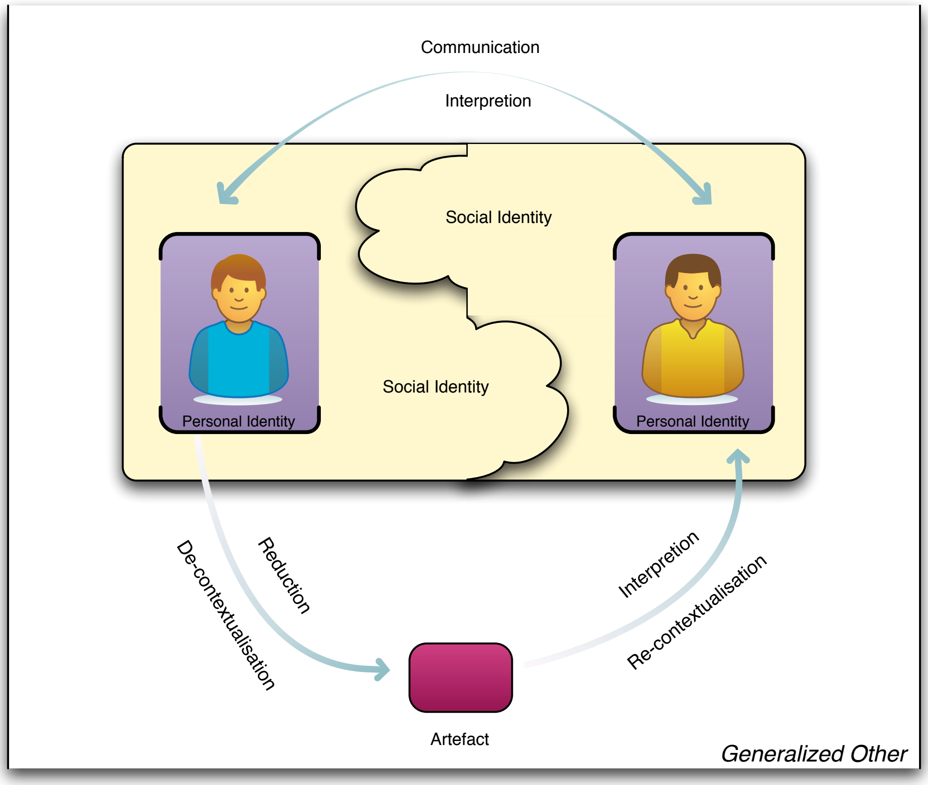

Figure 2.7: *Knowledge achievement explained by means of the Symbolic Interactionism (adapted from (Nelkner, 2009))*

and interpretation and re-contextualisation on the other hand, community building might be initiated and fostered, individuals may learn more intensively and time-indepently and norms and rules can be made persistent and reasonable (e.g. in laws).

The relations shown between personal knowledge achievement, its mutual dependency on the development of society and the important role of artefacts in the emergence of knowledge and its dissemination, led to a conceptualisation of three different dimensions of knowledge. The already existent notion of cognifacts, sociofacts and artefacts was taken and interpreted with respect to the context of knowledge maturing.

2.3.2 Three Knowledge Dimensions

The concepts cognifact, sociofact and artefact can be ascribed to Huxley (1955). He invented the term *mentifact*, which represents ideas in people's mind and the term *sociofact*, an object which is subsuming social interaction and their participants in a community. Engbring used the notion of cognifact, sociofact and artefact in order to describe the genesis of technology (2003). His deliberations go back to Krohn (1992), who described the mutual relationship between artefacts, social conventions and human competences in the genesis of technology. The main statement was that a genesis of technology (artefact) always involves a development or change of social conventions and competences. The genesis of technology not only creates, drops or modifies social conventions but more specifically results in a modified set of laws, norms, rules, and conventions. Thus, Engbring replaced *conventions* by *sociofacts*. *Cognifacts* comprise different individual qualities and competences, including experience, behaviour and attitudes and should be also understood broader than *competences*. Engbring explained the relationship between the three concepts in the context of the genesis of technology by means of the *Technological Triangle* (Engbring, 2003, p. 88).

As described with the theory of the SI, the genesis of cognifacts, sociofacts and artefacts is closely interwoven. Moreover, knowledge maturing focuses on learning in communities with a particular goal. Figure 2.8 shows the relationship between these three knowledge dimensions in the context of knowledge maturing.

Cognifacts are fundamental for the creation of artefacts, which may itself lead to the creation of new cognifacts during the process of re-contextualisation. The relation between sociofacts and artefacts is similar as sociofacts yield the creation of artefacts. By using artefacts, existing sociofacts might be changed or new sociofacts created. When mobiles became popular, for example, sociofacts changed in a way, that new rules had to be created when and where one is allowed to use them. These circumstances led to invent the vibration alert, which suddenly made it possible to be aware of new messages or calls without disturbing others, which reflects a change of sociofacts again by leading to less strict rules. In the context of knowledge maturing, the focus of the three dimensions cognifact, sociofact and artefact is slightly shifted to a micro-sociological perspective of knowledge development. Cognifacts aggregate personal characteristics developed within the personal identity as defined by the SI. Artefacts are, as mentioned before, an *external memory* (Keil-Slawik, 1992), "persistent and reproducible digital or non-digital outcomes of externalisation activities"(cf. 2.3.1). Sociofacts are discussed quite

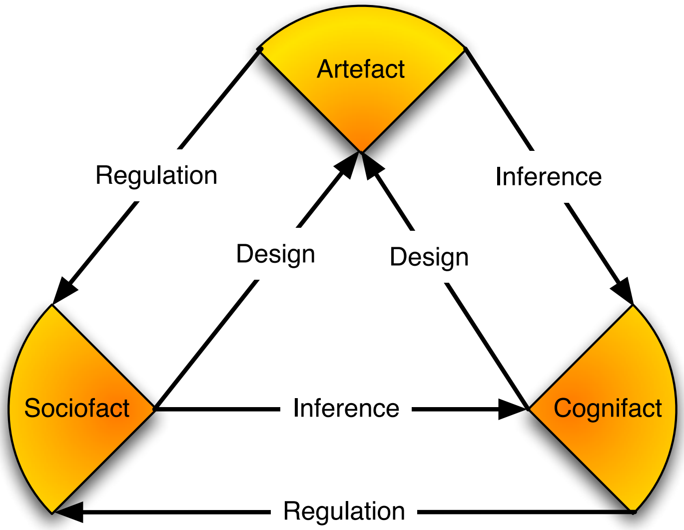

Figure 2.8: *Knowledge dimension relationship: Triangle describing the relationship between Cognifacts, Sociofacts and Artefacts. Adapted from (Nelkner, 2009)*

controversial (Riss, Witschel, Brun, & Thönssen, 2009; Nelkner et al., 2009; Riss, Magenheim, Reinhardt, Nelkner, & Hinkelmann, 2011) and there is no definite opinion about it. It was first introduced as representative for social norms, rules and laws (Nelkner et al., 2009) according and highly related to Engbring's definition. In (Riss et al., 2009) it is described as something that represents collective capacities to act, involving collaborative actions and tasks, and allowing to identify Communities of Practice[2]. This is in line with the SI. It picks up the fact that social collaboration of persons in context of their particular social identity enables the possibility to achieve a common goal within a social group (e.g. organisation). Thus, it makes sense to incorporate social activities as part of sociofacts. We identified a duality in the representation of sociofacts in (Riss et al., 2011). This is the internal representation, comprising the capacity to act and the external representation, the actual activity in a social context. Due to this duality, sociofacts can only made accessible by observing the externalised traces of their existence. This can only be indirectly realised by empirical observations of their participants' individual activities and the contextually produced artefacts.

[2]More on CoP in section 2.4.4

Let us assume a department is working on different projects and its members usually exchange the relevant information via e-mail, for example. Someone might start to codify the project name in the e-mail subject in square brackets, in order to realise the e-mail's topic faster. If this behaviour propagates through the department, such that everyone starts to do that, a sociofact has emerged. Hence, the emergence of sociofacts always goes along with a development of behaviour patterns. In order to identify sociofacts beyond such simple examples, we have identified several characteristics during our investigations.

> "[S]ociofacts [...]
>
> - ... have a group of people as carrier when regarded from an abstract perspective. But zooming in and getting the more specific close-up view leads to the disclosure of different individuals who are interacting within the group as their members and who are the carriers of internal representations of sociofacts.
> - ... have an internal representation in people's mind as a capacity to act in a social context. This demands a social dimension of the intended action.
> - ... have internal representations of mutual expectations, common understanding and shared values of individuals who are members of a group or e.g. an organisation. This concept includes 'unwritten' normative orientations (e.g. you should always meet the expectations of your supervisor) and regulating norms for actions (e.g. don't communicate directly with a person from a higher level in the organisational hierarchy).
> - ... are related to a target group and mostly actions; they are therefore goal-oriented additionally to the social dimension of their intended action.
> - ... are related to topics and include a different degree of shared topics and common understanding of those topics.
> - ... have an external representation, observable as social interaction and as activities of individuals within a group.

- ...imply a double duality: firstly a duality of internal representation of social interaction (capacity to act) and an externally observable manifestation of this interaction (performance of action); secondly a duality between the associated topics and the formal structure of actions.
- ...cannot be generated or extracted but emerge in social interaction and thus can be realised through personal involvement in the sociofact.
- ...actualize themselves in action.

" (Riss et al., 2011, p.58)

This list shows the multiple facets of sociofacts. However, it also shows that it is sometimes hard to differentiate between sociofacts and cognifacts, when considering the *internal representation in people's mind as a capacity to act in a social context.* Although it is important to incorporate this social dimension also in individual dispositions, the personal identity of the *Self* is exactly describing that assessment between the individual needs (I) and the recognition of expectations of others (Me) in a certain social context. This personal identity can also be ascribed to cognifacts, as cognifacts comprise individual attitudes and competences, including social competences. Thus, generally stated, there is a blur between the internal representation of sociofacts and cognifacts. It would be helpful to approach a more differentiated definition of *social interaction* and of the *internal social disposition* and its influence on sociofacts. This might clarify the following questions:

- How to classify actions, which are no sociofacts?
- How to deal with socially trivial (inter-)actions (e.g. repairing a car in time is not a social action but is obviously driven by norms and rules)?
- How to describe different degrees of complexity in sociofacts? What is the difference (in terms of sociofacts) between a short e-mail exchange and a long running organisational process involving several departments?

The relevant aspect is the avoidance of the impression that sociofacts are somehow everything, as far as at least two person are interacting. It should become clearer, to which degree a sociofact changes when characteristics or parameters are changing. Or in other words, if we compare two sociofacts, how can one distinguish between them and how are the following characteristics reflected in the model:

- One sociofact is a workflow task, the second is the process to which the task belongs
- One sociofact has three actors, the second has 200
- The workflow task might be changed in future, the process obviously changes accordingly

This example expresses a dependency between sociofacts and it clearly shows different quantitative dimensions. Hence, the question needs to be clarified, whether the dependency makes sense. Furthermore, it should be answered, whether sociofacts of such different quantitative dimensions exist and if those with different characteristics can be observed accordingly.

An additional initial idea is to describe cognifacts on different levels by ascribing a personal and social representations. An assumption is that also the relationship between the two internal representations can be explained more clearly, depicted in figure 2.9. Sociofacts should be thereby reduced to observable social interactions or probably renamed, maybe to *Socio-Acts*[3]. Furthermore, by introducing a (new) dimension representing the *generalised other*, confusion between social actions, internal cognitive dispositions and framing conditions (as norms or rules) might be avoidable. This might lead to an improved set of levers allowing to recognise and maybe support knowledge achievement and (in long term) also knowledge maturing. However, it still leaves open some questions regarding the difference and mutual dependency between the personal and the social identity, the definition of *social interaction* and the influence of (social) activities on the social identity.

2.3.3 Summary

The SI describes the genesis of knowledge by means of a symbolic medium. Moreover, the ontogenetic and phylogenetic developments are influenced by

[3]It would then probably be necessary to assume that every human activity is of social relevance(including the trivial activities), in order to include also not obviously social interactions.

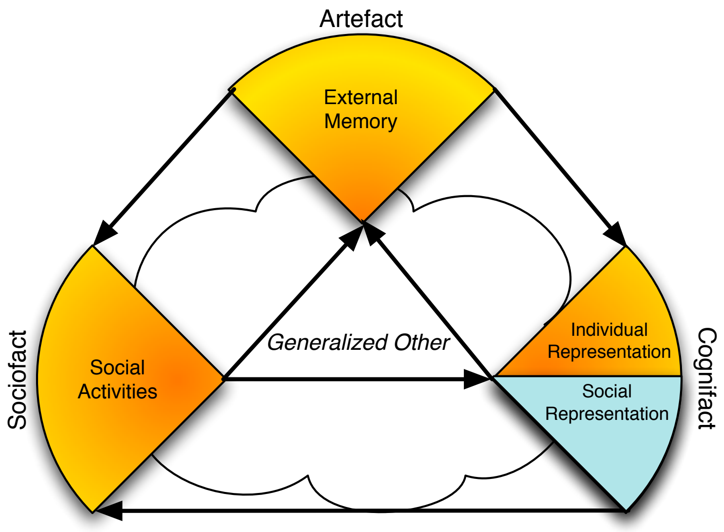

Figure 2.9: *The representation of sociofacts has changed to observable (digital or physical) activities or traces of such activities. The individual is considered with its own personal- and social representation.*

the *generalised other*, an imaginary individual representing aggregated mutual expectations, conveyed in social interaction. This was abstracted into three instantiations of knowledge. Cognifacts represent individuals' characteristics and attitudes. Sociofacts consider individuals in social contexts. Artefacts represent the external memory and persistent results of externalisation processes. These three instantiations of knowledge are orthogonal to the phases of the knowledge maturing phase model. They have to be incorporated when thinking about the support of each phase and the transition between the phases.

This thesis will provide a concept for supporting knowledge maturing on all three dimensions along the phases by means of an LME. There is a different degree of possible technical influences and support, computational complexity and monitoring opportunities, depending on the context. Having the discussion above in mind, it is important to point out that the concrete definition of the three knowledge instantiations are only partly helpful to create an LME. It is important to be aware that an LME can only

- support indirectly by providing awareness, recommendation, structure, process-patterns and so on

- monitor digital traces of individual activities and hardly whole processes
- derive blurred pictures of individual knowledge areas but can not provide users with a deterministic analysis

An LME will not or only hardly be able to mature actively sociofacts, cognifacts or artefacts (at least not the one designed and conceptualised in this thesis). And if it did, then only by chance and the software itself will not "be aware" of the fact.

This section described learning processes in a social context according to the theory of the SI. It presented the influences on the genesis of an individual's identity and the society's consciousness. Based on that concept, knowledge and knowledge maturing was divided into the three different dimensions cognifact, sociofact and artefact and the mutual relation was clarified. The knowledge maturing phase model is not supposed to be a holistic model on learning. Thus, the following section examines different theories on (social) learning and aims at explaining learning processes in the different maturing phases and how the transition between phases might happen. Based on these insights, it is aimed at deriving preliminary abstract requirements for a software that might support knowledge maturing.

2.4 Further Related Theories

In order to consider learning in an individual but also social context, the approach grounded on the Symbolic Interactionism (SI) provides access from different perspectives. It is considering learning processes of individuals by symbolic interaction, it relates conditioning expectations (e.g. norms, rules) to the learning process, and it also points out these individual learning processes by mutual social engagement. The KM phase model treats knowledge maturing from an individual to an organisational level. However, the conceptual approach is not supposed to propose an integrated or holistic theory. It is rather the approach to focus on social and goal-oriented learning. Other theoretic approaches however are more appropriate to explain a very artefact focused organisational learning (e.g. SECI model). Thus, it is worth to have a look at theoretic models which focus on areas of research that are also affected by the knowledge maturing phase model. As the phase model provides us with very abstract approach to learning in social networks, particular related theories might help in two ways:

1. They allow us to gain deeper insights in knowledge maturing in particular phases and in mechanisms for the transition between phases

2. These insights might allow us to derive general but abstract software requirements that might be helpful for supporting particular KM phases by means of an LME

Consequently, the following sections are introduced by a reflection and discussion of the procedure, followed by the examination of related theories and ends with a conclusion.

2.4.1 Preceding Thoughts and Considerations

In section 2.3, it was discussed that knowledge matures on different dimensions, on the artefact-, sociofact- and cognifact dimension. The knowledge maturing phase model itself states that knowledge matures along the five given phases. However, it is inherently different, if people apply knowledge individually, or if they contribute to a discussion with community members or if they create and publish organisationally standardised materials. In all three situations a possible learning process is considered differently, with different influencing factors, motivations, barriers, feedback and consequences. The phase model distinguishes the five phases with respect to contribution from and influence on the three levels of interaction *individual*, *community*, *organisation* (see figure 2.10). Thus, on a macro level the model tries to make statements about processes of individual and organisational learning, and artefact development related to these three entities.

Maier and Schmidt provided an idea of how learning happens in the different phases (2007). They identified the *Medium/Interconnectedness* and *Form of Learning* as properties related to the knowledge maturing phases, see table 2.1. The first is referring to the medium through which knowledge is represented and whether this knowledge is contextualised. The latter describes how learning occurs in the different phases. Here, clearly weaknesses of the model become obvious as learning processes are only represented by individual or social activities, concurrently suggesting that this is manifested almost always in artefacts (apart from the very first notion of expressing

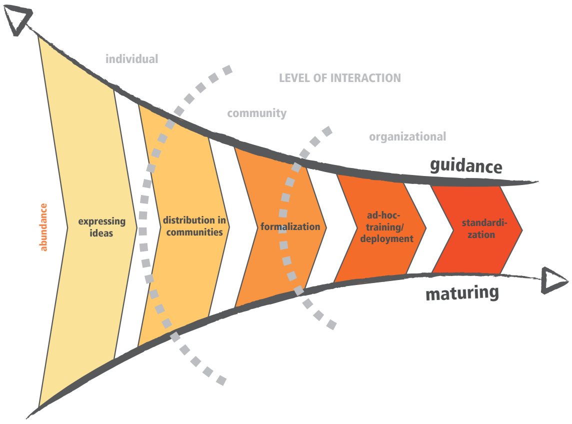

Figure 2.10: *A special focus is put here on the different levels of interaction along the knowledge maturing phases. The graphic is the official project figure.*

ideas). The table also shows again the very organisational-driven character and background of the model, it neglects or underestimates the role of individual learning processes. Thus, the objective of this section is to further investigate how different learning processes on the dimensions of artefacts, sociofacts and cognifacts along the maturing phases can be explained and probably supported.

From the very beginning of the development of the KM model until the end of the MATURE project, the model slightly changed due to new insights and lessons learned. In chapter 3 empirical studies are described including their outcome. These studies were part of the MATURE project and were implemented one after the other in the following order: Empirical Study, Representative Study, In-Depth Study. After the first and the second study, the KM phase model was extended and although not described yet, in this section about related theories the recent version v.3 depicted in figure 2.11 is used. As it is more differentiated compared to the first version, it

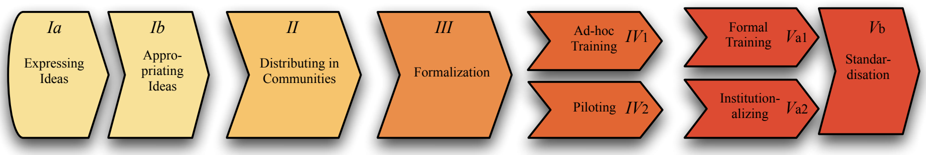

Figure 2.11: *This graphic depicts the phase model version 3, adapted from Mature Deliverable D1.2 (Mature Consortium, 2010a, p.156)*

Table 2.1: *Anitial ideas of how learning happens during the different phases of knowledge maturing according to (Maier & Schmidt, 2007, excerpt table 1).*

Phase	Type of Knowledge	Medium / Interconnectedness	Form of learning
Expressing Ideas	Rumours	Human, highly contextualized	informal & direct communication
	Personal experiences	Human, personal notes highly contextualized	direct communication, exchange of personal artefacts, emergence of communities
Distributing in Community	Ideas and proposals	Forum entry, suggestion form explicit connections to application context	organisational process for improvement capturing ideas, community format
	Questions & answers	FAQ, explicit connections to problem context	self-steered, on demand, informal seeking, beginning formalization
Formalization	Project results	project/milestone report with structure, explicit connections	on-demand information seeking
	Lessons learnt	LL-document, project context made explicit	case-based, self-steered learning
Ad-hoc Training	Learning objects	well-defined digital resource, formal metadata	ad-hoc training
	Good/best practices	best practice document, explicit creation context	case-based, self- steered learning, ad-hoc training
	Patents	patent application, explicit connections to potential usage context	specialized information seeking
Standardization	Reorganised busin. proc.	process models and descriptions	standardised training, courses
	Courses	interconnected learning objects, notion of curriculum	standardised training

allows at some points to understand better the maturing of knowledge on the different dimensions in different contexts. It includes additionally the following differentiation of phases:

- Phase *I* in *Ia - Expressing Ideas* and *Ib - Appropriating Ideas*
- Phase *IV* in *IVa - Ad hoc training* and *IVb - Piloting*
- Phase *V* in V_a1 - *Formal Training*, V_a2 - *Institutionalizing* and *Vb - Standardizing*

Where *Expressing Ideas* refers to a highly informal development of new ideas in talks, or by browsing the organisational knowledge, in phase *Ib - Appropriating Ideas* knowledge is refined and contextualised in a specific use case and then appropriated by the individual. The outcome is marked as valuable or invaluable, such that the new knowledge is assessed for later re-use or further development in another context. The explanation for split of the phases *IV* and *V* in a horizontal manner is simple: it came out that one of two different forms of maturing is dominant in these phases: instruction (phase *IVa - Ad-hoc training* or experimentation (phase *IVb* Piloting). Artefacts produced in phase *IVa* are improved regarding comprehensibility, ease of re-contextualisation and re-use. The experimental-driven phase *IVb* is about gaining experiences prior to a larger roll out of a product, a service or processes and thus includes the development of e.g. test-documents or help-databases. It addresses internal but also external target communities. The transition to phase *V* is still coined by the separation between the instructional and experimental setting. Thus, in the instructional continuation V_a1, artefacts are prepared for teaching novices including pedagogical considerations with respect to the way of presentation (e.g. enriched with pictures), the methodology (e.g. including exercises) and the procedure (e.g. organising a course). The experimental-driven approach is continued in V_a2 by the introduction of the product. Intra-organisational, this includes the implementation of processes or the use of well formalised documents. Extra-organisational, this includes the roll out of the product or service, it will be incorporated in the organisational portfolio. Phase *Vb* is similar for both paths again. It represents some kind of certification or standardisation. This includes the passing of individual formal training or the implementation of organisational processes according to certain standards (e.g. International

Organization for Standardization (ISO)) or rules and regulations. These need to be fulfilled for a certain product either voluntarily (e.g. the decision to produce organic food) or by law (e.g. for the security of firecracker).

The three dimensions of knowledge and the different phases are considered to be orthogonal to each other, spanning the matrix shown in figure 2.12. Each of the dimensions may have an impact on all phases. This

	Phase I		Phase II	Phase III	Phase IV	Phase V	
	Expressing Ideas	Appropriating Ideas	Distributing in Communitties	Formalisation	Ad-hoc Training - Piloting	Formal Training - Institutionalizing	Standardization
Artefacts							
Sociofacts							
Cognifacts							

Figure 2.12: *Matrix showing the orthogonal relationship between KM phases and the three knowledge instantiations.*

impact of a dimension might be stronger in one phase and weaker in another. The sociofact dimension for example, may have a weaker impact on the first phase as rather individual learning activities are considered there. However, it might have a stronger impact on the second and third phase, where social interaction is in the focus of observation. Moreover, the empirically observable manifestation of a knowledge dimension might be different in different phases. The cognifact dimension for example, might be best supported with contextual information in the first phases, in order to support individual knowledge creation optimally. Individuals might solve a problem faster. However, when it comes to standardisation, process knowledge and process management techniques become much more important beside the factual knowledge.

In the following subsections, different theoretical concepts on individual, community-based and organisational learning are studied. For each theory, the *theory's focus of description* will be related to the knowledge instantiation (whether it describes maturing processes that affect artefacts, sociofacts, cognifacts) and in which phase of the knowledge maturing model it helps to explain development processes. Three important points need to be clearly mentioned here:

- Putting a relation in one of the fields of the matrix does not mean, that the other dimension(s) are not considered or important when trying to support knowledge creation within an LME by making use of the theories' principles or findings. For example, the theory of Cognitive Dissonance (CD) is strongly related to the cognifact level as this is the focus of that theory. However, in order to initiate learning processes by creating a cognitive dissonance, artefacts and sociofacts play also an important role.

- A specific relation of a theory to phases and dimensions is not and can not be really selective. It should be read more in terms of "the theory explains mainly these aspects", though the surrounding elements might (contextually depending and different) also be affected.

- The intention of that exercise is not to develop one coherent theory but rather to look how knowledge maturing can be explained for the different relations of phases and dimensions and consequently to derive abstract and contextless requirements that should be considered in designing an LME.

In order to make it easier to follow the later achievements, the applied understanding of relations between the knowledge instantiations and the KM phases shall be provided in the following list:

- Maturing on the artefact dimension is quite easily tangible. Phase *I* is reflected by personal notes and jottings. Phase *II* by collaboratively developed artefacts as forum entries for example. Phase *III* is about the introduction of a structure and of a certain formalization of contents e.g. by adapting the parlance or adding graphs. In phase *IV*, artefacts are changed in order to be usable as training material, internal documentation, etc. Finally, in phase *V* artefacts are produced according to prescribed or standardised methods and rules. This may include invoices, described standardised processes, etc.

- Maturing on the sociofact dimension is not necessarily unambiguous. In phase *I*, people informally discuss with each other. This may be spontaneous and can have an arbitrary content and context, not necessarily related to the work. In phase *II*, people start to build a community discussing about specific work-related topics. They are not very well organised but are linked by the same interest regarding a topic. In phase *III* they start to increase the inner-community organisation, specify responsibilities and contact-persons. With the later phases, this kind of formal organisation increases. In phase *IV* the community has clear structures and roles, participants know about newcomers and those who are experienced. Phase *V* is coined by standardised work and communication processes. There is a clear order who talks to whom, who is the expert for what and so on.

- Cognifact maturing should be considered as similar unambiguous as sociofact maturing. In phase *I*, individuals' ideas, principal and maybe de-contextualised knowledge and the know-how of its application is represented, based on the internal representation, not on the social one. In phase *II*, the social representation is considered including the individuals' disposition to distribute knowledge in the community. This knowledge also includes mutual expectations with respect to discussion partners. Phase *III* represents best practice knowledge about methodologies, communication strategies, but also contextually relevant knowledge repositories. In phase *IV* factual and methodological knowledge about organisational topics, and the contextualised application of expert-knowledge and highly contextual process knowledge (e.g. project related) is considered here. In phase *V* finally, knowledge about explicit experts within the organisation is represented, as well as standardised communication strategies, the organisation's long-term strategy and aims.

It is not too hard to put the different theories in the matrix according to the definitions above. Nevertheless, real world situations which could be explained by means of the considered model are much more complex than the stylised and reduced theory descriptions. Hence, it is not always unambiguous that a knowledge dimension is considered in a certain phase or not.

Subsequent, different theoretic approaches are examined with the aim at discovering how knowledge maturing might take place in each phase and which role each knowledge dimension plays. They are examined and discussed in order to provide an enhanced overall picture of aspects of knowledge maturing and how it might be supported. Theories were selected in order to gain insights into knowledge maturing and learning from an individual, community and organisational perspective.

2.4.2 Cognitive Dissonance

The theory of Cognitive Dissonance (CD) was chosen for examination in order to get more insights into drivers, barriers and processes of individual learning. It is expected that the cognifact and artefact dimensions have a huge impact on the first phase. Moreover, possibilities of social interaction for supporting individual learning should become clearer.

CD theory is investigating the psychological tendency that people avoid or reduce internal dissonance (Festinger, 1957). The unconscious aim is to avoid having behaviour, attitudes, opinions and beliefs in dissonance. Dissonance exists when two or more things are in conflict with each other or are inconsistent. Someone who is buying a car, which is too expensive will try to find more and more arguments (safety, maintenance costs, etc.) that support the purchase and coincidently reduce the conflict of having spent more money than sensible.

> "Dissonance produces discomfort and, correspondingly, there will arise pressures to reduce or eliminate the dissonance. Attempts to reduce dissonance represent the observable manifestations that dissonance exists." (Festinger, Riecken, & Schachter, 1964, p.27)

People typically try to resolve the dissonance either by changing their opinions or behaviour, or by gaining new information or by suppressing cognitions and elements that are inducing the dissonance. They aim at improving the situation of discomfort (Festinger, 1957; Elliot & Devine, 1994). Hence, this situation of discomfort is a pre-condition for learning.

Piaget coined the notion of *cognitive disequilibrium* (1952), describing a status of individual uncertainty, confusion, astonishment or thoughtfulness. It is a consequence of experiencing something that is a contradiction or a contrast to the mental model, an obstacle to goals, an unexpected event or a similar experience, which is distorting the individual's (relative) satisfaction with the compliance of her/his mental model of the reality and the actual experienced reality. Keil-Slawik (2000) pointed out more specifically that learning is only possible by individuals' active involvement in processes of continuous dispute with their physical environment in order to create the cognitive disequilibrium. Moreover, he pointed out the impossibility of solving that status only by non-physical, mental operations. Communicative actions and especially the use of artefacts as external memory is of huge relevance for creating and dissolving the disequilibrium and thus for learning by initiating activities of information gaining.

CD has become an interesting theory in pedagogics. Olson, Colasanti, and Trujillo (2006) state that this psychological phenomenon should be fostered to prompt a critical examination of attitudes, behaviour or opinions by reflecting new experiences. Discussions which reflect critical questions may trigger learning (Lou, Abrami, & d'Apollonia, 2001). In general, creating the dissonance is crucial to initiating learning processes. Otherwise "[e]motions remain unengaged, memory is not reorganised, and motivation is not aroused. In short, nothing significant happens. Hence, no lasting changes occur." (Chee, 2002, p.11). Dabbagh (2005) states, an environment supporting technology enhanced learning, should provide different perspectives to its users in order to create the dissonance. Learners should be provided with different resources related to the issue of their current context. Discussions with or without a particular relation to an artefact should

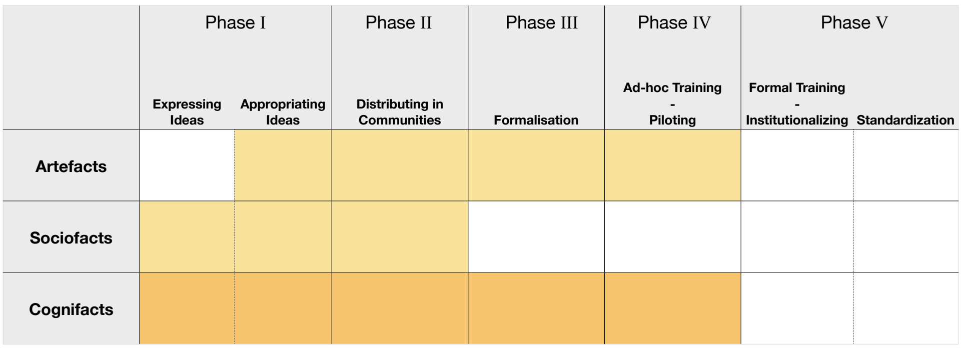

Figure 2.13: *The theory of CD is mainly related to the cognifact dimension. Nevertheless, social activities and artefacts are also important to create a situation of discomfort.*

be fostered by appropriate facilities. More specifically, critical discussions and reflections should be supported, for example by guiding learners along a particular structure. Contact to experts or expert recommendation may also be starting point for initiating discussions. The contact to something like a "relative" expert who serves as a more capable peer or even to someone who is a co-learning symmetric peer with (nearly) common goals is probably more important. Rather than with someone who is highly acknowledged to be an expert along almost all aspects of a domain, learning with a peer learner may lead to co-enculturating a common understanding so that learners develop one another in a more dialogical spirit (Ravenscroft et al., 2010; Bakhtin, Holquist, & Emerson, 1986). Learners might be more motivated and engaged as they do not encounter a barrier that might exist between an instructor and a student.

With respect to the KM model, the concept of cognitive dissonance is a highly individual-oriented approach. However, the inducement of discomfort should be triggered in a social context and by means of artefacts (Olson et al., 2006; Keil-Slawik, 2000). Thus, figure 2.13 shows the relation to the cognifact dimension more prominent but also reflects the importance of the artefact and sociofact dimension for the initiation of discomfort and hence for learning processes.

2.4.3 Zone of Proximal Development

Individual learning and problem solving is successful in many situations and an ability that is often required, e.g during studies. However, most often, it is hardly possible to solve problems as efficient as in collaborative settings. The theory of the Zone of Proximal Development (ZPD) provides an access to social learning by means of examining a instructor-learner relationship. It is expected that a mutual dependency between the cognifact and sociofact dimension is focused.

L. Vygotsky wrote

> “It is generally accepted that the sole and exclusive mental indicator is the ability to solve a problem independently. If, while solving a problem, a child is asked a leading question or given direction about how to solve the problem, this solution is not taken into account in determining mental age.” (L. Vygotsky, 1984, pp.262, translated by Zaretskii (2009))

In criticising the indicators for assessing children’s development status, L. Vygotsky discussed the importance of a (what he later calls) ZPD, which is taking into account what children are capable to solve with the help of adults. Thus, the ZPD is the range between the capability of children to solve a problem independently and to solve it with the help of an adult or by collaborating with more capable peers (L. S. Vygotsky, 1978). Zaretskii states

> "For the purposes of our discussion it should be pointed out that when development is assessed using problems arranged in order of difficulty, over the course of solving them, children will inevitably find themselves in a problem situation, where they will not be able to solve a problem independently. This is fundamentally important, since this type of problem situation is, from our perspective, the point connecting two ways of looking at the ZPD—from the perspectives of diagnosis (how to assess the level of development) and pedagogy (how to promote a higher level of development)." (Zaretskii, 2009, p.73)

Especially the pedagogical perspective was taken up and adapted often for learning activities of people of all ages, e.g. (Phyllis & Lauritzen, 1992; Bennison & Goos, 2010; Billett, 2011). Wood, Bruner, and Ross (1976) enriched the research on the pedagogy's perspective with the notion and activity of *scaffolding*. They refer to the ability of capable peers to control

> "... those elements of the task that are initially beyond the learner's capacity, thus permitting him to concentrate upon and complete only those elements that are within his range of competence." (Wood et al., 1976, p.90)

Collins, Brown, and Newman (1989) presented their idea of the social learning theory of *Cognitive Apprenticeship*. This is taking up these findings and models a pedagogic approach to the (peer) learning of an apprentice with the help of a master in a real world context. This *master* is most often a teacher, an instructor or a trainer. This role allocation can be predefined for example by a concrete educational situation in an organisational apprenticeship. It can also be a spontaneous situation, where someone has more experience regarding a particular entity (task, concept, process) than someone else. In literature this is generally conceptualised with the notion of a more capable peer or the More Knowledgeable Other (MKO)[4]. With respect to the knowledge maturing model, a clear support of cognifact maturing in

[4]MKO is a rather self explaining term, without a special co-notation. Hence, no-one explicitly coined that expression, not even Vygotsky himself who talked about a *more capable peer*.

a highly social context is described, see figure 2.14. Although, artefact cre-

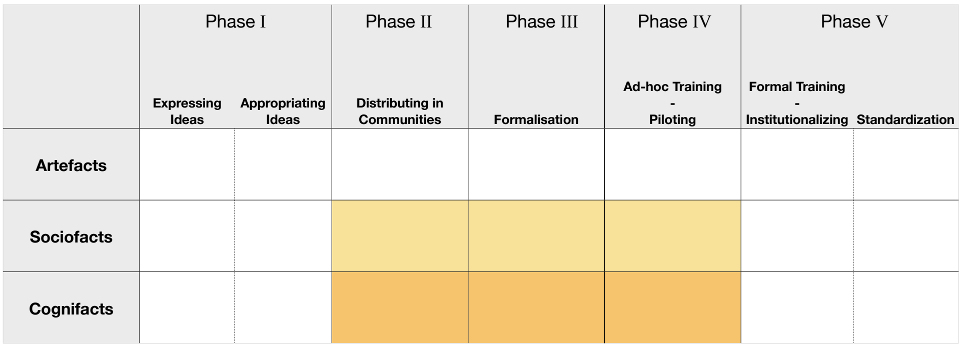

Figure 2.14: *Affected knowledge instantiations when supporting the development of learners and MKOs in the ZPD*

ation might be part of the learning process, it can be very differently and is not the focus of investigation here. Moreover, though not directly a focus of the ZPD concept, supporting sociofact maturing is an extremely important part of the learning and teaching approach. This interaction with the MKO also shapes the ability of social interaction, processes of collaboration and the understanding of expectations of the counterpart (cf. 2.3). As the idea of the ZPD is mainly about the improvements of competences by means of an MKO, this theory can be mainly related to the later phases of the knowledge maturing phase model. In terms of the *Cognitive Apprenticeship* approach, the MKO has to model the problem solution, has to coach the learner and has to scaffold a learning approach (Wood et al., 1976). This is only possible when a kind of formalisation phase has been passed, ad-hoc training or better a standardised process is available. In terms of spontaneous peer learning situations, this can also mean that the MKO has typical ways of explaining certain aspects (e.g. examples she/he always uses, tools, sequences of movements, pictures, reading materials) while knowing that her/his explanations typically lead to observations of increased understanding of the peer regarding the problem situation. In terms of requirements for an LME the learner and the MKO need to be supported. The learner needs to be supported in identifying the problem situation and to find help to establish new knowledge that can be turned into a viable work result. Modeling a problem solution can mainly be supported by providing awareness for similar tasks fulfilled by others or by the learner herself/himself. Other possibilities are the provision of resources related to a certain task or concept, or by the presentation of standardised process patterns. In helping the learner to become aware of a problem situation and especially in order to scaffold her/him, recommendations may help to find support while solving a particular problem. Recommended resources and the provision of documented and finalised processes could be a solution (Cagiltay, 2006). Not a direct support but an approach to it might be an expert recommendation (or expert list). It serves for finding an MKO, a coach that is able to provide help and scaffolding. Regarding the MKO, two aspects are relevant

1. From an organisational perspective, identify an MKO or (if not available) install it and make it accessible and findable

2. Support the MKO in coaching and scaffolding of learners and learning material

The first point is not only about identifying or employing an expert but is also about creating information databases including standard processes and general information. Moreover, making experts accessible should be a major objective to improve knowledge transfer. In turn, as stated with the 2nd point, MKO's need the possibility to communicate to learners, share best practices and helping material, to provide a solution to the problem. They need the possibility to create scaffolds that reduce their own effort by increasing the impact. Wikis or standardised learning courses may be helpful examples (Peters & Slotta, 2010; Kazlauskas & Applebee, 2007).

2.4.4 Communities of Practice

The ZPD gave us interesting insights in learning processes, which are rather formal and where learners are scaffolded by MKOs. However, learning often happens informally, spontaneous and on demand. Learners are part of a community dealing with a particular topic. The concept of Communities of Practice (CoP) is expected to shape the understanding of sociofacts in social learning processes and their particular role and influence on the knowledge maturing phases.

According to Lave and Wenger, the concept of CoP can be defined as

> "A community is a set of relations among persons, activity, and (social) world, a long lasting, informal group, composed of a number of people who join the community voluntarily with common

> interests, common work practice and/or common objectives that satisfy some of their individual needs, with low coordination but with many weak ties among members, where no member is critical for the survival of the group or the accomplishment of common objectives" (Lave & Wenger, 1991, p.98)

A community is formally or informally connected by common activities and participation must not necessarily be permanent (Wenger, 1998). It can also be spontaneous but recurring. Lave and Wenger argue that learning in such social complexes shapes the participants' identity and can motivate as they can increase their social reputation by becoming an expert in a group. A kind of peer learning/teaching is established as those practitioners that have participated for a while in the community can take the role of a teacher for a particular context without necessarily being herself or himself a master (Lave & Wenger, 1991). The mastery of knowledge and skill drives novices to full participation in the social activities of CoP, which describes a situated learning process. A community aggregates the relations between persons and their formal or informal activities, considering a certain time span, with shared expertise and anchored at a certain shared passion. One is typically a member in several different CoP. Hence, communities might also overlap. Wenger describes three different structural elements a CoP consists of (Wenger, 2006):

- **The domain**: A CoP possesses an identity that has emerged through a shared interest of members in the same domain. This can be a professional domain or not, might be implicit or explicit, or might be recognised by "externals".

- **The community**: In order to form a CoP, members need to interact with each other. They need to talk or write and help each other, share information and eventually learn from each other. Learning might be the reason for community creation but can also be an incidental outcome of the interaction. The interaction is not necessarily bound to a certain amount of time (though regularly), not associated to a specific place or to the media used.

- **The practices**: The members of a CoP develop and engage in a shared practice. Together they develop artefacts, problem solutions and a shared repertoire of experiences, best through a long-term interaction within the community.

As shortly outlined above, this concept of CoP is an approach to situated learning in a social context, resulting from participating in daily life and by engaging in Communities of Practice. William F. Hanks states in his foreword to *Situated Learning: Legitimate Peripheral Participation* that the perspective on learning differs from investigating the cognitive processes of individuals in that it spots on social co-participation and the specific social context that enables learning. Learning is understood as an "[...] encompassing process of being active participants in the practices of social communities and constructing identities in relation to these communities." (Wenger, 1998, p.4). Lave and Wenger (1991) illustrated that concept by describing the observation of different groups, including US Navy quartermasters, a group of Alcoholics Anonymous, meat-cutters and others. When people initially join a group, they learn at the periphery. By gaining experience and new knowledge, by learning relevant practices and by moving these practices forward in improvements, changes, or replacements, learners can move into the centre of the particular community, i.e. they become a full participants. This developmental, almost evolutionary process was described by Lave and Wenger as "Legitimate Peripheral Participation". Knowledge needs to be understood in context. "... the purpose is not to learn from talk as a substitute for legitimate peripheral participation; it is to learn to talk as a key to legitimate peripheral participation" (Lave & Wenger, 1991, pp.108). This process of learning is the generation of meaning and thereby of knowledge skills. It affects the person's identity and behaviour outside that CoP (Tennant, 2006). However, there is a certain danger that learning and thus in long-term the community fails, especially when the group is weak in terms of a missing stable core group, members do not trust each other, are not willing to share knowledge, do not communicate with each other (Probst & Borzillo, 2008) or when power structures block, over-regulate and thus weaken or delay participation (Contu & Willmott, 2003).

Although not merely developed in an organisational context, the ideas brought up by Lave and Wenger have been mainly implemented in strategies of organisational learning (Brown & Duguid, 1991; Wenger, 2010; Halliday & Johnsson, 2010). This approach to informal, social and context related learning was recognised as important to improve the organisational agility

(M. & Plessis, 2008; Kahkonen, 2004). Thus, many organisations started to implement programs providing room to their employees allowing to connect, exchange and enhance their knowledge informally, e.g. Nokia (Kahkonen, 2004), Chevron (Stuckey, 2004), IBM (Millen & Fontaine, 2004) or Siemens (Millen & Fontaine, 2004).

Apart from learning in context, the participation in CoPs can have the effect of developing boundary spanners, people who are capable to mediate between different communities (cf. 2.4.6). This is typically the case when community participants became masters in at least one community who are able to transfer their knowledge, thereby initiating knowledge development in another community with another focus and context.

In terms of knowledge maturing, the theory of CoP clearly reflects the social but also the individual knowledge instantiations, sociofacts and cognifacts. Though, artefacts play an important role within communities and their members' developments, it is not in the focus of the theory and rather an expedient. As figure 2.15 depicts, this approach to situated learning was

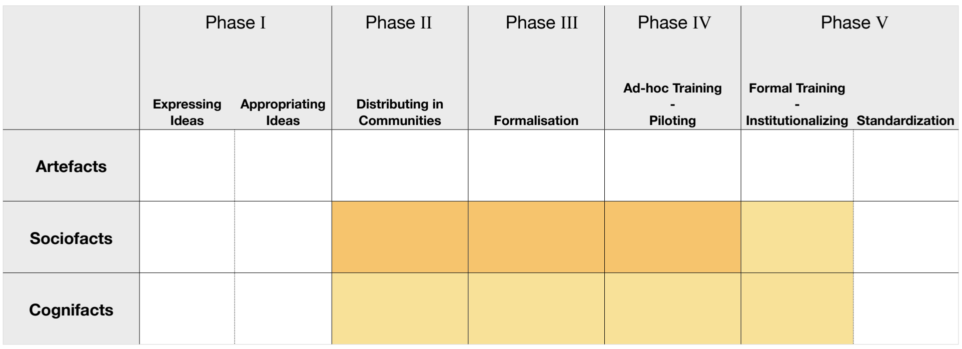

Figure 2.15: *Working in a CoP can enhance the transition between the KM phases* II *and* IV*. Furthermore, its conceptualisation aims at support maturing of the cognifact and the sociofact dimension of knowledge.*

mainly considered in the context of organisational learning. However, there is a clear tendency that communities are supposed to be a seeding platform to improve the organisational agility. Thus, the formation of CoPs supports at least the phases *II* to *IV*, *Distribution in Community* to *Ad-hoc Training*. Standardisation processes might follow, but are less direct activities of informal and fluidly developing CoPs.

In terms of software requirements, CoPs clearly need to be supported in collaboration. This could be realised by means of engagements in processes and their implementation, the creation of artefacts and fostering communication (Ardichvili, Page, & Wentling, 2003; Gongla & Rizzuto, 2001). With respect to theory, it is important that activities are transparent to peripheral learners. It has to be ensured that knowledge can be shared, as artefacts but also in talks and that members are aware of co-members (Wenger, 1998; Brown & Duguid, 2001). Thus, it helps to know about members' recent activities within the respective domain of the group. The availability of a kind of *yellow pages*, which allow to get information on team members including the possibility of contacting them might be helpful. However, also a weakness turns out here as actually only members of the CoP are addressed. This might reflect a barrier as members might know experts, who could be invaluable but who are not part of the community. This is a social and cultural barrier as member had to introduce alleged experts but also a technical barrier, as these persons could not be captured by a recommendation mechanisms. The artefact based co-operation might be fostered by integrating an organisational wiki or a Content Management System (CMS) approach. In terms of processes, transparency of task-related people or resources would be helpful. Moreover, task pattern recommendation or expert recommendation can help to improve or to learn about certain activities. Hence, both, the initial engagement in a CoP and the legitimated peripheral participation is facilitated.

2.4.5 Transactive Memories

After introducing the idea of scaffolding learning, the concept of CoP was presented, which describes collaborative learning processes in communities with a common goal. Novices can develop to masters within the community by legitimate peripheral participation. However, it was not clearly discussed to which degree a collective might be more powerful, knowledgable or efficient in problem solving than the sum of its individuals. Therefore, the theory of transactive memories is discussed and possibilities will be examined which potentially support knowledge maturing by fostering this conceptual approach.

In criticism to theories of group mind, which consider the group as something with a mental activity (similar to individuals) that defines the group's behaviour, Wegner, Giuliano, and Hertel presented (1985) the idea of the *Transactive Memory.* A transactive memory consists of the knowledge of the individual memory systems of the group members and the social interaction between these members (transactive processes). Transactive processes between communication partners are possible as the partners are aware of a transactive memory structure, *connecting* the individual memory systems (Wegner, 1987). Being aware of the structure means, that a group member knows to a certain degree what is in the others' memory. Thus, considering the group as a system, the transactive memory structure resides in all group members. Processes of communication within the group by individual group members are based on this structure. These transactive processes are essential for the creation, storage and retrieval of knowledge in groups The results of these processes might not have been produced by the individual members. For example, let us consider the organisation of a research conference. The organising committee is discussing the format, the necessary tracks, the call for papers, every group member from her/his perspective with specific experience in the field. The result might be (among others) an organisation plan with upcoming tasks, responsibilities, a time plan and so on. It may be that an individual could have produced the same alone but it is more probable that no one of the group members would have achieved that result on her/his own.

> "Transactive memory is therefore not traceable to any of the individuals alone, nor can it be found somewhere "between" individuals. Rather, it is a property of a group." (Wegner et al., 1985, pp.191)

This quality of a group is built up over time, but once established it may in turn influence the individual's memory.

> "In short, transactive memory derives from individuals to form a group information-processing system that eventually may return to have a profound influence upon its individual participants." (Wegner et al., 1985, pp.191)

Thus, it is worth aiming for a well working transactive memory system in a group. In order to build the structure, group members need to learn and acknowledge the others' expertise. According to Wegner, there are two ways of attributing expertise to a person. This can be based on the actual personal expertise a person has or generally on a more spontaneous, circumstantial responsibility arising from certain knowledge or domain (e.g. the deliverer of message, contact to a particular person or group). Consequently, responsibility for a particular domain is assigned to these people and often it is difficult to slip off responsibility once the expertise is acknowledged in a group. In terms of knowledge maturing it is important to support 1st) building up the transactive memory structure and 2nd) the transactive processes. This means, implicitly or explicitly people need to take responsibility for a certain domain. This can be explicitly supported by introducing some kind of accessible competence management, e.g. people tagging or a some more formalised approach. Group members should be able to assign competences and (with the same importance) they need to be enabled to find out who is an expert and who can take responsibility for which domain. This could also be achieved by awareness or even recommendation services that have analysed the usage behaviour and the content of created or consumed resources in order to infer expertise (implicitly derived but explicitly presented). Transactive processes should be supported in different ways. Communication facilities should be provided and the emerging process of a certain topic should be made persistent. This also includes the linkage to the involved persons. This would allow to re-enact certain decisions later on as input for new processes. Figure 2.16 relates the theory of *Transactive Memory* to the early phases of the knowledge maturing model. It needs to be said that the transactive memory structure and the transactive processes can only indirectly be observed. Although its (semi-) automatic recognition and re-utilization by means of LME functionalities would work on artefacts, the concept addresses the cognifact and sociofact dimension. Therefore, the artefact dimension is not reflected in the matrix.

Influenced by the memory system, people might express ideas and distribute them into the community. There, they are discussed, shaped or maybe discarded as a result of transactive processes. As discussed above, the distribution into the community might lead to an individual learning process and thus might lead to cognifact maturing. The learner can increase the knowledge about a certain topic but also about the memory system structure (who is expert and/or responsible for what). In terms of sociofacts, social activities have emerged, which are observable in chat protocols, team meetings or e-mail threads. This represents a (well) working group, which possibly has the potential to broaden its capability and its range of

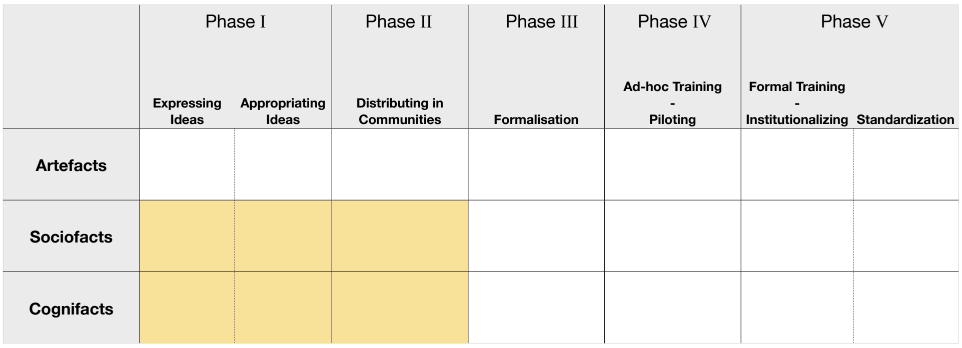

Figure 2.16: *Affected knowledge instantiations when supporting the group in establishing an effective transactive memory system.*

domain expertise (considering the group performing as a whole). Hence, the respective self-awareness of group members needs to be increased, maybe by supporting the reflection e.g. via blogging (Dabbagh, 2005).

2.4.6 Boundary Objects and Boundary Spanners

Up to this point, the focus was mainly on learning in social interaction. Though, artefacts were always implicitly premised, the actual role of artefacts in learning processes was not considered explicitly. Therefore, the theory of Boundary Objects is discussed in this section in order to shape the understanding and role of artefacts as mediating objects for knowledge maturing.

Star and Griesemer (1989) brought up the idea of Boundary Objects (BOs) by studying the creation and maintenance of Vertebrate Zoology at the University of California. During its conceptionalisation and implementation, representatives from several social worlds had to work together, mainly motivated by different regional and professional interests e.g. university administration, professional and amateur scientists, and more. A *social world* comprises people with a certain common interest in a particular domain, partly working together, using common techniques, probably sharing experiences and following a common goal, in short, they form a CoP (cf. 2.4.4). In the example presented by Star and Griesemer, BOs were collaboratively produced by the different social worlds in order to implement the museum. These BOs are (partly) understood different in the different social worlds but yet provide an abstract or concrete means of translation between the worlds.

They are "[...] an analytic concept of those scientific objects which both inhabit several intersecting social worlds [...] *and* satisfy the informational requirement of each of them." (Star & Griesemer, 1989, p.393) Different types of boundary objects were identified in the research context of Star and Griesemer. These types might serve as an entry to support the creation of BO by an LME:

- **Repositories:** Sets of well/standardly managed informational material of one or more domains (e.g. library). They are accessible for the social worlds without demanding or fostering a direct negotiation of differences in the perspectives.

- **Ideal type:** It represents an abstraction from a concrete object and domain. Ideal types are adaptable to different social worlds. Star and Griesemer mention the example of the concept of "species" in the biological taxonomy of creatures. Concepts from other domains could be means of transportation, imaging procedures or even knowledge management.

- **Coincident boundaries:** These are common objects with different contents but the same boundaries. This can include e.g. comments to political decisions by different parties or probably also a company's management.

- **Standardised forms:** These are representations of standardised communication processes. Actually, (according to the example given by Star and Griesemer) this should be classified as standardised externalisations of certain activities. *Standardised* should be understood as agreed across the social worlds. It comprises e.g. prescribed forms for gathering certain data and might also comprise process definitions.

Especially the second and third type of identified BO is blurring the concept and makes it quite abstract, which makes it necessary to be careful not to see a boundary object in everything. Although it obviously makes sense to consider different perspectives on the same thing (coincident boundaries), Star and Griesemer describe here an ontological approach, which defines the BO not only by an object of interest itself but also by means of the different perspectives one can obtain regarding it. Ideal types may give an anchor in particular contexts for participants of different social worlds to enter another social world by learning about its perspective and related sub-concepts.

Park used the notion of *marginal man* (1928), describing people that inhabit more than one social world. In the context of economic sciences the concept of a *boundary spanner* was brought up by Aldrich and Herker (1977). Similar to the marginal man a boundary spanner inhabits to a certain degree more than one social world but is additionally supposed to link the worlds and to mediate between them. For example, a software development project manager is supposed to mediate between the developers and the customers in order to end up with the desired result but also between the project team and the management in order to secure a high profit. It is the role of a boundary spanner to connect different social worlds with fundamentally different perspectives. For her/him, it is important to create boundary objects that help to link participants of the different social worlds and that help the participants to understand the counterpart's context and objectives.

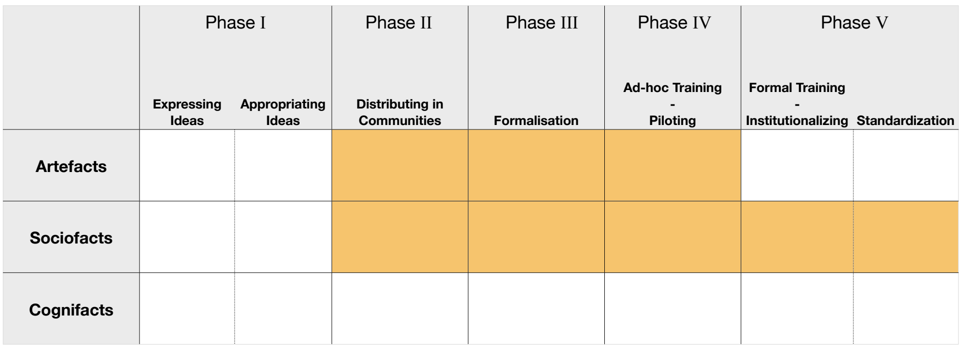

Figure 2.17: *Boundary spanners should be supported in initiating, enabling and fostering sociofact maturing by means of boundary objects. That might lead in itself to the maturation of artefacts.*

Mediating between the different worlds by means of BO fosters knowledge maturing especially on the sociofact level as the way of communication between the worlds is maturing. Initial interaction but also defined processes may emerge during the collaboration, supported by BOs. However, it is necessary to support that process by artefacts, which fit to the particular community, serving e.g. as ad-hoc training material or even standardised mandatory processes that define the collaboration of those communities. Figure 2.17 shows the KM support, where mainly the sociofact level is addressed and also the artefact dimension.

With respect to software requirements, the relation between the maturing of sociofacts by means of matured artefacts is conspicuous. Thus, boundary spanners should be supported in compiling repository-boundary objects containing material, which can be picked up by participants of all communities and which is reflecting the different perspectives to an appropriate degree. Moreover, as already observed by Star and Griesemer, standardised forms may improve the communication between social worlds by sticking to a certain vocabulary, order of description and so on. In the course of time, participants may learn about the mutual concepts and can go beyond such standardised BO. Thus, it might also be useful to provide the possibility to discuss about artefacts (e.g. documents) and moreover to provide a taxonomy of concepts and the possibility to discuss about the concepts as well.

2.4.7 SECI Model

The concept of Boundary Objects presented artefacts in the role of mediating objects between different social worlds. An issue that is discussed by means of the SECI model is the creation, distribution and utilization of artefacts in organisations. The important aspect is the description of a lifecycle of artefacts, which makes knowledge workers' knowledge persistent, valuable and accessible to their colleagues. It is expected to gain insights how the artefact dimension can be supported in the later phases of the knowledge maturing model.

The classical model for (intra-) organisational knowledge creation, and at that time an initiator for a new age of research on knowledge management is the SECI model provided by Nonaka and Takeuchi (1995). Still very influential, its main contribution is the emphasis on tacit knowledge and the general assumption that tacit knowledge can be made explicit (Nonaka & Takeuchi, 1995; Johannessen, Olaisen, & Olsen, 2001; Nonaka, Toyama, & Konno, 2000). Thus, as already described in 2.2.1, Nonaka and Takeuchi have a different understanding of tacit knowledge from the one Polanyi had. Polanyi's understanding of tacit knowledge refers to a less codifiable dimension than the one Nonaka and Takeuchi proposed, cf. 2.2.1. The SECI model describes a spiral transformation between tacit and explicit knowledge. The four instantiations are described through:

- **Socialisation:** New tacit knowledge is created and shared through social interaction and daily experiences.
- **Externalisation:** The process of making tacit knowledge explicit so that it can be shared and form the basis for new knowledge. The result can comprise artefacts but also new concepts. They can be mediated through dialogues.
- **Combination:** Describes the process of creating systematically new explicit knowledge artefacts by combining several artefacts gained from inside or outside of the organisation.
- **Internalisation:** By reading or using external artefacts, new knowledge is created by individuals through the internalisation process. This should be understood as applying knowledge in praxis and is accompanied by a process of reflection and re-contextualisation, allowing individuals to relate new knowledge to existing (cf. 2.3).

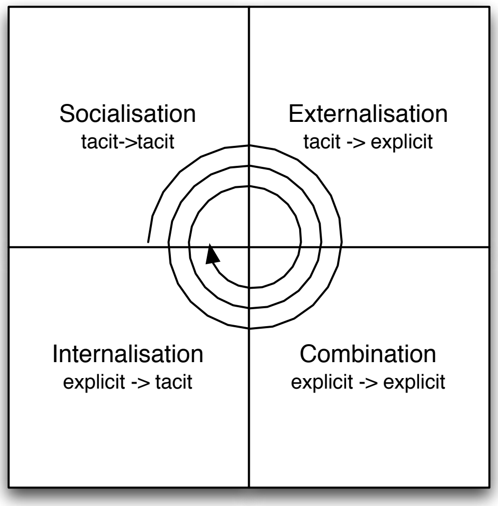

Figure 2.18: *The SECI model, describing the spiral of organisational learning through making explicit individuals tacit knowledge. Adapted from (Nonaka & Takeuchi, 1995)*

Figure 2.18 shows the spiral of transitions between these four instantiations of internal and external knowledge creation.

With respect to the KM phase model, the SECI model can be cautiously interpreted to support all phases, though not explicitly. With *Socialisation* the expression and generation of ideas can be associated, the first phase of the KM model. This happens on the cognifact and sociofact dimension due to the relevance of individual but also due to collective experiences. During *Externalisation*, ideas and seeding input are provided to the community (phase *II*). This affects the sociofact and artefact dimension. According to (Nonaka & Reinmoeller, 2002), *Combination* is about the aggregation of internal and external artefacts in order to create a more complex and systematic whole. Hence, the phases *III* to *V* can be regarded to be supported by the SECI model as all three phases are parts of the combination process, which occurs according to Nonaka and Takeuchi explicitly on the base of artefacts. The internalisation process is again addressing the individuals' learning processes and thus covered by the cognifact dimension.

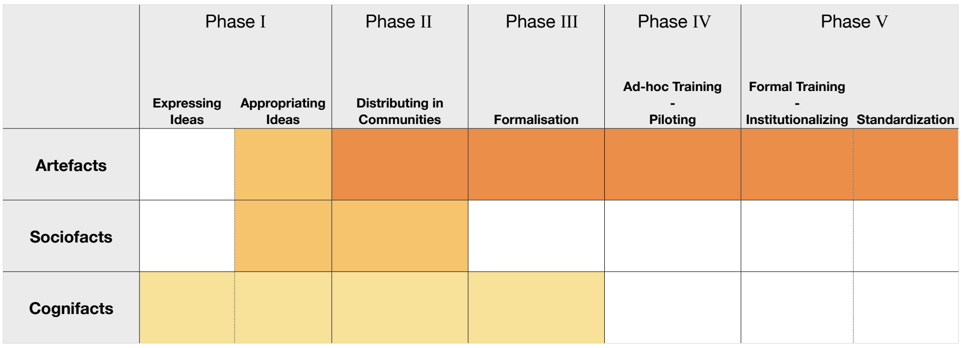

Figure 2.19: *The SECI model can be (cautiously) interpreted to support all phases of the KM model, aggregated on the different instantiations of knowledge. However, it is very artefact-oriented and does not really explain individual learning processes.*

In terms of requirements for a LME it is typically quite problematic to derive a construction guideline from abstract theoretic models. Due to the theory's level of abstraction, context is absolutely missing and thus concrete proposals for designing software supporting the theory is almost impossible. However, some higher abstracted software requirements can be derived that may support (in this case) the entities of the SECI model. *Socialisation* and *Externalisation* could be supported by communication facilities, the latter especially by means of a repository for sharing and accessing artefacts, and of course for creating artefacts. The *Combination* might be supported by different recommendation and awareness services for improving the use and aggregation of internal or external documents in terms of quality, currentness, context relation or viability. A service supporting the creation of taxonomies according to working structures or work-related concepts might be helpful to improve findability and traceability of artefacts. The process of *Internalisation* might be supported by providing transparency about processes and their outcomes, documentation of projects or action-result relations through context-related provision of information. Similar to most of the theoretical concepts, the concrete implementation of an approach to support the model in organisational reality is going far beyond the specification of a software system. Motivation and barriers for different important activities (e.g. sharing, communication) have to be considered. Furthermore, guidance for the provision of documents, processing of tasks etc., and a particular cultural spirit is necessary for a SECI oriented implementation of knowledge management (Pratomo & Bakar, 2007; Gorelick, Milton, & April, 2004).

2.4.8 Distributed cognition

The theory of *Transactive Memories* aims at explaining collective knowledge creation. The SECI model describes processes of knowledge creation over an undefined large timespan in a rather distributed local setting. Compared to that, the theory of distributed cognition is expected to provide us with more insights into collaborative knowledge creation in a temporally and locally restricted setting. It is asked for particular possibilities to support knowledge maturing in spontaneous tasks and processes.

Distributed Cognition (DCog) is a descriptive framework, which provides tools and methods (mainly coming from cognitive ethnography) allowing to understand work context embedded social activities, their relationship, the relationship between the actors and the relationship between actors and artefacts (Hutchins, 1992; Rogers & Ellis, 1994). Distributed Cognition concentrates on cognitive activities and knowledge distribution on a process level. Hutchins (1995a) understands a cognitive activity as the (deterministic) transition of knowledge from one representational state into another, possibly between different media. The media comprise internal memory and external representations of individuals using speech, artefacts, non-verbal communication, etc. for propagating knowledge. The framework of DCog understands cognitive processes as an array of cognitive activities of the elements participating in it and the relationship among them. Hollan, Hutchins, and Kirsh (2000) point out that cognitive processes could be distributed across the individuals of a group. It involves coordination between the material or environmental structure, and could be distributed through time where earlier processes influence later. Hence, DCog is considering broader cognitive events and systems "...that can dynamically configure itself to bring subsystems into coordination to accomplish various functions." (Hollan et al., 2000, pp.175). For example, Hutchins presents in his initial investigation the analysis of processes on a ship's deck (Hutchins, 1995a), later on the processes in an airplane cockpit (Hutchins, 1995b) and C. Halverson in his PHD thesis those in an air traffic control (1995). All these are complex social processes with a high demand on coordination. DCog can be used to understand distributed social systems and the interaction between the single actors from a macro-perspective, showing which activities lead to which consequences.

From the beginning, Hutchins aimed at developing a framework that could help to design computer systems, especially supporting Human Computer Interaction (HCI) and CSCW tools. However, DCog is not about understanding individual learning processes, neither during isolated activities nor in collaboration within a social network. Furthermore, it is also not appropriate as such for supporting teams and leverage collaboration, as it is only about the analysis of processes. It focusses on a specific unit of analysis (cognitive system). Thus, it provides us with an ethnographical methodology that can help to understand cognitive processes and eventually to develop levers and indicators for supporting individuals, teams or even organisations to improve processes. These levers and indicators might also be transformed into requirements for a software system. However, the theory of DCog alone does not directly allow the inference of requirements to an LME. However, with respect to the knowledge maturing matrix, a system analysis in terms of the DCog may outline needs for improvement on the sociofact level. As *broader cognitive events* are considered, a certain degree of experience, comparability and repeatability has to be given and thus the later phases of ad-hoc training and standardisation are addressed (see figure 2.20). Concluding, the Distributed Cognition may help in the analysis of a particular context for providing a lever to support process improvement, but does not allow to derive context-free requirements for an LME. Moreover,

	Phase I		Phase II	Phase III	Phase IV	Phase V	
	Expressing Ideas	Appropriating Ideas	Distributing in Communities	Formalisation	Ad-hoc Training - Piloting	Formal Training - Institutionalizing	Standardization
Artefacts							
Sociofacts							
Cognifacts							

Figure 2.20: *The DCog especially considers the sociofact instantiation and addresses the later phases of higher maturation the phase model.*

additional theoretic considerations might be necessary for the interpretation of the outcome of a context analysis by means of DCog.

2.4.9 Activity Theory

The theories discussed before, addressed particular single aspects, which are potentially relevant for knowledge maturing. By examining the activity theory, a better understanding of the relationship between the different relevant entities (e.g. artefacts, actors, society) in knowledge maturing processes is expected. This might also further shape the understanding of the knowledge dimensions cognifacts, sociofacts and artefacts.

A theory about tool mediated activities with respect to their role for human development was already formulated between 1920 and 1930 by the founders of the *cultural historical psychology*, Vygotsky and his pupils and collaborators Luria and Leontev (Jonassen & Rohrer-Murphy, 1999; Bødker, 1991; Engeström, 1987). However, at least in recent HCI research in the non anglo-american countries, Engeström's work "Learning by Expanding: An Activity - Theoretical Approach to Developmental Research" (1987) gained a lot of attraction and is often meant when referring to Activity Theory (AT) in the context of HCI (Nardi, 1995; Engeström, 2000). He tried to develop a root theoretical framework explaining the evolutionary (mutual) impact of tool-mediated actions on learning in socially embedded activities. It combines the object-oriented ideas of Vygotsky, Leont'ev and Luria with approaches of German philosophy (Kant, Hegel) and ideas of Marx and Engels (Engeström, 1999).

> "A historically evolving collective activity system, seen in its network relations to other activity systems, is taken as the prime unit of analysis. Goal-directed actions, as well as automatic operations, are relatively independent but subordinate units of analysis, eventually understandable only when interpreted against the background of entire activity systems. Activity systems realise and reproduce themselves by generating actions and operations." (Engeström, 2000, p.964)

Engeström's main contribution is the incorporation of findings of philosophy (e.g. Pierce, Popper) and sociology (e.g. Mead) into the existing activity theory approach (1987). He developed a methodological framework that allows the understanding of the impact and relationship between different aspects of human activities. Figure 2.21 shows these aspects described in a triangle. Actions of an activity are mediated by tools in order to achieve a certain

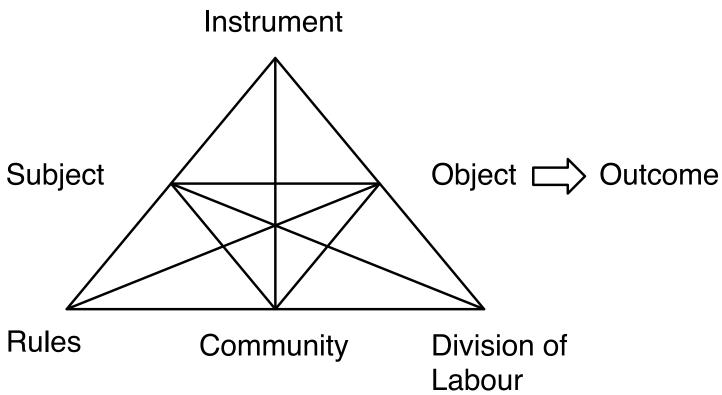

Figure 2.21: *The triangle shows the relationship between relevant entities influencing operations of an action contributing to an activity with particular outcome.*

objective by subjects. These actions are typically embedded in a social environment, described by *Community* ("those who share the same object of activity" (Engeström, 1991, p.249)) and are influencing, supporting, driving and enabling the subjects operations. *Rules* (e.g. laws or norms) are a constraining factor. These guide the actions between the subject and different people in the community. The roles and relationships between people who participate in an activity are subsumed by *Division of Labour*. It influences the activity and the related object according to the participants' particular identity. This refers to the different expertise but also to inner-community power structures.

> "An activity is a form of doing directed to an object, and activities are distinguished from each other according to their objects. Transforming the object into an outcome motivates the existence of an activity. An object can be a material thing, but it can also be less tangible." (Kuutti, 1995, p.27)

Each node and the overall system may be affected by the outcome of actions, the activity as a whole and external factors by perceiving contradictions to the current status. Hence, the system can in turn dynamically change the activity, can adopt new elements or it initiates new or changed actions (Engeström, 2001).

AT provides us with a descriptive model. It can be used as an ethnographically shaped framework to understand socially embedded activities, the mutual influence of containing entities and (partly) their effect on the overall dynamically changing activity system. It is not prescriptive and although AT focusses on the individual situated learning in a social context it does not provide explanations about cognitive processes (whether with respect to internalization- nor externalization processes). It rather provides a kind of roadmap to the understanding of context specific activities by means of ethnographical methods (C. A. Halverson, 2002). It is a tool, which helps to analyse ethnographic observations. In that way, the role of each entity can be clarified and weaknesses in the observed process can be identified. Similar to the DCog, AT can help to understand concrete organisational processes. Based on analysis results of those processes, hypotheses can be described for a better software support. Thus, it is not possible to derive abstract functional requirements directly from the theory. Moreover, it is not helpful to come up with a maturing matrix depicting the AT's focus of investigation. Depending on the focus of a particular investigated activity, one of each matrix grid might be focused.

2.5 Conclusion

2.5.1 Summary

The knowledge maturing phase model in version 3 consists of five phases that are overall divided into seven sub-phases. These phases depict goal oriented learning on a collective level, i.e. knowledge maturing (Mature Consortium, 2009a). In all phases learning may be considered on different instantiations: on the artefact-level, on the sociofact-level and on the cognifact-level. This process-oriented model is not supposed to explain and model learning in detail. Moreover, it was not the aim of this or previous MATURE related work to develop a holistic model of knowledge maturing that covers all details of learning. However, it was the objective of this chapter to relate well known theories and concepts to the maturing model in order to

1. review, which model may be helpful in order to explain learning in different phases and on different instantiations
2. derive abstract requirements that can be turned into contextualised software requirements of an LME

The investigated theories were supposed to explain different aspects of learning, collaborative knowledge creation, social interaction, community creation, knowledge distribution in social interaction and more. The assignment of theories to the different knowledge instantiations and maturing phases should be considered cautiously. In critically reflecting these assignments, it has to be said that one might also come to slightly different results. I think the main reasons for this missing selectivity are:

- **Missing contextualisation:** Neither the theories behind the base matrix (SI, phase model) nor the considered related models are somehow contextualised. An idea is presented, for which contexts the different models might be applicable but the transferability to a certain context is neither described nor narrowed. Thus, it can be discussed whether different examples might also lead to a consideration of neighbor matrix grids to those that were already focused.
- **Weakness in the phase model and matrix respectively:** The phase model contains some weaknesses regarding consistency, focus

points, abstraction, and descriptiveness. Although knowledge maturing is referring to collective learning, processes of learning are often mixed up with processes of (collaborative) artefact creation or the definition of organisational processes. Including the missing focus of each phase whether it is about individual learning or organisational learning or even incorporating social networking aspects, it describes different levels of abstraction. For example, it is concretely describing the creation of artefacts for process definitions (phase *V* - Standardisation) but it does not give a clear explanation of phase *I*- expressing ideas, or even more concrete, phase *Ib* - appropriating ideas. In turn, this results in some diffuseness regarding the exactness of assigning a concrete context to a certain phase. Consequently, this weakness remains in the matrix and in the assignments.

- **Blurry borders and transferability of theories:** Apart from the weaknesses of the phase model, it can be generally stated that theoretical concepts have blurry borders. Due to the nature of theoretic models, the provision of a generalised specific viewpoint on a certain issue, several context-specific aspects are neglected.

Figure 2.22 shows the overlay of the matrices of CoP, ZPD, Transactive Memories (TM), BO, CD and the SECI model. The color of each matrix point was defined according to the number of theories that focus on it. This can be an occurrence between 1 and 5. The darker the color is, the more often this point has been focused. Clearly, the overlay depends on the selection of examined theories, a rather organisationally oriented selection would have brought another result. A perceived underrepresentation of a certain knowledge dimension in a particular maturing phase might exist due to that fact. Hence, it comes to the effect for example that artefacts seem less important for phase *II* than cognifacts, which is of course not generally correct.

The selection of theories focused on concepts that try to explain learning with respect to particular issues from an individual or community perspective (e.g. CD vs. CoP). Thus, the result shows a quite natural and expected tendency that phase *I* is more related to individual learning and knowledge on the cognifact-level with a decreasing covering in the later phases. Sociofacts are mostly considered in the phases *II* to *IV*, less in the first and the

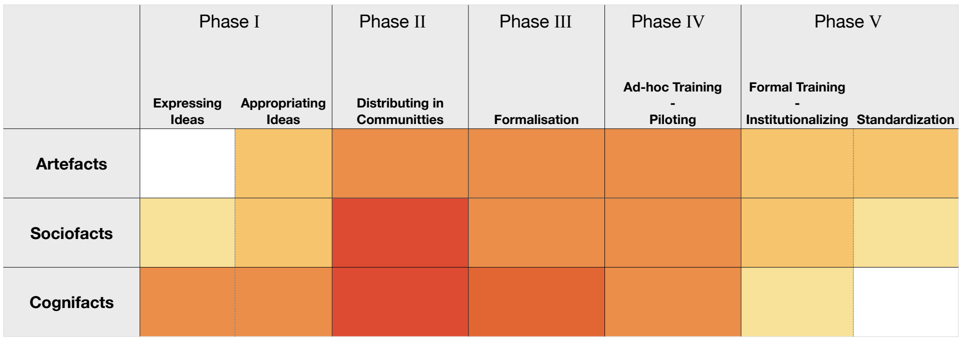

Figure 2.22: *This matrix represents an overlay of all matrices described before. Obviously, with that choice of theories almost all points can be covered. It remains open, whether standardisation on the cognifact level and expressing ideas on the artefact level is achievable.*

last. It is interesting that phase *II - Distributing in Community* is mostly covered by theories focusing on sociofacts and cognifacts. This might reflect the fact that learning is considered as an inherently social activity. Artefacts play an almost constant role over all phases but are in phase *V* more important than cognifacts and sociofacts, but not covered at all in phase *I*. This is quite surprising. Though, none of the theories is focusing on artefacts in phase *Ia* (e.g. informal notes, jottings, transcribed ideas), all accept and require more or less explicitly the existence, generation and exchange of artefacts as precondition for learning. Actually, artefacts are a basic prerequisite for any kind of sociofact and cognifact maturing in each phase. As argued in section 2.4.2, learning is only possible by an active interaction with the environment in order to create a cognitive dissonance, which can not be solved only by mental operations. It is the goal-oriented use of artefacts that allows individuals the creation of external representations of thoughts. These external memories help to reduce the cognitive effort of mental and physical operations. Although artefacts are sometimes rather considered as a means to an end, the maturing of artefacts should be fostered particularly as they have a mediating role. Especially in higher maturing phases it is specifically aimed at increasing the amount and formalisation of artefacts, which support the community or the organisation. Thus, artefact maturing should consider the context related structure, acceptance, clarity, readability and other parameters that might improve the context-related quality.

2.5.2 Derived Requirements

One particular conclusion from each theory discussion was the derivation of the different abstract software requirements. It is typically quite problematic to derive a construction guideline from abstract theoretical models (Keil-Slawik, 1992). Due to the theory's level of abstraction, context is absolutely missing and thus providing concrete proposals for designing software supporting the theory is almost impossible. However, some higher abstracted software requirements can be derived that may serve to, support or foster certain aspects of theoretic considerations. Table 2.2 summarises the respective findings of each theory. Distributed Cognition (DCog) and Activity Theory (AT) are not considered as they were not found to be appropriate to derive requirements.

Table 2.2: *This table provides the abstract software requirements derived from the different theoretical approaches.*

Theory	Derived Requirements for an LME
Communities of Practice	support collaboration
	transparent processes: task-related people or resources
	co-operative creation of artefacts
	communication
	makes activities transparent to peripheral learners
	knowledge can be shared via artefacts or in talks
	provide awareness of community members
	provide knowledge about members' recent activities
Zone of Proximal Development	supported identification of problem situation
	providing awareness for similar tasks fulfilled by others
	support finding resources related to a certain task or concept
	standardised process pattern may replace an MKO
	recommendations for finding artefacts or MKO
	support identification of and contact to MKOs
	support the MKO in coaching and scaffolding of learners and learning material
	provide communication facilities between MKO and learner
	support sharing of best practices and helping material

Transactive Memories	provide communication facilities
	formal and informal processes should be replicable
	the social network related to a formal or informal process should be explicit and accessible
	input recommendation for new processes based on finished tasks
	transparent social activities for reflecting processes
	provide overview of domain expertise of a work group
	expertise related self-awareness of group members needs to be increased
	support the reflection about activities, experiences and group processes
Boundary Object	provide BO-repositories that can be accessed by all communities
	support boundary spanners in creating BOs that reflect different (target-) perspectives to an appropriate degree
	provide possibility to discuss about artefacts
	support creation of standardised artefacts and processes in order to improve the communication between social worlds
	support boundary spanners in learning typical characteristics of the spanning worlds
	support identification of boundary spanners
	provide taxonomy of world specific-concepts and the possibility to discuss about the concepts
Cognitive Dissonance	support critical discussions and reflections
	create the dissonance by providing different perspectives to users
	provide users with different resources related to one issue, which demands a kind of classification
	support the contact to experts for initiating critical discussions (e.g. by expert recommendation)
SECI	provide communication facilities
	provide a repository for creating, sharing and accessing artefacts
	foster recommendation and awareness about organisational related knowledge and social activities
	support use and aggregation of internal or external documents in terms of quality, currentness, context relation or viability
	create process transparency through context-related provision of information about processes and their outcomes

These abstract software requirements can be used to shape the concept of an LME. They are a means to describe, which user activities an LME basically has to enable in order to potentially support knowledge maturing. However, as all contextual information is missing, these requirements can not serve as a construction plan or guideline for implementing an LME. In a concrete scenario, these requirements should be considered and enriched with contextual information. They can provide a guideline and a focus, along which the requirements analysis could be oriented in order to develop a Learning and Maturing Environment.

2.5.3 Next Steps

The theoretical considerations of this chapter are important for

- introducing and understanding the knowledge maturing model
- the motivation and implementation of the empirical studies and thus the
- the direct and indirect derivation of software requirements for designing an LME.

The following chapter will present the conduction and the results of the project's empirical studies and explorative user centered design work. It helps to derive concrete services and guidance aspects for the contextual implementation of Knowledge Maturing as a whole and for the implementation of LME in particular.

Chapter 3

Empirical Findings

The project conducted three studies, an ethnographically-informed, and two interview-driven studies. The results of these studies shaped the understanding of knowledge maturing and the knowledge maturing model. Based on these studies, the set of software requirements can be enhanced and shaped, so that services will be derived, which may support knowledge maturing. Moreover, *Knowledge Maturing Activities* will be described, which provide a kind of checklist for knowledge maturing during the software design process. *Knowledge Maturing Indicators* will be discussed as a manageable way to operationalise and identify knowledge maturing that can be used in Maturing Services. Thus, these studies provide a valuable input for the concept of an LME.

3.1 Ethnographically Informed study

For the purpose of designing and creating a PLME and OLME[1] the ethnographic study delivered valuable input, which helped to describe Personas, to create Use Cases (cf. 3.2.1), and to derive requirements and services. Figure 3.1 depicts the outcomes of the study and relationships to other project activities. The outcomes of the study comprise Persona descriptions, which are explained and examined in the following sections. Furthermore, the grey box "other outcomes..." comprises outcomes like the description of long running knowledge maturing processes, an initial set of Knowledge Maturing

[1] According to the official *Description of Work*, PLME and OLME were actually the official terminology at that point in time, later the LME terminology with personal and organisational perspectives prevailed (in compliance with reviewers).

Indicators (cf. 3.3.3.2) and more (cf. (Mature Consortium, 2009a)). These will partly play a role later on but not for the further description of the service derivation process based on the identified Personas. Furthermore, a relationship between the results of the Ethnographic Study and the Use Case description process is depicted. This is a rather loose relationship which will be described in detail in section 3.2.

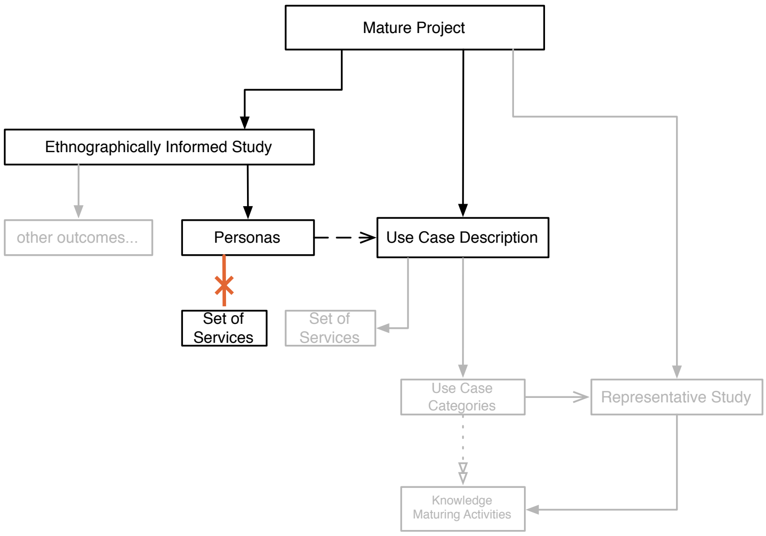

Figure 3.1: *Relations between the ethnographically informed study and use case description. The further role of the representative study is not that important in this section and thus grey.*

It was abandoned to derive services directly from Personas, as symbolised by the red line. Time constraints and different research interests and views on the procedure may have been responsible for that decision. However, in order to grant more completeness of services supporting knowledge maturing, this step was made up for this thesis. The results will be presented in the following sections.

3.1.1 Introduction

Ethnography is a specific empirical approach to studying human behaviour in complex settings by trying to capture what people do and why they do it (Agar, 1996). Anthropologists developed that qualitative methodology mainly to study new (exotic) cultures (Jordan, 1996). The key factor of ethnographic studies is the participation in the life and community of the subject of research (Fetterman, 1999), later in sociology also called *Participant Observation* (Lamnek, 2005). However, ethnographic work also includes purposeful communication and question asking in order to understand certain activities.

> "The ethnographer, then, is a transactor of sorts: a translator, a cultural broker, seeking to achieve an equivalence in value among ways of life by allowing us [...] to see ourselves in them." (R. Anderson, 1994, p.160)

Other sciences, as sociology, behavioral science, educational research or computer science have taken up that approach and found how to study communities and processes within their particular settings. According to Harper (2000), ethnography played a huge role during the 90s in the context of designing and developing CSCW systems. However, the procedure was only partly comparable to the systematically developed methodology in anthropology and sociology. One of the reasons of deviation in methodology is the need for saving time and money. This was especially important when a system context analysis (or end-user analysis) is only a part of development or research, not the subject itself. Moreover, the complexity of the ethnographic task increases as tools, collaboration or organisational issues not only have to be understood but additionally have to be reflected in a software design. Thus, Hughes, King, Rodden, and Andersen (1995) propose to collect as much information as possible in a short time frame.

> "This 'quick and dirty' approach is capable of providing much valuable knowledge of the social organisation of work of a large scale work setting in a relatively short space of time. Indeed, it can be argued that the 'pay off' of the 'quick and dirty' ethnography is greater in that a great deal is learned from a relatively short time expended on fieldwork. [...] What the 'quick and dirty' fieldwork provides is the important broad understanding that is capable of sensitising developers to issues which have a bearing on the acceptability and usability of an envisaged system rather than on the specifics of development. " (Hughes et al., 1995, pp.6)

Referring to that proposal and taking into account the stricter approach to ethnography in anthropology and sociology, the project's consortium decided to refer to the Mature approach as an *ethnographically-informed study*. However, due to the specification in the project's *Description of Work (DoW)*, each official reference used the original name.

3.1.2 Theoretical Approach and Conduction

Within the ethnographically informed study, more than 10 knowledge workers in 7 small to large organisations[2] were observed by project partners. The project partners had a background in business, computer science, vocational training, and consulting. The organisations were chosen either because they are application partners (which was especially deemed helpful in terms of requirements analysis) or because of prior partnerships with project partners. The sample is diverse in terms of size[3], culture (country) and industry sector (cf. table 3.1). Organisations are settled in the sector of professional services, IT services, health care and telecommunication with an IT intensity[4] of medium to high. The heterogeneity helped to get meaningful cross-section information about knowledge work, knowledge maturing processes and barriers as well as engines of knowledge maturation.

Moreover, the studied people and processes were selected with respect to their characteristic as knowledge worker. Knowledge work was defined by Maier, Hädrich, and Peinl as

> "an ideal type of work, an abstraction comprising key characteristics of a wide array of activities in organisations across occupations that creates, translates or applies new knowledge." (Maier et al., 2009, p.23)

Thus, a too narrow and focused view on the overall set of studied persons was avoided and very different viewpoints were involved in the subsequently created Persona descriptions (cf. 3.1.3.2).

The study was designed to have direct in-situ observation two times a week with two weeks in between of reflection, participants' self-description and communication between ethnographers and participants. The first week

[2]The size of the organisations was classified after OECD standards. They employ between 30 and 20000 people.

[3]The size of the organisations was classified after OECD standards. They employ between 30 and 20000 people.

[4]According to OECD, IT intensity is derived from the relevance respectively the use of information technology for the organisations' primary business and thus takes into account the effort of investments into IT.

Table 3.1: *Characterization of the sample. Taken from Mature Deliverable D1.1 (Mature Consortium, 2009a)*

Organisation	Size (employees)	Sector	IT intensity	Country
Careers Scotland	large (>1,000 employees)	professional services	medium	United Kingdom
Connexions Kent	large (>300 employees)	professional services	medium	United Kingdom
GISA GmbH Halle	large (400 employees, in group > 10,000)	IT services (group: utilities)	high	Germany
Städtisches Klinikum Karlsruhe	large (4,000 employees)	health care	medium	Germany
Structuralia	small (30 employees)	professional services	medium	Spain
Swisscom	large (20,000 employees)	tele-communication	high	Switzerland
Synaxon AG	medium (130 employees)	IT	high	Germany

of fieldwork was dominated by learning about the participants, their daily work and obvious knowledge maturing processes. Furthermore, it was used to make the observed aware of what knowledge maturing is about. This was helpful, so that on the one hand they understood the point of our work, and on the other hand they were enabled to identify additional aspects and processes of knowledge maturing during their daily work. The two weeks in between were used to hold contact, to support the self-reflection of the participants and to pre-analyse the collected data. The ethnographers held contact to their observed persons and asked them to provide a self-description especially of their own reception of identified knowledge maturing processes. In the fourth week, the same ethnographers visited the organisations again, on the one hand to collect more data in general but on the other hand also to discuss about the participants' self-reportings and reflections and to conduct interviews to learn more about particular knowledge maturing processes and stories in the organisations.

3.1.3 Outcomes for Requirements Analysis

As described in the introduction to this section, the ethnographic study delivered valuable input. This thesis mainly makes use of the Persona descriptions in order to describe LME requirements and services. Based on the identified Personas, services will derived which may be used in order to create a Learning and Maturing Environment in a particular context. The process of Persona description as well as the service and requirements specification will be described subsequently.

3.1.3.1 Data-Analysis and Clustering Process

The data analysis of the study results was done by coding the field data by means of the software ATLAS TI. The codes were used to describe Personas. In the Mature project these Personas were used for specifying Use cases and subsequently requirements and services, cf. 3.2.1. In this thesis, Personas were also explicitly used to derive services supporting the Personas processes of knowledge maturing in their specific context.

3.1.3.2 Personas

The persona concept, proposed by Cooper (1999), is attracting a lot of attention in user centered design (Aoyama, 2007). A persona is a precise description of an idealised future end-user in a particular scenario. Their characters are fictional but should be based on actual existing qualitative field data (Pruitt & Grudin, 2003; Cooper & Reimann, 2003). Personas can complement the overall software requirements analysis and design process. Personas are a means of predicting and anticipating user reactions to a certain software design (Pruitt & Grudin, 2003). Users' goals, foci and needs are central points mediated and thereby personas form a central communication media within the development team (Pruitt & Grudin, 2003; Blomquist & Arvola, 2002). Decisions about functional and non-functional requirements and implementation are guided along the characteristics of used personas.

Within the Mature project personas have been created from the results of the ethnographic study. They were used to generalise individual observations (Mature Consortium, 2009a). Each ethnographer described a set of personas based on the observations within the study. Depending on identified behaviour and characteristics of people, a described persona may represent an extreme for one or more of them (Goodwin, 2002). Overall 17 characteristics were identified, which are related to dimensions of behaviour patterns and characteristics defined by (Pruitt & Adlin, 2006). An overview and explanation is listed in appendix A.1.

However, each persona represents a mash-up of one or several persons observed during the ethnographic study. Overall, 21 personas have been identified. All of them are described closely to the local context, in which their representatives have been observed[5]. Table 3.2 shows an excerpt of persona description as they were provided by the ethnographers. A complete example can be found in appendix A.2.

Table 3.2: *An excerpt of a persona description as provided by the ethnographers.*

Characteristic	Description
provided by	UIBK
name	Sally
motto	If I have not seen it working, I do not believe it anyways.
education and professional background	She has a Bachelor degree in Computer Science and has been employed for four years.
learning	Sally has to continuously acquire new knowledge to fulfill her tasks. Sally's demand for learning occurs during execution of work tasks. Usually, she learns during problem solving.
knowledge	She needs knowledge about, e.g., configuration parameters and their consequences, systems interfaces and underlying procedures or client decisions. Her tasks require a wide variety of knowledge and this volatile knowledge highly depends on involved systems and clients.
problem solving and other knowledge routines	If Sally has a problem and she needs knowledge to solve it, her first approach is to try something. In case of system functionalities, she changes several parameters and looks at the consequences. After some unsuccessful trials, she opens the system help or manuals. She has local copies of manuals and training presentations and she searches in her local data. By browsing through documents, she usually has some new ideas and starts some new trials in the system. Should these tests be unsuccessful as well, she starts searching in the Internet. She uses well-known developer pages or search engines to find relevant information. Again, she experiments with new solution ideas directly in the system and applies her search and test approach for a longer period of time.
communication strategy / approach to knowledge sharing	Sally principally dislikes discussions or other verbal interactions with her colleagues. If a discussion occurs in her office, she ignores it and concentrates on her current tasks. She likes clear task descriptions and therefore, writes tight e-mails that make the receiver understand if her/his request was imprecise.

[5] It has been decided not to generalise them from a global perspective in order to avoid the loss of understanding of Knowledge Maturing. Moreover, for developers it is obviously easier to have contextualized descriptions of people's characters.

3.1.3.3 Persona Analysis

Integrating personas into the software requirements analysis process enhances its value added and allows for a supplementary extraction of functional and non-functional requirements (Castro, Acuña, & Juristo, 2008) additionally to standard requirement tasks. Therefore, in this work a similar approach as proposed by Aoyama (2005) was chosen to extract functional requirements: Abstract software services were derived from the personas' characteristics. This was especially useful, as most described characteristics were contextualized and described quite detailed. Table 3.3 shows an example how services were derived from the descriptions. The characteristics

Table 3.3: *This is an example of the service derivation: Services are retrieved from the persona characteristics.*

Characteristic	Condensed description	Derived service(s)
Knowledge	knowledge about systems, definitions and client decisions	Visual decisions graph service
		Topic related people activity awareness service
Formal Training	likes task related trainings	Training Recommendation Service
Content Types	training materials on local disk; maintains collections of documentation, personal notes, emails, business proposals	Resource Search Service

were compressed and repeated in bullet point form to keep the origin of each service derivation and make it comprehensible (middle column). Based on these characteristics, services are described which are supposed to support knowledge maturing on the artefact, sociofact and cognifact level. The result of this analysis is a list of 73 services. As these are an essential result of this thesis, all services are presented with a short description in table 3.4.

Table 3.4: *List of all LME services derived from the Persona descriptions.*

#	Service	Short description
1	Topic or context dependent information and resources gathering and aggregation service	Information aggregation service that gathers automatically web resources and organisational resources and summarizes them
2	Context specific topic filter and access views	Service that provides different context-dependent views on the overall database
3	Client related information databases, information and resources gathering service	Information database which bundles resources about a specific client

4	Specific information database services	Service that delivers information based on a pregiven topic (market/business) or on the current context
5	Information source recommendation service	Service that recommends information databases for a specific topic
6	Resource Search Service	Service for searching resources in the internet
7	Organisations‘ employments opportunities collection service	Service that collects possible employments in different organisations as part of LMI data
8	Structure and hierarchy recommendation service	Service that recommends a resource structure
9	Project-status awareness service	Makes users aware of the progress of a project and current or upcoming tasks
10	People activity awareness service	Shows peoples last activities with respect to their work
11	Topic related people activity awareness service	Shows people activities that are relevant to the current work context (e.g. related to a task)
12	Topic related keeping-up-to-date service	Service that makes users aware of new resources and information regarding a specific topic
13	General keeping-up-to-date service	Service that provides a summary of organisational activities
14	Topic related resource awareness service	Service that makes users aware of new artefact related to a particular topic
15	Social Network Activities Awareness Service	Provides up-to-date information from people's activities in the social network
16	Topic related experience awareness service	Service that supports the context-depending reminding of shared experiences
17	Training Recommendation Service	Service that recommends formal training according to the current task
18	Resource Recommendation Service	Service that recommends resources according the current tasks, context or people
19	Event recommendation service	Service that recommends conferences and workshops
20	Private and Shared Frequently Asked Questions (FAQ) Service	Service to manage private and shared FAQs
21	Question and Answer Service	Service that provides the possibility to ask and answer questions
22	Data visualization service	Service that visually represents statistical data
23	Structure creation and management service	Service that supports the creation of hierarchies for a topic or given digital resources
24	Resource Ontology Service	Service supporting the semantic linkage of digital resources
25	Structure extraction service	Service to support the extraction of a hierarchy or structure out of given resources
26	Service Level Agreement Management	Service for managing Service Level Agreements
27	Process Management Service	Service for managing processes and its related entities
28	Event Planning Process Management Service	Service that helps users to plan certain events by making them aware of typical tasks, problems and solutions in that planning process
29	Task Management Service	Service for managing, comparing, optimizing tasks

30	Project Management Service	Service that supports standard project management tasks
31	Individual (formal and informal) task management	Service that supports individual task management and todo‘s
32	Collaborative experience management tool	Service for a shared collecting of work practices and experiences
33	Schedule Optimization Service	Service for optimizing the personal schedule
34	Process and Task Management Recommendation Service	Service that recommends patterns for documents or processes
35	Learning Path Reflection Service	Service that supports the reflection of the individual learning path
36	Experience Reflection Service	Service that supports the reflection of recent experiences
37	Process Reflection Service	Service that supports to reflect recent process
38	Protocol reflection service	Service that supports to reflect recent meeting minutes
39	Knowledge reflection and externalization service	Service to support the reflection and summarizing of employees‘ (soft) knowledge
40	Pattern Management Service	Service for managing report patterns
41	Graphic service	Service that allows to create visual representations of structures, facts or problems
42	Collaborative social networking service	Social networking service for communication and collaboration
43	Idea management service	Service for managing an idea database
44	Protocol management service	Service for supporting the creation and management of meeting minutes
45	Personal notes service	Service for creating and managing personal notes
46	Story Board Management Service	Service to support the creation of a story board in the context of creating learning courses
47	Pedagogy recommendation service	Service that recommends a certain methodology e.g. for a training course
48	Task annotation service	Service to support the annotation of tasks
49	Visual decisions graph service	Service that visually represents former project, design or client decisions and attaches a certain description to it
50	Shared organisational and personal resources access service	Service that provides important data in the cloud to be accessed from everywhere
51	Dissemination Service	Service that allows to assign shared resources to specific persons depending on their roles/tasks and the current context
52	Organisational resources access service	Service that provides locally restricted access to the organisational database
53	Resource Tagging and Annotation Service	Tagging service for tagging and annotating resources
54	LMI provision service	Service that provide specific LMI data
55	LMI development, sharing and presentation service	Service that allows to develop, share and present LMI data
56	Permissions Database	Service that controls system accesses
57	User Directory Service	Service that provides a register of all organisation‘s employees
58	People Tagging Service	Service that allows to assign tags to people

59	Personal information social network service	Social network service that provides information about tasks, attitudes, knowledge, interests, expertise of a person
60	Expert Recommendation Service	Service that recommends an external or internal expert for a problem or topic
61	People and Expertise Search Service	Searching internally/externally for experts/people
62	Skill Matching Service	Service that matches people skills to given opportunities
63	Artefact-Actor services	Service that supports the identification of relations between people and resources
64	Social network visualization	Service that visualises the relations of certain people to their nodes in the social network, including people, topics, expertise
65	Communication Service	Service that allows to discuss about a specific topic in form of a chat, forum, etc.
66	Remote (active) training and presentation service	Service for providing remote active training and presentations
67	Entity assessment service	Service to support the assessment of resources
68	Feedback service	Service to give feedback to certain entities
69	Statistical Data Processor Service	Service that is able to calculate statistical data, especially Labour Market Information (LMI)
70	automatic LMI data analysis service	Service that automatically analyses LMI data from different pages after specific criteria
71	Motivation Service	Service that supports the motivation of people in doing tasks or in making use of a particularrganisation software
72	Virtual Desktop Service	Service that provides a virtual desktop
73	Inter-tool communication service	Service that provides arbitrary tools the possibility of Inter-communication

The relation of these services to the characteristics of the 21 personas can be found in appendix A.

Regarding the level of abstraction of these services, the term “service” should not be regarded as a SOAP web service for example. In this context it is meant in a more general and non technical sense.

The level of granularity of those services listed in table 3.4 is quite different. For the implementation of some of them, rather a lot of additional context information and specifications are needed for an implementation (e.g. *2. Context specific topic filter and access views*) and for some others less context information is necessary (e.g. the *6. Resource Search Service*).

In order to make this set of services manageable, it will be clustered according to Knowledge Maturing Activities, which were fixed during the

Representative Study and which are described in the section 3.3.3.1. As part of the software prototype description in chapter 5, it will be shown, which of these services were implemented.

3.2 Contextualised Use Cases

The Use Case description process was an important activity in order to describe possible relevant features and functionality for an LME. Figure 3.2 denotes this process. As mentioned before, the Use Case description process

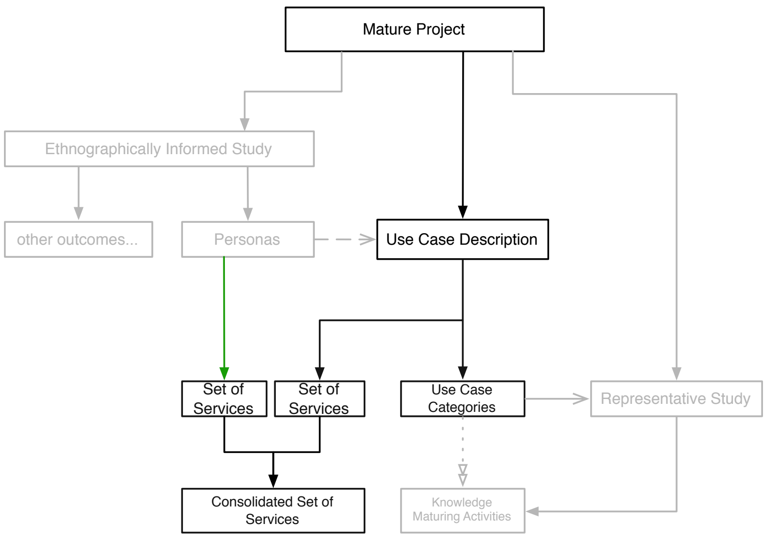

Figure 3.2: *Relation of Use Case description process to other results of Mature and this thesis.*

was a parallel and independent process. As indicated with the dashed arrow from Personas to the Use Case Description, there is a certain relationship between both. During the process of Use Case description, the authors have assigned Personas to the Use Cases. This should indicate, what kind of personalities and context the described functionality mainly addresses. However, different to the theory of Personas as a user centered design tool (cf. 3.1.3.2), they were not used to describe the use cases, there is only a loose relationship. Based on the created use cases, services were defined, which are necessary for their implementation. These services will be aggregated with those derived in the preceding section 3.1. Furthermore, these Use Cases were classified into different categories, which will serve later on for defining Knowledge Maturing Activities.

3.2.1 Use Case Analysis

Complementary to the ethnographic study and especially to the persona descriptions, it was part of the user centered design process to derive use cases, which are relevant to the application partner context. These were considered helpful for describing the system design and the system's role in knowledge maturation (Mature Consortium, 2009b, 2009f). The use cases were written in teams of project members where each team consisted at least of one ethnographer, one application partner representative[6] and one technical developer. Thus it could be ensured that the results of the ethnographic study were linked to real scenarios when describing a technical approach to support knowledge maturing. All in all, 47 use cases have been created and clustered into the nine following areas, which describe different types of knowledge intensive activities that are supposed to be supported:

1. Find relevant artefacts
2. Collect and structure information
3. Awareness of Changes
4. Getting an overview
5. Gardening
6. Discover, refine, and execute processes
7. Create, develop, and share content
8. Finding people
9. Communicating with people

These areas are relevant to the overall requirements analysis process and have a huge influence on the Knowledge Maturing Activity definition, described in section 3.3.2.

[6] Because of the project structure, we had direct contact to one application partner and indirect contact to another one via research partners that have a long tradition of co-operation with them.

Table 3.5: *The table shows an example use case.*

UC III.3: Keeping track of changes to collected information	
Short Summary:	The user is notified about changes in information sources and can recognise fast the amount and impact of these changes.
Category:	PLME
Authors:	Pablo Franzolini, Tobias Nelkner
Personas involved:	Sally
Description:	Sally likes to collect web info and arranges it according to her own personal preferences. However, if the information is changed elsewhere (a significant improvement on value) she would like to be made aware of such changes in order not to use outdated information. Not only the fact that something has changed, also the information what has changed and which impact the change has is relevant to her.
Problem statement:	Isolationist gets disconnected from the knowledge maturation process. Knowledge worker wants to be aware WHAT has changed.
Organisational aspect:	Support processes as KW are faster and more concretely aware of changes in documents, which can be also documents that are relevant in organisational processes.
Contextual assumptions and limitations:	Almost universal, although in case of notification of changes the KW wants to be aware of the concrete parts of changes and it's impacts.
Relevance to knowledge maturing and added value:	Contribution to knowledge maturing: Isolationist people tend to have their own local collections. This endangers to slow down maturing processes are they do not receive and are able to use updated material. This ensures that (a) they become aware of changes and (b) work on the most current information.
Maturing phases covered:	Formalization
Triggering event:	A document has changed and is in the scope of the personal or organisational knowledge base and is important for the knowledge worker.
Flow of activities	1. a document in the scope of a KW's knowledge base has been changed by someone 2. the KW gets a notification of the change and additionally the possibility to see a graphic what has changed and which impacts this has 3. the KW quickly recognises the changes and therefore is able to react on it specifically

Based on these use cases, services were specified, which were supposed to support knowledge maturing in the particular application context. An example Use Case is shown in table 3.5. Although these use cases played a key role in the Mature project's requirements specification process (Mature Consortium, 2009f), a revisable and repeatable methodology of use case specification was missing. Researchers from different background contributed to them. Software developer for example, came up with their ideas, experiences and interests that did not necessarily have any relation to the ethnographic study but more a relation to their (early) idea of knowledge maturation and their vision of how to support that. Researchers who were not directly involved in the study have also contributed to the design process based on their work experiences and visions. Thus, results from the ethnographically-informed study were not always the basis for the Use Case specification, although they have influenced the use cases to a certain degree. There is no indication whether these use cases cover all observations of the study. The weak relationship between the ethnographically-informed study and the minor uptake of study results in the software design process has turned out as weakness of the project. Time constraints between the work packages were the highest barrier for a better integration but it was hardly possible to correct that later on. Hence, the methodology of requirements specification followed in this work, i.e. investigating the personas and the use cases detached from each other, yields a rather more complete list of possibly important services for supporting knowledge maturing. However, it was tried to map the services derived within the project and described in (Mature Consortium, 2009b) and (Mature Consortium, 2009c) to those identified in section 3.1.3.2 (Personas) in order to identify overlaps and subsequently a complementary listing. The complete mapping can be found in appendix A.4. Finally, table 3.6 shows all new services extracted from the deliverables, which amend the list of services derived from the Persona analysis.

Table 3.6: *A listing of those services identified in year 1 of Mature, which have not already been derived from the personas.*

Mature-Service	Description
Metadata Storage Service	Acts as a storage repository for general metadata information associated with knowledge objects stored in other services.
Pervasive Permissions Database	Ubiquitously accessible database with graduated access permissions for the entire system to ensure privacy and confidentiality.

Access Moderator Service	Watchdog / guard service that acts as an intermediary between a user and other users' data, relying on the Permissions Database or (optionally/possibly) smart heuristics.
Search Persistence Service	Provides saved searches / smart folder functionality.
Introduction Service	Introduces two users previously unknown to each other but connected through their organisational or social network, using a safe and moderated approach.
Social Network Analysis Service	Processing and analysis of network structures and graphs to support the management and understanding of social networks by the system.
MATURE-enabled Communication Services	Mature-enabled versions of common place web communication platforms (forums, blogs, messengers, ...)
Context Awareness Service	Userspace analysis to determine individual working contexts and problem sets for users in the system.
Notification Service	Uses one or more of the communication methods available to the system to inform a user about events.
Context-Independent Artefact Assistant Service	Aids knowledge workers with forming relations from an artefact to its context or making an artefact independent of its context, enabling transplantation of artefacts from one context to another.
Media File Analysis and Extraction Service	Generates usable metadata from audio or video files so they can be better processed by other services.
Automatic Metadata Translator	Translates on-the-fly between various standards of metadata description.
Competence Management and Assessment Service	Passively tracks user's interaction with the system and the valuation of their generated knowledge artefacts, creating a competence profile, distributed by topic, over time.
Ontology overview service	The service displays ontology elements, together with user details and descriptions and how they are related to others. It shows a list with web resources, other users have associated with an ontology element. Additionally, users can explore related discussions. If a user needs more information and wishes to start a new knowledge maturing dialogue, the service proposes potential dialogue partners.
Adaptive execution service	Flexibly adds or removes tasks depending on user behaviour. Tasks can be assigned not only to organisational members, but also to clients.
Combination of modeled and ad hoc processes	Users are enabled to add resources or subtasks to a workflow-generated task. These resources or subtasks may be generated by users themselves or retrieved from a repository that stores data on historical tasks executed previously by other users (see task-related process support below).

Task-related process support	During the execution of a task, being it within a given workflow or in any other situation, provides information on previous related/similar tasks that other users have executed based on the work context of a user. This can happen on demand by the user or proactively.
Metadataservice	Supports annotation of artefacts with metadata during process execution.
Wiki structure service	The service visualises the structure of categories and relations in a semantic Wiki. The user can reorganise categories and relations via drag'n'drop. She/he can also rename them and delete and create new ones.
Ontology structure service	The service supports users with identifying candidates for cleansing of unused ontology elements or marking very similar elements.
Semi-Automatic process refinement service	At a later stage, the service also supports the transition between task patterns and process models. For instance, the combination of ad hoc tasks and modelled processes (see process support services above) can be exploited by observing which types of subtasks or resources users frequently add to a workflow-generated task. By providing aggregated information on user behaviour during workflow execution, the service supports the refinement of process models, frequently by adding subtasks pointing at amendments that need to be made to the process model.
Collaboration Initiation	Offers the facility to initiate easy collaboration with authors of articles or interested persons via skype without having to switch to another tool since it is embedded into a wiki and enables easier use. Users can send messages or web-links to wiki articles in order to support negotiation of and consolidation of artefacts. Additionally, within the visualisation of the wiki network, every user who is also an author in the wiki can be contacted by clicking on the node.
Maturing dialogue service	Supports the negotiation of ontology changes (e.g. splitting a concept in two) via dialogue games. In order to structure their discussion, users choose from specific Moves and Openers with which they start their contributions. At the end, the involved users can make a voting about the proposed solutions. After reaching a decision, the service supports users in implementing the decision with change suggestions. The dialogue is saved and linked to the relevant ontology elements.

3.3 Representative Study

Additional outcomes of the ethnographic study was an initial set of Knowledge Maturing Indicators (subsumed under “other outcomes” in figure 3.3). These indicators can be a means to identify processes and the status of knowledge maturing. This initial list of indicators was extended and requested in the Representative Study. This resulted in an approved list of general KMI, which can be helpful when contextualised and used in the services derived in 3.1 and 3.2 or implemented in Maturing Services as described later in

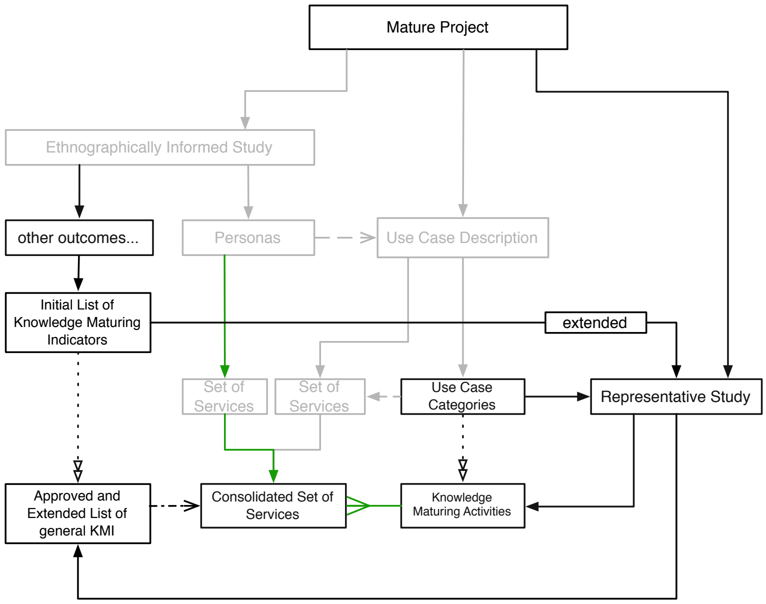

Figure 3.3: *Results and outcomes of the Representative Study. The green arrows depict those developments that are exclusively contributed by this work.*

4.3. Furthermore, the categories identified during the Use Case description process were transferred into a set of Knowledge Maturing Activities, which was approved during the Representative Study. This set served this thesis for clustering the consolidated list of services derived from the Personas and the Use Cases. Both processes, the transfer of indicators and activities (depicted by the dotted arrows) into an extended and final result, are described in the following sections.

3.3.1 Introduction

The ethnographically informed study described above, as a first of three empirical studies conducted in the Mature project yielded interesting results. This includes especially the concept of personas, which was used to develop the list of services that may support knowledge maturing and an initial set of Knowledge Maturing Indicators. The Use Case analysis yielded service descriptions and an initial set of Knowledge Maturing Activities. The Representative Study[7] refines some of these results. It aimed at gaining more

[7]The representative study was announced in Mature's Description of Work as a representative study. However, because of several cultural constraints against the *Cold-Calling-*

information about how knowledge maturing emerges, how can it be supported, what is the role of software and that of organsational measures. Knowledge workers from organisations of different size, culture, sector and knowledge intensity[8] were asked. The Representative Study was conducted on the basis of interviews between project partners and known interviewees or by calling employees of organisations arbitrarily (cold-calls).

3.3.2 Theoretical Approach and Conduction

For the study semi-structured interviews were conducted. The corresponding interview guideline consisted of open questions, leaving room for discussing important aspects of knowledge maturing in the different contexts and 7-point Likert-scaled[9] questions as well as a combination of both. Thus, a combination of qualitative - interpretive and statistical methods was applied[10].

In order to push the conceptual and technical development, the Representative Study was designed to gain a deeper knowledge of knowledge maturing activities, the division and applicability of the phases of the knowledge maturing model and of the knowledge maturing indicators. Hereby, information was sought on:

1. Perception of importance
2. Support from organisation and ICT
3. Perception of success
4. Tools and infrastructures
5. Barriers and motivational factors.

The points 1 to 3 are under special investigation with respect to concrete knowledge maturing activities. These are especially important in this work

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method, availability of interview-partners and time constraints, the study could not be conducted representatively; though, the label *Representative Study* was kept.

[8] The OECD defines knowledge-based industries with the help of certain indicators like the amount of money put for R&D, knowledge intensity is referring to an overall aggregation of indicators (OECD, 1996).

[9] Although mainly telephone interviews were conducted, a 7-point Likert scale was chosen for comparability with other studies in the field of knowledge management, knowledge development, knowledge sharing etc.

[10] For more information on the concrete design of the interview guideline, see Mature Deliverable D1.2 (Mature Consortium, 2010a).

for identifying clear needs and requirements that are reflected in services. However, interviewees were asked how they assess the aspects enumerated above for the knowledge maturing phases in their specific context. With regard to the knowledge maturing indicators, interviewees were asked whether they think that these indicators sufficiently express and represent knowledge maturing in their own personal context. The interview guideline can be found in (Mature Consortium, 2010a, pp.180).

3.3.2.1 Knowledge Maturing Activities

In Mature, Knowledge Maturing Activities (KMA) are defined as

> "individual or group activities that contribute to the development of knowledge within the organisation." (Mature Consortium, 2010a, p.30)

These activities are basically derived from the use case derivation process and a literature review. The nine KMAs identified in the use case definition process and already depicted in 3.2.1 are:

1. Find relevant artefacts
2. Collect and structure information
3. Awareness of Changes
4. Getting an overview
5. Gardening
6. Discover, refine, and execute processes
7. Create, develop, and share content
8. Finding people
9. Communicating with people

Hädrich (2008) identified in a series of interviews with knowledge workers a huge set of knowledge actions, which he grouped into a set of knowledge activities. These knowledge activities could be mapped to the nine shown above. In a refinement process, three additional activities were introduced based on Hädrich's results, namely: *Share and release digital resources*, *Restrict access and protect digital resources*, and *Assess, verify and rate information.* Furthermore, for the purpose of the study phone calls, the naming was slightly changed to increase the comprehensibility for people not involved in the creation process. This led to the set of Knowledge Maturing Activities used in the study and presented in table 3.7:

Table 3.7: *Knowledge Maturing Activities used in the study. This table is based on (Mature Consortium, 2010a, pp.32).*

Use case area	KMA used in interviews
Find relevant artefacts	Find relevant digital resources
Collect and structure information	Embed information at individual or organisational level
Awareness of changes	Keep up-to-date with organisation-related knowledge
Getting an overview	Familiarise oneself with new information
Gardening	Reorganise information at individual or organisational level
Discover, refine, and execute processes	Reflect on and refine work practices or processes
Create, develop, and share content	Create and co-develop digital resources
	Share and release digital resources
	Restrict access and protect digital resources
Finding people	Find people with particular knowledge or expertise
Communicating with people	Communicate with people
	Assess, verify and rate information

3.3.2.2 Knowledge Maturing Indicators

Knowledge Maturing Indicators might be an approach to operationalise and measure processes and status of knowledge maturing. They could be a means to follow and trace activities during which knowledge maturing might happen. Finding knowledge maturing indicators on an organisational guidance level is helpful to direct decisions regarding the use of tools or the deployment of experts or the implementation of certain strategies. On a technical level, indicators may help to give a hint to digitally represented activities, which are part of a knowledge maturing process. A (semi-) automatic detection of indicators can help to infer maturing processes from that. However, this detection is based on digital artefacts, like resources, processes or tracked user activities. Thus, the knowledge about the relevance of certain indicators and whether interviewees assess them as important and helpful, might directly influence the development of services for an LME and will contribute to the development of maturing services (cf. section 4.3). The ethnographically informed study came up with a preliminary set of indicators (Mature Consortium, 2009a). Before the representative study started, this set of indicators was revisited and extended with the help of the results of an online questionnaire given to associated project partners beforehand the Representative Study. This yielded a slightly changed and enlarged list of 38 Knowledge Maturing Indicators, which were asked to be confirmed within the Representative Study. These are depicted in table 3.8 and explained in more detail in (Mature Consortium, 2010a).

3.3.2.3 Study Sample

The sample of the study was chosen according to three characteristics: the organisations' size, principal economic activity and knowledge or technology intensity of the business sector. All these characteristics are classified according to the European standard NACE (Eurostat, 2008). The people were contacted mostly by cold calling, some organisations were also known industry partners of the interviewers. The overall stratification can be found in (Mature Consortium, 2010a, p.40).

The size of studied organisations was medium (50-249 employees) and large (>249 employees) according to the NACE standard. Small companies (<49 employees) were not considered. It was assumed that their representatives cannot sufficiently enough reflect on the perception of importance, support and success of knowledge maturing activities due to less systematic work processes and practices.

The principal economic activity of the chosen organisational unit or company was either *(Manufacturing) Industry* or *(Knowledge Based) Services.*

Table 3.8: *A list of 38 KMI that was assess in the Representative Study.*

A digital resource	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 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 resource
	has been the subject of many discussions
A person	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	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

The classification regarding knowledge or technology intensity of a certain business sector was aggregated in two different sets[11]: *Low (technology/knowledge-intensity)* and *High (technology/knowledge intensity).*

The selection of interviewees followed certain criteria the persons should meet. This selection should increase the probability of getting an overview of details for the entire organisation rather than for single departments. These characteristics refer to the workers' experience (also in the company) and

[11] Although Eurostat provides 4 levels of classification of the technology/knowledge-intensity, these were aggregated into two classes. Otherwise, the stratification sample had to consider more than 200 organisations.

the general topic of responsibility, e.g. knowledge management or human resources.

3.3.3 Outcome for Requirements Analysis

The results of the representative study highly enrich the requirements analysis of this thesis. Especially the findings regarding the support of Knowledge Maturing Activities are of special interest. Moreover, the results regarding the Knowledge Maturing Indicators are of concern for this thesis.

3.3.3.1 Knowledge Maturing Activities

Regarding the 12 identified KMA, interviewers in the representative study asked for their

- perception of importance
- support from organisation and ICT
- perception of success

Obviously, the most interesting findings are about activities that are deemed very important but not well supported and those considered important but perceived to be not or less successfully performed. Figure 3.4 shows the relation between the perceived support of a Knowledge Maturing Activity and its perceived importance. Quartiles of the level of agreement were used to create that portfolio[12]. The color-shading signals the relevance of sectors according to the defined strategy of developmental support.

This portfolio shows the importance of *(4) Familiarise oneself with new information*, *(11) Communicate with people* and *(10) Find people with particular knowledge or expertise* but also its well perceived support in organisations. Thus, on the one hand, these aspects always have to be considered when designing an LME. On the other hand well working solutions already exist and probably does not have to be re-invented. The other extreme clearly shows that the activities *(5) Reorganise information at individual or organisational level*, *(7) Create and co-develop digital resources* and *(9) Restrict access and protect digital resources* are of far less importance and

[12]Portfolios are based on a technique balancing potential risks (organisational, business management) based on two dimensions showing the relative relation between several items (David, 2001).

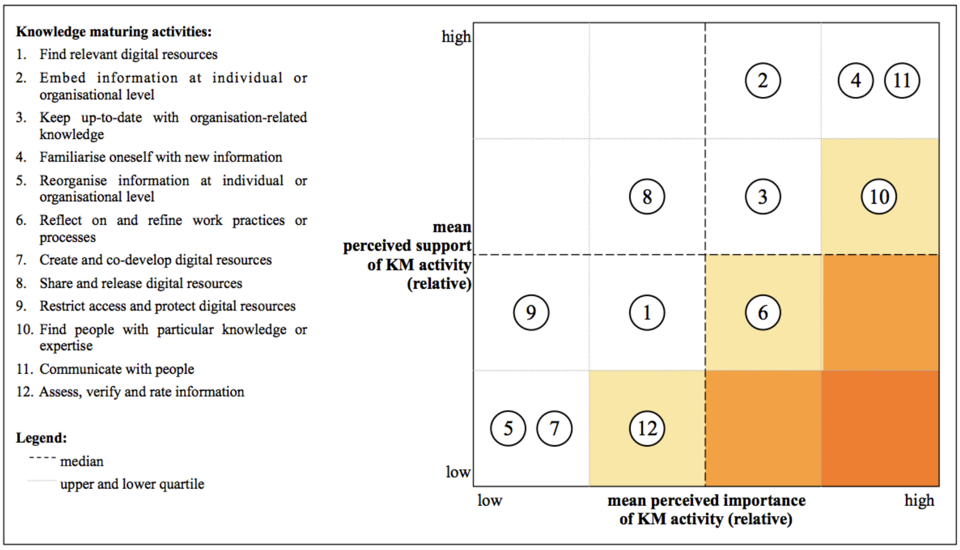


Figure 3.4: *The portfolio diagram depicts the degree of agreement to activities on both dimensions relative to the others. It is taken from (Mature Consortium, 2009a, p.65)*

probably due to that fact not well supported. *(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 of certain importance although the latter is the one, which is deemed less supported than the others. The activities *1* and *12* are perceived to be at least not unimportant and not very well supported. This is somehow ambivalent. From a theoretical point of view, reputation and trust systems like a star-rating for example are judged to be helpful in order to get a fast impression of the rated entity's quality, which also applies for information and resource quality (Metzger, 2007; J.¸Sang, Ismail, & Boyd, 2007; Ghose, Ipeirotis, & Sundararajan, 2007). Moreover, it can be assumed that people are now and then faced with that concept at least for product, hotel or online-shop ratings. Hence it is interesting that such a criterium is not chosen to be important for work-related information. Some reasons for that could be that people do not trust their colleagues or that they do not see an additional value as they know their resources or they do not have a long-lasting artefact development process or they simply do not know such an assessment approach in an organisational context. Similar to this, the result of the activity *Find relevant digital resources* is quite surprising as it is deemed not to be very important compared to the others although effective search mechanisms are typically one of the major challenges to be tackled with in modern knowledge management systems (Jackson & Williamson, 2011; Davies, Grobelnik, & Mladenić, 2009).

Figure 3.5 shows the mean perceived importance on the horizontal axis and the mean perceived success on the vertical axis. *(6) Reflect on and refine*

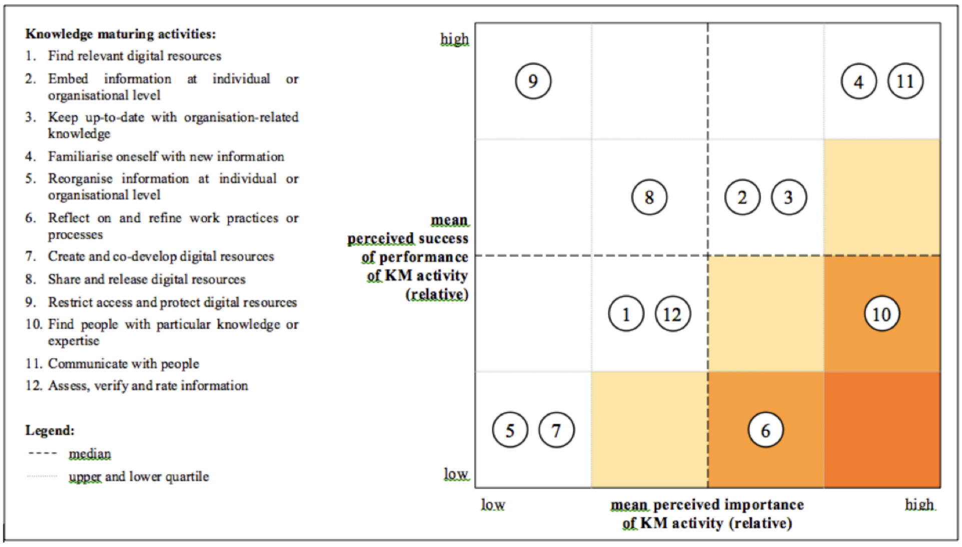


Figure 3.5: *The portfolio diagram depicts the agreement to activities on dimensions "Perceived success" and "Perceived importance" relative to the others. It is taken from (Mature Consortium, 2009a, p.67)*

work practices or processes and *(10) Find people with particular knowledge or expertise* are activities with little support and even less success but high perceived importance and thus an important candidate to be supported by an LME. Compared to that, *(4) Familiarise oneself with new information* and *(11) Communicate with people* obviously need to be considered in an LME but can be based on existing approaches as these are highly supporting both activities and are perceived as highly successful. Compared to figure 3.4, the activity *(9) Restrict access and protect digital resources* is perceived to be performed very successfully although deemed not to be not well supported. However, it is not deemed to be important at all. On the contrary, *(2)* is perceived to be well supported but not to be that successful. Furthermore, *(5)* and *(7)* are absolutely not deemed to be important nor supported nor successful. Thus, digitally-based collaborative work is either something many people are not used to or they are not aware of or they simply really do not favor it. Regarding gardening activities, the reason might lie in the fact that this is not really a typical and known collaborative work where each knowledge worker is involved. If important at all, most often an administrator is executing some management guidelines. All other users only have to follow the guideline and use the given structures. More successfully performed is the activity *(12) Assess, verify and rate information.* This shows that people are at least aware of such possibilities, although we will see also in the evaluation that rather few people perform this activity. The activities *(1)*, *(3)* and *(8)* are deemed to be performed successfully to the same degree as they are perceived to be supported.

Although knowledge maturing activities were mainly queried by quantitative 7-point Likert scale questions, interviewees had the opportunity to comment on the activities. The activity *(9) Restrict access and protect digital resources* provoked a lot of comments. People argued very differently here, as some think it is very important to save and secure organisational knowledge in order to keep a competitive advantage. On the other hand, they see a barrier here for knowledge maturing. This clearly shows that privacy and data security is a highly contextual question. Measures need to be taken according to the particular case. For the design of an LME, this needs to be considered carefully. A model that is open for knowledge maturing but can also restrict access to relevant organisational knowledge to certain user groups needs to be considered here.

3.3.3.2 Knowledge Maturing Indicators

Knowledge Maturing Indicators are an approach to operationalise and measure the process of knowledge maturing. This is not necessarily an automatic analysis but should be understood as a principal approach to make this objective more manageable. An initial set of potential indicators has already been identified in the ethnographic study, which was extended by a pre-study online questionnaire in advance of the Representative Study. Finally, the interviewees were asked about a set of 38 indicators, to which degree (on a 7-point Likert scale) they agree to an indication of knowledge maturing. Indicator are for example:

- A digital resource has become part of a guideline or has become standard.
- A person has a central role within a social network.
- A process was improved with respect to time, cost or quality.
- A digital resource has been edited by a highly reputable person.

The set of indicators are clustered into the four domains *Digital Resource*, *Person*, *Process* and *Combination* (combines the first three, like the last point in the listing above). Figure 3.6 shows the aggregated mean values of

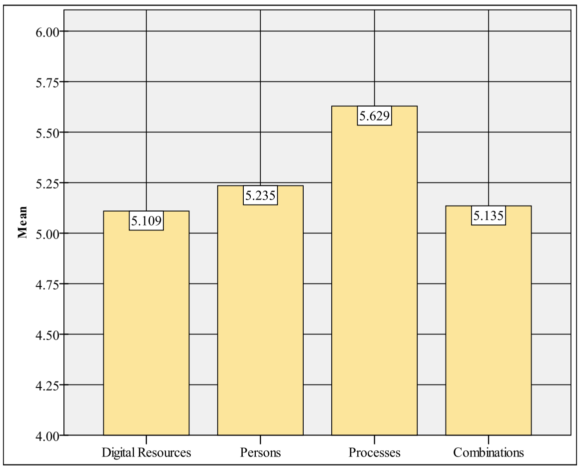


Figure 3.6: *Mean values of the four indicator clusters. Taken from (Mature Consortium, 2010a, p.76)*

the indicator dimensions in which all indicators were clustered. Although, the pair-wise difference between the particular values is quite low, according to (Mature Consortium, 2010a), the ratings of the process-oriented indicators and the person-oriented indicators were higher and significantly higher than the other two. Overall, interviewees *slightly agreed* to the presented indicators. A factor analysis revealed 13 higher level abstractions of the indicators (cf. table 3.9). Each of the 13 abstractions has one of three different types of occasion. Eight factors represent state changes due to single occasions of knowledge maturing events. One is indicating knowledge maturing only after multiple occasions of events. Three factors are representing knowledge maturing only over a period of time not through a specific event

Table 3.9: *Result of the factor analysis. Taken from (Mature Consortium, 2010a, pp.81)*

#	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 standardisation 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)

that occurred once. One is related to both, a single occasion of an event over a period of time.

3.3.3.3 Conclusion

Within the representative study more than 130 people were interviewed regarding the phases, activities, indicators and more topics which have to do with the huge field of Knowledge Maturing. With this study a variety of objectives were pursued: It was a means to improve the understanding of knowledge maturing, to test the applicability of the model, to identify barriers and engines of knowledge maturing, to test and identify high level activities according to their contribution to knowledge maturing and to test the indicator relevance used for (semi-)automatic analysis.

The most important results for the requirements analysis of this thesis are those of the Knowledge Maturing Activities analysis. The study revealed that the activities grasped from the ethnographically informed study are stable and complete in terms of selection and validity. Additional suggestions made by the interviewer could either be mapped to existing indicators or are referring to rather wider management strategies which are not activities (Mature Consortium, 2010a).

Considering the two portfolios discussed above, one might tend to classify activities into some priority schema according to their relevance. However, it is not clear how this could look like. In case the perceived importance of a knowledge maturing activity should be the main parameter for classification, one might exclude or neglect innovative ideas (e.g. a groundbreaking way for assessing information quality) as one would focus only on the current situation of the knowledge workers. If one would chose the actual perceived support for KMA, one might waste resources when implementing it, as the value added is too low. Hence, it would be important to do another analysis for the specific context. The activities found in the Representative Study can serve as a starting point then. It is to be expected that the results of such context specific analyses differ from context to context. Activities that are already supported well would probably not be as much prioritised as the unsupported ones. Therefore, the important point for the system design is the flexible architecture in order to be able to integrate existing solutions into new ones.

However, because of their high level of abstraction, the activities are not directly helpful to derive services from them, but it makes sense to map the services derived in section 3.1.3.3 (Persona analysis) and 3.2 (Use Case analysis) to these activities. Firstly, it makes the set of services more manageable as it assigns the 73 and 22 services to the justified 12 clusters. Secondly, it helps to identify possible gaps in terms of services supporting the different activities. Table 3.10 shows a summary of this clustering. The overall mapping can be found in appendix A.5.

Table 3.10: *Table shows the number of LME services mapped to each activity.*

#	Activity	# Services
1	Find relevant digital resources	7
2	Embed information at individual or organisational level	3
3	Keep up-to-date with organisation-related knowledge	13
4	Familiarise oneself with new information	4
5	Reorganise information at individual or organisational level	8
6	Reflect on and refine work practices or processes	18
7	Create and co-develop digital resources	10
8	Share and release digital resources	7
9	Restrict access and protect digital resources	2
10	Find people with particular knowledge or expertise	10
11	Communicate with people	5
12	Assess, verify and rate information	4
	not mapped	4
		95

The table shows that each activity is represented by at least two services, up to 18. However, the fact that some are under-represented compared to other activities is not an indicator for quality or completeness. This is rather a result of the empirical basis and would probably be different if the personas and the use cases were different.

Regarding the Knowledge Maturing Indicators, a quite stable and accepted set was found. Nevertheless, some of the indicators are highly controversial, e.g. *A digital resource has not been changed for a long period after intensive editing*, and yielded a lot of different comments, as it depends on the case specific interpretation. Here, the digital resource may be stable

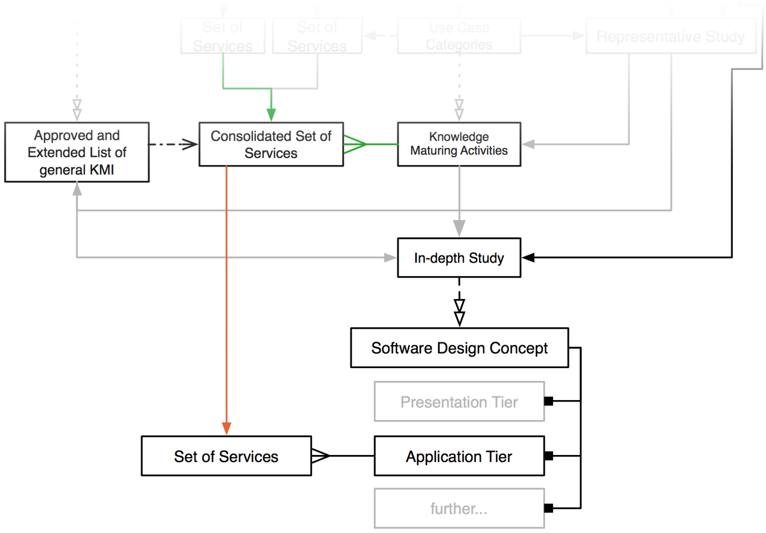


Figure 3.7: *Depicts the relevance of the KMI in the system design. Some relations between empirical results, which are irrelevant for this issue were blanked.*

and has a high quality. However, it can also be seen as obsolete, and thus turns out to be something very negative. Hence, the general message was that making use of such indicators for trying to measure knowledge maturing is highly contextual and depends to a high degree on the organisational culture. This also means, for the development of the generic concept of an LME, Knowledge Maturing Indicators are not of direct value, as it does not influence the core design (cf. figure 3.7). They are used in the services, which are instantiated in the application tier of the LME. Independent from decisions regarding the backend design and in how many tiers an LME should be logically divided, there would be always one tier that holds some kind of services. These services do not necessarily have to implement and make use of KMI. The most use of the indicators can make Maturing Services, which are subsumed in figure 3.7 under the "Set of Services" and which are described in section 4.3.

The implementation in services has to be carefully reviewed from case to case and probably needs to be adapted either in terms of activation or threshold parameters or even in terms of its meaning. Furthermore, where possible, it absolutely has to be considered, how different indicators can be coupled and weighted in relation to each other in order to reflect a possibly higher evidence of knowledge maturing processes. If an indicator for example states, a digital resource "was created/refined in a meeting", the resource might have a profound maturing status. However, this indicator alone may also fail if taken as decision basis. Thus it is necessary to consider additionally the information whether an author of the resource "has significant professional experience". In that way, one can think of combinations of KMI, which describe a certain context in a meaningful way regarding knowledge maturing. As already stated, two problems still have to be solved. Firstly, the relative weighting of each indicator and (more important), the indicators have to be contextualised to the application domain. That is to say, in the example above, it has to be quantified what it means to have "significant professional experience" and how that can be measured with respect to the local situation.

3.4 In-depth Study

The In-depth Study took relevant results from the Representative Study and implemented a series of interviews based on these results in order to gain more insights about the actual practice of knowledge maturing and the role and relevance of the KMI and KMA (Mature Consortium, 2011a). The outcomes were manifold and they showed that successful knowledge maturing depends on many organisational measures. Only a few of them can be implemented by means of an LME. Much depends on motivational activities, guidance measures, team building measures and more. Hence, this section about the In-depth Study focuses on those aspects, which can mainly contribute to the design of an LME. As depicted in figure 3.8, this comprises reasons, measures, barriers, and software used for supporting knowledge maturing.

3.4.1 Introduction

The In-depth study mainly based on the results of the representative study and the ethnographic study. The main objective of this third empirical study was to get a deep understanding of parameters which describe drivers and engines of organisational knowledge maturing processes. Moreover, it was sought measures for influencing these parameters systematically by management decisions and LME implementations. This includes fostering of positive

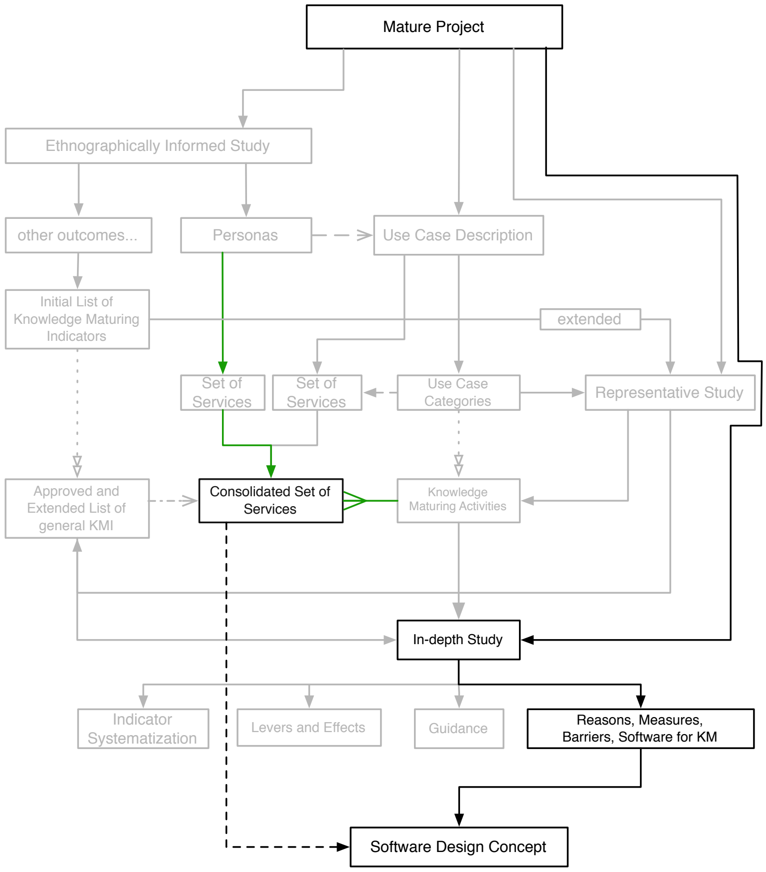


Figure 3.8: *Results of the In-depth Study. Those colored black are important for this work. The green arrows depict those developments that are exclusively contributed by this work.*

activities but also overcoming of negative barriers. Thus, we had a focus on guidance. This includes a further investigation of the role and validity of Knowledge Maturing Activities.

3.4.2 Theoretical Approach and Conduction

In order to cover the different aspects that may influence guidance activities, research topics have been defined that were part of all interviews. These are described in detail in (Mature Consortium, 2011a, pp.17):

- Performance: Reasons for performing knowledge maturing better than other. Why do people think that they perform KM better than others they compare themselves to?

- Organisation: Organisational measures that are deemed to support knowledge maturing. How is KM supported?
- Information Technology: IT-oriented measures that are deemed to support knowledge maturing. How is software used to support knowledge maturing?

The study was conducted by researchers interviewing people, who fulfilled different criteria. Mainly, knowledge workers were addressed that have a high degree of education, have a lot of experience in their work, are well connected with a high need of communication and who know their organisations (respectively in one case a network) well. The interviews were led using a semi-structured guideline. Open-ended dialogues were encouraged. In order to get a broad and detailed picture of the studied organisation, a snowball sampling was applied. Each researcher asked her/his contact person for other possible interviewees (also matching the criteria above) (Patton, 2002). Altogether 5 project partners have studied 6 different companies and a network. The number of interviewees ranged from 2 to 15 within one case but in 6 of the 7 cases, at least 5 people were interviewed.

In order to get a broad overview over all cases, a cross-case analysis regarding different topics was done, which is presented in the following section.

3.4.3 Outcomes for Requirements Analysis

The cross case analysis concentrated on deeper insights regarding Knowledge Maturing Activities and Knowledge Maturing Indicators, on further requirements for the tool development, and on new insights into a model of guidance and the motivational model[13].

3.4.4 Cross-case analysis

The cross case analysis was conducted along the 5 different research questions presented in 3.4.2. The following subsections will condense the results to aspects important for the requirements analysis.

[13] The guidance model and the motivational model are important aspects of the Knowledge Maturing model landscape. Although both refer to important aspects of supporting knowledge maturing, this work does not focus on them. Both views on knowledge maturing can hardly be implemented in software, they rather provide insights that can be used for providing in-organisational consultancy.

3.4.4.1 Reasons for better knowledge maturing

For this first topic, 9 reasons influencing knowledge maturing were found, the following 3 are deemed less important for this work, as the reasons presented there can hardly be supported by software but are rather important for consultant activities (with respect to "willingness to share knowledge"). These are:

- Best practice model to improve workflows, tasks or processes
- Employees' willingness to reflect on the nature of Knowledge Maturing itself
- Willingness to share knowledge

However, the following 6 reasons strengthen the relevance of some already proposed services.

- **Informal relationships**: Almost all cases revealed the importance of a constructive discussion culture including informal networking and positive relationships between employees in order to foster the distribution of ideas and information. Thus, this culture should be supported by providing informal communication channels, either by including e.g. instant messenger or by connecting to social network software of a certain kind (e.g. Facebook[14] - externally, or Edmodo[15] - internally). Particularly, the KMA *Communicate with people* and *Share and release digital resources* are related to this point and should be considered when trying to achieve a sustainable support.
- **Accessibility of knowledge**: This aspect was pointed out to be very important in over almost all cases. The interviewees of the studied organisations want access to their resources via internet, intranet but also via persons as hubs. More specifically due to implementing Web 2.0 tools (mostly Wiki) together with individual "old fashioned" databases, shared file systems, or project-databases, an open culture of providing knowledge is fostered. Many approaches exist, which support employees in accessing organisational and organisationally relevant resources. In terms of KMA, this reflects the need for supporting *Find relevant*

[14] www.facebook.com, last accessed on 31.10.2011
[15] www.edmodo.com, last accessed 31.10.2011

digital resources (which was not perceived as very important during the representative study), *Embed information at individual or organisational level* and also *Share and release digital resources*. Nevertheless, a conflict exists to the activity *Restrict access and protect digital resources*, which needs to be considered carefully in such organisational settings with the need for omni-available information.

- **Availability of different channels for sharing knowledge**: Sharing knowledge was often related to communication. Thus, channels do not only refer to databases delivering artefacts. They enable communication about artefacts or topics and shape the social network in building Communities of Practice. Software should not build up or foster existent barriers in organisations (Gilchrist, 2007; Levy, 2009). In terms of software requirements, this is important as resource management should not be treated in an isolated way, it needs to be connected to communication channels. As already mentioned, this is related to Knowledge Maturing Activities which refer to communication and to resource access. However, it shows the necessity to give people the possibility of sharing different information in different contexts in a different way. On the one hand, this could also lead to a scattered and ineffective use of different channels as people do not become aware of the most relevant or mostly used channel. On the other hand it could be assumed that some kind of social and cultural pressure helps the community to commit itself to best practices of using the different channels in the different contexts.

- **Employees' attitude towards Knowledge Maturing Activities and their awareness of it**: Organisations perform differently regarding the intra-organisational awareness of certain KMA and their results. Some consider it fruitful to do work twice, as it provides different views on the same thing. Others introduce a quality management approach to improve formal processes or support the personal development by revealing possible learning objectives. In an LME awareness could be fostered by using recommendation systems, pointing to the next process steps, relevant resources or important persons. This is covered by the activities *Keep up-to-date with organisation-related knowledge* and *Familiarise oneself with new information*.

- **Mechanisms de-freezing thought patterns**: Reflection on work processes and practices is very important. Organisations try to achieve this by pushing people to externalize their experiences with the help of Web 2.0 media, e.g. a blog, twitter or wiki articles. Another approach is the frequent change of roles of team members, which fosters perspective dependent problems, solutions and strategies. Thus, this aspect of reflecting work practice should also be considered when designing an LME. The latter idea of changing roles is not very easy to implement but could be fostered by making aware of boundary objects and supporting their creation and use in order to become aware of different points of view (cf. 2.4.6 and Star and Griesemer (1989)). Thus people need to *Reflect on and refine work practices or processes* (KMA #6) and would probably benefit from some kind of software which supports reflection processes. Some ideas how this could be realised are presented in section 7.2.1, where some first approaches and results of the European Commission (EC) co-funded MIRROR project are shortly presented.

- **Community of practice offering advanced training and expert finding**: Finding the right people for the right tasks is always important, problematic and is highly demanded in organisations. Some organisations already provide intra-organisational expert finding systems, allowing to identify people with certain skills based on former projects or traditional training courses. As employees have free access to these, a kind of community of practice has evolved, connecting different people within the organisation. Going beyond traditional competence management systems and including the people tagging approach should be thoroughly considered and evaluated (cf. 5.1.2). There is a great demand to support the activity *Find people with particular knowledge or expertise.*

All in all, these reasons for better knowledge maturing strengthen the insights regarding the Knowledge Maturing Activities found in the Representative Study. Interestingly, three activities are not covered by the points mentioned above, these are:

- Reorganise information at individual or organisational level

- Create and co-develop digital resources

- Assess, verify and rate information

These are exactly the three KMA which are perceived not to be supported at all and almost not to be successfully performed at all. Furthermore, they are not considered to be very important compared to the others (for both cf. KMA discussion in section 3.3.3.1). For some reason, there seems almost no awareness of these activities in organisations. Another reason might be that they are actually not relevant in knowledge workers' work context or they were possibly misinterpreted in both studies. The first one is a typical gardening activity that is demanded and needed when department- or organisation-wide structures are introduced or emerge, e.g. a file structure, wiki structure, or a folksonomy (Braun, 2012). Folder hierarchies need to be changed and tags renamed or deleted. It might be possible, that people are not used or allowed to do such things collaboratively but rather see this in the responsibility of an administrator. The second, "creating and co-developing digital resources" refers to basic collaborative work. Text documents and presentations developed in common or collaboratively edited wiki pages are typical examples here. As wikis play an increasing role in organisational knowledge management and learning (Standing & Kiniti, 2011; Moskaliuk & Kimmerle, 2009; Bughin, Chui, & Miller, 2009) and the collaborative work on artefacts can hardly be new, no obvious explanation can be given here regarding the negligence of this activity. It may even be that it is normal for people to have such well-practiced (informal) processes for this activity that they do not see the necessity to consider it specifically. For the third and last activity, the reasons might be twofold. The concept as such is new and especially in an organisational context not a very typical activity. Additionally, workers typically have a quite clearly limited and small audience for the created documents (for example department leader, department colleagues and clients). Hence, even if technically possible, there might be a social and cultural barrier to provide assessments. A critical mass of participants might be missing, which probably leads to a complete break off of such activities.

3.4.4.2 Current measures for knowledge maturing

Measures found in the different studies were mostly supported by a management level. For example, installing a supervisor for locally distributed teams (as a kind of a boundary spanner, cf. 2.4.6) or organisationally arranged regular meetings are important ways of supporting KM by the management. Nevertheless, more insights regarding a technical support of knowledge maturing and KMA could be found. The following list of aspects reflects support activities that can be considered during a system design.

- **Provision of IT**: This is a general issue that mainly points out the awareness of the importance of software for the support of knowledge maturing. It should allow the support of (informal) learning, process management, communication and collaboration or securing organisational resources, etc. It is a basic and essential precondition for supporting knowledge maturing.

- **Formal Training at regular intervals**: Regular formal training is considered to be very important. In order to define the objectives of training, competence profiles are compared to the needs relevant in a project or the overall organisation. In one example, balanced scorecards are used for this[16]. These comparisons of needs, identification of competences and objectives for advanced training can obviously be supported by software. Various approaches exist to transfer the balanced scorecard principles to computer software (Marr & Neely, 2003). Furthermore, recommendation systems can be used to support the identification of gaps between requirements and actual experiences of employees. This could be based for example on tag based expert finding systems or project annotations and competence profiles, cf. (Braun, 2012; Reichling & Wulf, 2009; Ley & Albert, 2003) and section 5.1.

- **Technology-enhanced boundary objects**: This is also not referring to a measure but could be a tool to support the discussion between different "social worlds", cf. 2.4.6 and (Attwell, 2010; Preisinger-Kleine & Attwell, 2010). Technology-enhanced boundary objects was circumscribed with:

  > "Effective learning could follow from engagement in authentic activities that embedded models which were made more

[16] The Balanced Scorecard is a management tool to support the measurement, management and documentation of organisational activities along a long-term strategy. This is achieved by defining operational goals, which are then quantified. After a defined period of time the outcomes are measured in order to check the results against the targets (Kaplan & Norton, 1992).

> 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), providing software based individual and organisational learning resources." (Mature Consortium, 2011b, p.58)

Additionally, it might probably make sense to install a person serving as boundary spanner, knowing both worlds.

- **Collaborative activities to increase a group's performance within a company**: This aspect especially stresses the importance of awareness of social activities. Awareness leads to knowledge about colleagues' tasks, where they are, which tools they are using, which resources they edit, which experience they have, etc. This is a basic requirement for creating Communities of Practice and should be supported by software as far as possible (cf. CoP in 2.4.4). Employees could be made aware of changes of specific documents, of (electronic) discussions led about certain issues, presence of people in virtual team rooms or communication facilities and more. This supports the informal and spontaneous information exchange and leads to the creation of sociofacts.

- **Written or unwritten rules which contribute to efficiency and effectiveness of communication**: An LME should support users in being aware of whom to contact for which reason. This can be one defined person but also a distributed team for different aspects (cf. ZPD in 2.4.3). Software should help to find the right person. This could be done by considering strict rules or by trying to derive informal rules (e.g. with the help of Maturing Services, cf. 4.3). On a more standardised level this also includes processes and the related certain tasks. A process management system should recommend the next step based no the current results. This may include contacting people but also finalising the process by publishing a document.

- **Performing benchmarks, initiatives enabling awareness and orientation for quality management**: It needs measures for the reflection on organisational processes. Although these aspects are mainly settled at the management level, it could be supported by software in various ways in order to raise even more awareness of the quality and the consequences of completed tasks. It also improves the transparency of the processes and of action-result relationships. In one example, Key Performance Indicators (KPI) were gathered in order to calculate the success and efficiency with respect to different targets[17]. Raising the awareness of changing KPIs due to specific employee activities could be a means of improving the reflection on strategies.

The study results clearly show an awareness of the importance of supporting knowledge maturing. Furthermore, it confirms the relevance of the knowledge maturing activities introduced before. Many of them were deemed important, as *Communicate with people*, *Keep up-to-date with organisational knowledge* or *Share and release digital resources.* However, some other still might have to be brought into the focus of organisations, such as *Find people with particular knowledge or expertise* or again *Create and co-develop digital resources.*

Apart from the technical approaches, it shows that organisations want their employees to engage in informal and formal learning activities, that they communicate with each other, that they reflect on processes and improve them and that communities of practice emerge.

3.4.4.3 Software used for knowledge maturing

In terms of creating and providing an LME, existing software appeared to be a huge implicit barrier of knowledge maturing. Most cases show a very heterogenous and diverse Information Technology (IT)-landscape not implemented with a holistic view on knowledge maturing in mind. At some companies, employees use the whole MS Office suite in order to create documents, visualisations, data wrapping and communication (e-mail). For sharing their new ideas and insights, they change over to a Wiki or an organisation-specific database. For managing, changing and reflecting on work practice and processes, employees are then forced to use the organisational and often branch specific software systems. Hence, without an LME implementation, users already have to cope with media disruptions due to the scattered software

[17] KPI are used for measuring performance and efficiency of critical parts of organisations with respect to prior defined strategic goals. This can include single processes as well as whole departments or other sectors of a company, cf. (Parmenter, 2009)

landscape, which can be a huge barrier for knowledge maturing. Consequently, it is hard to provide a software system, which is complementary to the existing landscape and which is not increasing the perceived complexity but rather lowers barriers for knowledge maturing support.

Having the historical dominance of scattered stand alone (sometimes over-specialised) software in mind, companies are now facing the challenge of incorporating software which supports communication, collaboration, and idea exchange. However, employees are not always able to adopt new software into their work practices and processes. This might be either due to personal attitudes and resentments or due to a missing seamless integration and a perceived negative influence on their own work efficiency. Furthermore, often people are not aware of the long-tail effects of co-operative approaches (C. Anderson, 2004; Ravenscroft, 2009). This means for an LME that the design needs to be adapted to the context of use, so that it provides a directly perceived value added. Where possible, it should be integrated into the systems, which are already in use. This avoids an increase of the perceived complexity of the organisation's tool landscape. Furthermore, guidelines are needed to introduce a new system, especially in order to facilitate employees' motivation and understanding of the relevance of the new software product. Such guidelines have to consider gathering of user requirements, the offering of training and the provision of sustainable support (Bansler, Damsgaard, Scheepers, Havn, & Thommesen, 2000; Kyratsis, Ahmad, & Holmes, 2012).

The feedback of the interviewees regarding this topic of the cross case analysis was not really new or surprising. For the sake of completeness, the following list wraps up the used software stated in the different studies (cf. (Mature Consortium, 2011a, pp. 62)).

- **Communication and collaboration software** is used and includes: Blogs, Bulletin Board, Forums, Wiki, Chat, Video- and telephone conferencing software,

- **Resource databases**, which could be a context specific self-development or a bought software: Certain databases for saving and accessing resources, DMS, MS Sharepoint, MS Access

- **Self-developments or branch specific software**: Branch specific software (e.g. car construction), Self-administrated intranet pages, Self-developed macros

- **Task specific software**: Eclipse[18], Lotus Notes[19], CorelDraw[20], Adobe Reader[21], MS Visio[22], MS Project[23], MS Office[24]

It is evident that the overall software design and implementation process needs to consider the existing tool landscape. Furthermore, it has to involve the end users over the whole process. On a long-term it has to be sustainable in terms of training, support and requirement-based adaptations. During the implementation phase, people have to be enabled to recognise current gaps that have to be closed. They need to learn new concepts, should be incorporated in the software design and have to learn to work with it (Vredenburg, Mao, Smith, & Carey, 2002; Venkatesh, Speier, & Morris, 2002; Gunther, Janis, & Butler, 2001).

3.4.4.4 Further Results of the Study

As already depicted in figure 3.8 at the beginning of this section, further valuable results were found. This comprises especially the concept of "Guidance", "Levers & Effects" and the "Knowledge Maturing Indicator Systematisation". All three topics do not play a role for the system design, as they can not serve for deriving requirements. They are rather helpful for the implementation and support of Knowledge Maturing in practice as they address context-based management strategies. It was already described that guidance of knowledge maturing plays a huge role for implementing an LME in an organisation. However, apart from software implementation, strategic and management measures need to be guided in order to convey the organisational goals.

The Knowledge Maturing Indicator systematization reflects a taxonomy of maturing indicators and can be also used as a strategic tool. Moreover, they can be useful for the design of Maturing Services. Although they are very abstract, it might be helpful for the in-situ identification of specific contextual knowledge maturing indicators in a particular context of an organisation.

[18] http://eclipse.org/, last accessed: 03.11.2011
[19] http://www-01.ibm.com/software/lotus/products/notes/, last accessed: 03.11.2011
[20] http://www.corel.com/corel/product/index.jsp?pid=prod3670089,last accessed: 03.11.2011
[21] http://www.adobe.com/products/reader.html, last accessed: 03.11.2011
[22] http://office.microsoft.com/en-us/visio/, last accessed: 03.11.2011
[23] http://www.microsoft.com/project/en/us/default.aspx, last accessed: 03.11.2011
[24] http://office.microsoft.com/en-us/, last accessed: 03.11.2011

The description of all results can be found in (Mature Consortium, 2011a, sections 5.2, p.88; 5.3, p.97; 5.4.4, p.109)

3.4.5 Conclusion

In all case studies of this in-depth study, it seemed that interviewees had quite a good understanding of what knowledge maturing is and how it is influenced, positively or negatively. Thus, barriers, measures and software for knowledge maturing could be identified. Furthermore, for the KMA described in section 3.3.2.1, additional justification could be found. Although a priority of certain KMAs can not be provided, those that are perceived very important (*Familiarise oneself with new information*, *Communication with people*, *Find people with particular knowledge or expertise*) were stressed quite often. Rather open questions leave three of them, for which no further evidence of higher importance could be found, namely *Reorganise information at individual or organisational level*, *Create and co-develop digital resources* and *Assess, verify and rate information*. This does not necessarily mean that these activities can not play an important role as such, but it is not clear to which degree they really support knowledge maturing.

However, all in all, designing the LME along the KMA is well justified and confirmed by this cross-case analysis. However, huge differences exist in the various application contexts with respect to pre-conditions, objectives and integration that need to be considered, when implementing a new software approach in an organisation.

Apart from technical implications, the in-depth study also showed that a lot of guidance activity is important in order to introduce a new software system, especially one which is supposed to become central for goal-oriented learning within the work context. This has to be part of a user-centered design process taking into account concrete problems and requirements users have, comprising functional as well as non-functional requirements. This shows again abundantly clear that it is not possible to derive design criteria directly from theory. One has to formulate hypotheses on which base software can be designed (cf. 1.3). This might happen more or less context specific, depending on the particular situation. However, the software development in the MATURE project was implemented in a user centered design process. The procedure of this development model, its results but also a reflection on that process, its advantages and disadvantages, its barriers and engines is presented in the next section.

3.5 Participatory Design Process

The participatory design process of MATURE helped in two ways, as presented in figure 3.9. Firstly, the on-site experiences made during that process have helped to decide for a particular backend architecture design, which will be described later in section 4.2. Secondly, this process helped to gain context related information for designing the prototypes, which have been developed in the course of the project (cf. 5). Thus, this section will shortly describe the process and the main outcomes.

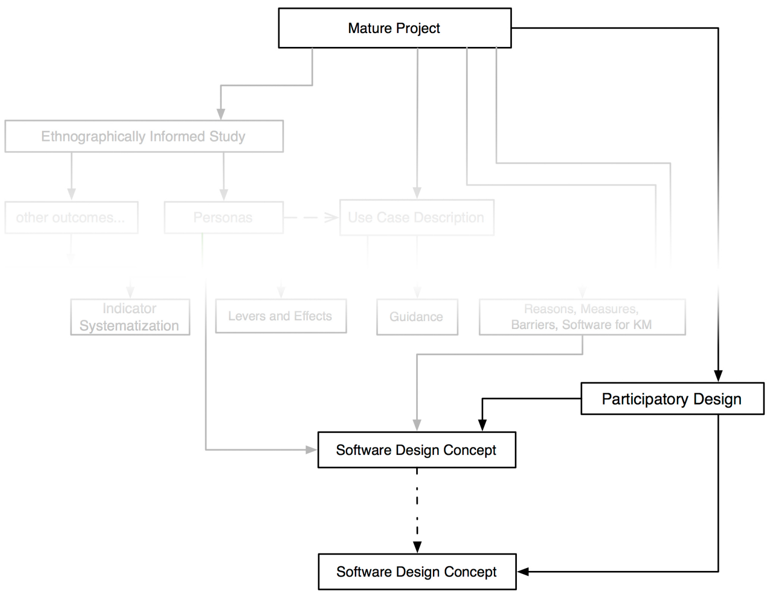


Figure 3.9: *Impact of the Participatory Design Process. Some relations of the empirical studies were blanked in order to keep the readability of the figure.*

3.5.1 Introduction

Apart from the studies and the input of experts in form of the use cases, the software development of the MATURE project was intensively following a User Centered Design (UCD) approach. The demand was to develop software applications that are strongly embedded into the project's application partners' context. These partners were searching for ideas and for software that supports work-integrated and distributed learning within their context and were willing to participate in the design iterations. Thus, this section reports about the basic ideas and background of UCD and its implementation in the project, especially regarding those activities which have influenced this thesis to a great extent.

3.5.2 User Centered Design

User Centered Design (UCD) was initially presented by Norman and Draper (1986) as a new approach to a collaborative system design of future users and developers. Hence, UCD should play an important role in usability engineering (Vredenburg et al., 2002). It can be defined in a broad sense as " [...] the practice of the following principles, the active involvement of users for a clear understanding of user and task requirements, iterative design and evaluation, and a multi-disciplinary approach." (Vredenburg et al., 2002, p.472) Several methods exist and they are quite well operationlised but typically (especially in organisations) the cost-benefit tradeoff determines the method applied (Gunther et al., 2001). According to Vredenburg et al. (2002) the following methods are commonly used, although it is explicitly stated that they are not necessarily the most effective ones.

- **Iterative design:** The software design is iteratively discussed with future end-users.
- **Usability evaluation:** Certain usability methods are (regularly) applied, e.g. cognitive walkthrough, or respective questionnaires, cf. (Holzinger, 2005)
- **Task analysis:** Typical tasks for certain roles in the organisation are identified, how they are performed and how they should be performed in the future. Moreover, it is assessed for which role the highest relevance exists. According to this analysis, a requirements and priority list is created.
- **Informal expert review:** Internal or external experts are interviewed and asked for input regarding a particular design.
- **Prototyping on paper or other media:** Based on the individual perspective, developers have on the software target context, paper

prototypes or mockups are created and discussed with the end users (Sefelin, Tscheligi, & Giller, 2003; Snyder, 2003; Memmel, Reiterer, & Holzinger, 2007)[25].

A very effective but quite costly and time intensive example of an UCD method are field studies, where developer do ethnographic work in the work context in order to derive requirements. Apart from the costs, the choice of the actually adopted method highly depends on the application context. However, UCD methods have a huge positive influence on professional software development in industry (Vredenburg et al., 2002; Mao, Vredenburg, Smith, & Carey, 2005; Venturi, Troost, & Jokela, 2006).

3.5.3 Design Work with Application Partners in MATURE

3.5.3.1 Application Partners

During software development, not all of the activities (detection, design, development) are typically implemented with user involvement (Vredenburg et al., 2002). In the MATURE project this was tried and almost achieved at least with one application partner. The role of the application partner is to collaborate with the research and development teams and to spend resources in the co-operative design and contextualisation of research software prototypes. These prototypes are evaluated formatively and summatively within the application partners' organisation. Of course, this results in a software design, which is very unidirectionally designed.

Generally, the project had three different application partners: Connexions Kent, Careers Scottland and Structuralia. Due to financial and political reasons, Careers Scottland had to drop off and was replaced by a similar institution: Connexions Northumberland. It follows a short description of the application partners and their typical work, taken from the respective project deliverable:

- **Connexions Kent** "is a service providing free impartial and confidential advice, guidance, support and personal development services to all 13-19 year-olds, and to those up to 25 who have learning difficulties

[25] Mockups are software prototypes, which typically do not provide any functionality apart from presenting the design and navigation through the software; they are also called *disposable prototypes*.

and disabilities, throughout the county of Kent." (Mature Consortium, 2009b, p.31)

- **Connexions Northumberland** "is a local service for young people aged 13-19 years (up to age 25 for people with special needs). It helps with decision making about study, jobs and careers by offering impartial information, advice, guidance and personal support." (Mature Consortium, 2010b, p.79)

- **Structuralia** is a "[provider] for e-learning material for the construction branch in Spain." (Mature Consortium, 2009b, p.31)

3.5.3.2 Design Iterations

Table 3.11: *User centered design activities in the course of the project for the development of SIMPLE.*

Project Year	Activity
Year 1	Design Studies: APOSDLE Design Studies: Semantic MediaWiki Design Studies: Interacting Widgets
Year 2	Mockup Evaluation Workshop First Software Walkthrough
Year 3	Formative Evalution: Series of 3 workshops Formative Evalution: On-site workshop Intermediate Evaluation and Design Workshop
Year 4	Summative Evaluation

According to the different implementation strands in the project, not every software development team was co-operating with every application partner. This was spread. This thesis was heavily influenced by the development activities for Social Interactive Mashup PLE (SIMPLE) (cf. 5.3). This prototype, which is also the subject of the evaluation case studies, was mainly developed in co-operation with Connexions Kent (CK). The software was designed from scratch in several iterations depicted in table 3.11.

In the first project year, mainly technical tryouts were developed and discussed, called Design Studies (DS). The APOSDLE[26] design study has its origin in the eponymous EC co-funded project (S. Lindstaedt & Mayer, 2006). It was about testing potential approaches to developing so called maturing services. These are backend services that are supposed to visualise,

[26]Advanced Process-Oriented Self-Directed Learning Environment

support and foster knowledge maturing (cf. 4.3). The Semantic MediaWiki study was accomplished in co-operation with CK. It aimed at finding out whether a wiki approach is suitable to create a knowledge base by making use of technical semantic structures for linking people and resources. Furthermore, information about quality (e.g. readability, completeness) and contextual relevance as part of recommendations and awareness should be calculated by means of Maturing Services (Weber et al., 2009).

The second year was dominated by the development of a first version of the LME. First a mockup workshop was organised. Developers came up with many ideas for functionalities the LME should have in the context of CK. Together with practitioners it was discussed, what is useful, what should be changed and what is not useful at all. The results of this workshop informed the development of the first version of the LME. That was presented in a second workshop in the same year to the practitioners again. This meeting allowed the developers to discuss the setup, to gain experience in practical use and to collect first experiences regarding usability questions. Although, the practitioners were asked to estimate whether the software had the potential to support knowledge maturing, no valuable information could be gathered here. However, the meeting was important to foster and drive the further development process.

In the third year, the formative evaluation was implemented, which was a formal part of the project. This evaluation was implemented in two major steps. First, a series of three workshops was organised in which the practitioners used the software in groups and fulfilled certain tasks (Mature Consortium, 2010d). Each day was ended by summing up and collecting the experience they had gained. A few month later, another workshop was organised, this time attended by a developer. The objective was to collect information about the usability, therefore a two-fold strategy of videotaping and thinking-aloud was applied, followed by a group discussion. The formative evaluation was very helpful as we found out a lot about the usefulness of the software. Furthermore, we got an idea of its possible impact on knowledge maturing and further important information, e.g. we had to refine the backend conceptualisation, cf. section 4.2. The most relevant results for this work, which are partly requirements, are discussed in the following section. As part of the regular UCD process with CK, an intermediate software test was scheduled in order to collect and discuss the progress and new developments of the recent LME version.

The project's year 4 activity was mainly the conduction of the summative evaluation. The setup and results are discussed in the evaluation chapter 6. Due to time restrictions, it was almost not possible to feed back the results of that summative evaluation in the course of the project.

3.5.3.3 Results for the Development Process

The summative evaluation allowed us to check, to which degree we had achieved our objectives (Mature Consortium, 2012). However, for two reasons it makes sense to conclude this section with insights gained from the formative evaluation:

1. Results of the formative evaluation were incorporated into the system, which was tested during the summative evaluation. Therefore, requirements that went into that system are described here.
2. The project's UCD process ended with the formative evaluation sessions. Hence, any possibilities to get more user feedback on the system and possibly its design discontinued.

Of course, we got a lot of feedback regarding usability aspects, especially in the extra workshop, which was set up for that purpose. Although, this is admittedly important in order to provide a contextually well programmed software, it shall be neglected here as it hardly helps to find design advices for an LME system design. Apart from those findings, four other topics could be identified as important and should be shortly described in the following paragraphs (cf. Mature Consortium (2010d), p.31).

Co-operation and communication was identified by the practitioners as the most important aspect. Sharing resources and creating tags were important to them and valued higher than private collections of resources and notes. The communication provided by a discussion facility supports these activities and is vital for the entire process.

Co-ordination was considered to be a necessity for information awareness, which is contextually provided and moreover, where feasible, selected according to the users' needs and expertise.

Tagging and Recommendation Services are required and appreciated. Tagging was deemed very important, on the one hand for a later retrieval, on the other hand for building a shared knowledge base by means of a common vocabulary. The latter should be supported by recommendation services that facilitate the vocabulary evolution.

Retrievability of resources in a multidimensional information space was mentioned as an important requirement. Assuming that tagging is given, it was deemed as useful to have the possibility of linking tags semantically to each other (i.e. create a collaborative ontology, cf. 5.1 and (Braun, Schmidt, & Zacharias, 2009)) in order to retrieve resources more specific. Moreover, such functionality might also foster the development of a shared vocabulary and a common meaning (Braun et al., 2009; Braun, Kunzmann, & Schmidt, 2010).

All in all, these aspect especially show the need for supporting and facilitating

1. the sharing of resources
2. the collaborative development and negotiation of a common vocabulary including associated semantics and the
3. communication about resources, processes and the vocabulary.

Apart from that, an approach to reflect and improve information quality could be realised through certain kinds of rating mechanisms, which was very appreciated.

3.5.3.4 Conclusion

The user centered design process helped us to adapt the software to the particular context and to a huge degree to the application partners demands. Beyond the mere software development aspects, the entire process helped us to gain some very useful insights, which are described in the subsequent paragraphs.

The Software as Boundary Object The concept of Knowldege Maturing is not easily conveyed and takes some time. Additionally at the beginning, the whole project team had a rather initial idea of that concept, which was shaped during the course of the project and led to a common understanding between the partners. Nevertheless, it was hardly possible to describe that concept easily as something new, without leaving questions open and without clearly providing a value added. Thus, when talking to the application partners about the software, their tasks, their objectives and their demands with respect to knowledge maturing aspects, the software served as a boundary object. It was much easier to get a better understanding of knowledge maturing processes in that particular context and in general.

The General Approach to Participatory Design The UCD process followed in the project was very helpful to build a common idea of software supporting knowledge maturing in the particular work context. However, it became obvious that the communication between the development team and the application partners is the key factor to success. From the experience made, it needs short development cycles and quick feedback loops in order to develop a software according to the users' needs. However, in order to get the most out of it, it needs a very active boundary spanner (cf. 2.4.6). This person or group should have at least a basic technical understanding in order to hold the communication to developers and should also have insights in the work of the application partners. This enables them to translate between both worlds and could ensure that a common understanding is emerging. This would also include the active engagement to intervene in case the one world or the other is not sticking to the commonly agreed process.

Rather few Conceptual Findings Although the work with application partners was quite fruitful, it has only helped marginally in terms of gaining technical conceptual findings. Nevertheless, the particular contextual situation was important for us to rethink the general architectural design in order to cope with internet bandwidth problems and mobile scenarios. The discussion about that and the subsequent design decisions for the overall architecture is presented in the following chapter 4.

3.6 Conclusion

The empirical studies and the explorative work with the application partners helped to gain detailed information for the design of an LME.

The ethnographically informed study resulted in persona descriptions, which were used to derive services that are supposed to support knowledge maturing in different contexts. These were enriched by the findings of the use case analysis and resulted in an overall set of 95 services.

The Representative Study resulted in a list of 12 Knowledge Maturing Activities. These are justified to represent knowledge maturing and its support may lead to knowledge maturing. Although, not all of them seem to be of the same relevance, they are a manageable set of activities, which reflect requirements for an LME. Hence, the services derived before were successfully clustered according to these activities. Apart from the KMA, Knowledge Maturing Indicators were identified. These are important in order to have a means to operationalise the process of knowledge maturing and to provide a concrete lever to measure and improve it. The 38 presented general KMI are too decontextualised to be used in software. They need more specification and adaptation firstly, to the target context and secondly to the software itself. One indicator is for example "A digital resource was selected from a range of digital resources". For using it in a software, it has to be related to the usage context and has to be measurable. Thus, it needs to be described clearer in order to clarify the terms "selected" and "range of digital resources". Such a specific indicator could be for example "A document was opened from within a list of search results". It implicitly states that "selected" was translated to "open" and a "range of digital resources" refers to a list of search results. This can be easily traced and implemented in software. Such contextualised and specific KMI can be especially used by Maturing Services to detect and visualise knowledge maturing processes. Furthermore, these (specific) indicators need to be combined and weighted in order to retrieve bundles of indicators, which try to describe a particular context.

The in-depth study was especially helpful to justify the knowledge maturing activities and to become aware of the important role of guidance when trying to improve knowledge maturing. A software tool alone is probably not very helpful for the support of knowledge maturing. It always needs to be accompanied by organisational measures which has to be adjusted wisely. Employees have to be enabled to establish a new culture of knowledge maturing in their team, department and organisation.

The User Centered Design process informed the tool development in the context of the particular application partner and led to important general findings on the application of participatory design methods.

Concluding, it can be additionally said that all levels of knowledge instantiation have to be addressed when trying to support and improve knowledge maturing. Especially the in-depth study showed the importance of sociofact maturing. Interviewees clearly stated the necessity of supporting a socially active workplace, e.g. by initiating CoPs or by implementing regular meetings or by providing communication software. Furthermore, lifelong learning is an aspect which is deemed very important, organisations want their employees to be engaged in informal and formal learning processes.

Based on these findings, especially on service derivations, on Knowledge Maturing Activities and on the Knowledge Maturing Indicators, the following chapter 4 will develop a conceptual system design of a Learning and Maturing Environment.

Chapter 4

System Design

This chapter develops and discusses the architecture design of an LME. It recapitulates the hitherto found results of the theoretical and empirical work and shows how it contributes to the architecture development. Afterwards, a heavyweight backend architecture is examined for the purpose of an LME and it will be argued that a lightweight architecture is more appropriate. Furthermore, an infrastructure for Inter-Widget Communication (IWC) is introduced, which serves the backend as communication service on a user interface level. By means of Maturing Services, Knowledge Maturing Indicators are implemented in order to detect, foster and visualise Knowledge Maturing. A discussion about non-functional requirements and the distinction between a Personal Learning and Maturing Environment and Organisational Learning and Maturing Environment will lead over to the rationale of the system architecture of a PLME framework.

4.1 Recapitulating Hitherto Existing Results

In order to clarify how the results of the two chapters before will serve as input for the design of an LME, it should be shortly recapitulated what has been found so far.

In chapter 2, the relation of the knowledge maturing phase model to other theories of individual and social learning was described. One result of these examinations were a list of abstract requirements, which should be considered for the development of an LME and which are summarised in table 2.2. Interestingly, these requirements can be completely covered by the (admittedly even more abstract) knowledge maturing activities found in the Representative Study (cf. 3.3.3.1), the second empirical investigation. The examination of the results of the ethnographically-informed study focused on the persona analysis. In that process, a list of concrete but contextually different services was developed, which might support knowledge maturing. Moreover, the use case analysis was discussed, which revealed even more relevant services. All these, as will be seen in this chapter (cf. Maturing Services, 4.3), can partly draw on the detection of Knowledge Maturing Indicators 3.3.3.2, a means of operationalising Knowledge Maturing.

Figure 4.1 shows how the results of the theoretical, empirical and explorative examinations contribute to the general system design. It separates between those aspects that are important for general design decisions and those aspects that are considered to be important during the software instantiation in a particular context. Although this forestalls the general architecture design, the figure helps to understand the central theme. In the center of the figure, the LME system design is depicted in green tones, with the four tiers *Presentation*, *Communication*, *Application Logic*, and *Persistency*. Orthogonal to the latter three, the *Backend Design* subsumes design decisions, which have an impact on these three tiers. The *Maturing Services* are related to the *Application Logic* as they are part of it. This green block represents the general LME Design Concept. Left to this block is a blue box referred to with *Contextual Implementation Aspects*. This box subsumes all aspects, which are helpful or which have to be considered when an LME is going to be implemented in a specific organisational context. It does not reflect general design decisions but a kind of guideline that should be considered when instantiating an LME.

The yellow, orange and red boxes refer to the examinations that were presented in chapter 2 and 3 of this thesis. The yellow two represent the theoretical examinations, which were helpful to describe abstract requirements of an LME. These have to be considered when the LME concept is instantiated in a particular context. Depending on the specific requirements, a subset of these requirements should be implemented in order to support knowledge maturing. The red box represents the results of the participatory design process. Based on the experience made there, some design decision were taken regarding the backend infrastructure. In order to cope with fast changing requirements, very context specific demands, low inter-

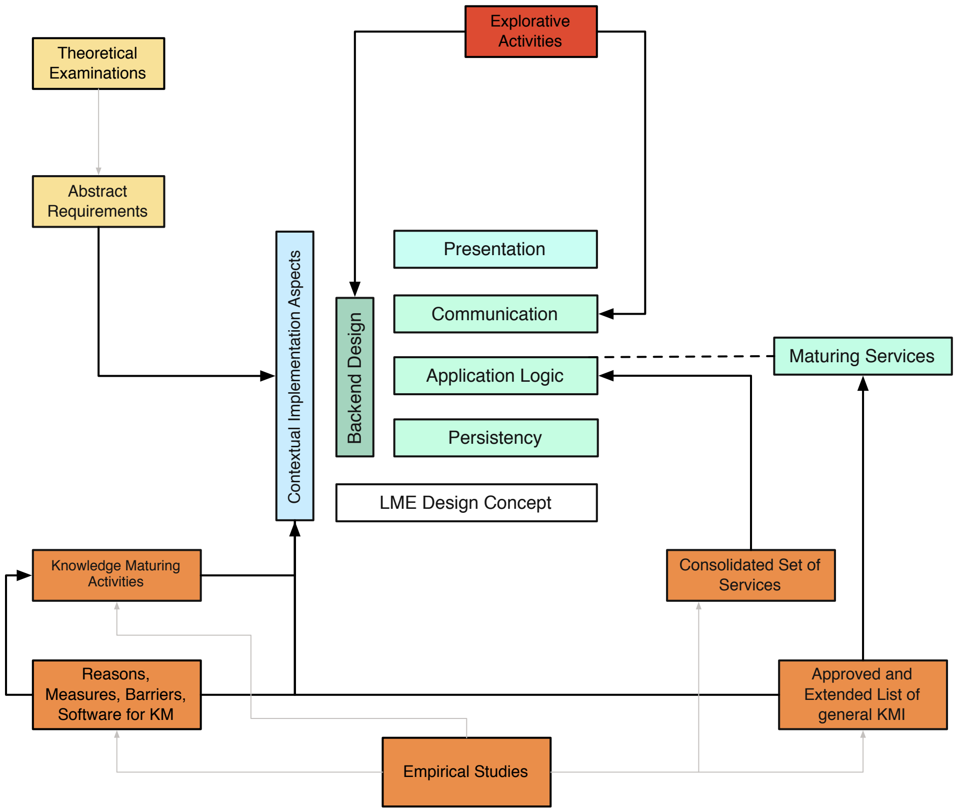


Figure 4.1: *Impact of the hitherto existing results on the architecture design.*

net bandwidth and the demand for easy maintainability, it was decided to implement a REST-like architecture. The discussion about advantages and disadvantages of such an architecture compared to a SOAP based Knowledge Bus architecture is presented in the following section 4.2. Moreover, the participatory design process confirmed our decision to develop a solution for Inter-Widget Communication (IWC) as a communication layer between the presentation tier and the application logic. The design and rationale of this server based solution is presented in the upcoming section 4.2.2. Furthermore, the results of these explorative activities were used to develop the MATURE prototype for the particular career guidance context (cf. chapter 5). This should not be mistaken with the blue box, hence there is no contribution to that box depicted. The blue box "collects" general advices for necessary requirements for an LME, which have to be converted into software. The User Centered Design helped to shape the instantiation but did not give new advices (cf. 3.5.3.4). The orange boxes represent the results of the empirical studies. The consolidated list of services can be used for implementation in the Application Logic. The other three contribute to the *Contextual Implementation Aspects* as they give advices what should be considered when designing an LME for a particular context. Additionally, the box with “Reasons, Measures, Barriers, Software for KM” represents one of the outcomes of the In-depth Study and contributed to the Knowledge Maturing Activities as it prioritised them to a certain degree. The list of KMI additionally contributes to the development of Maturing Services, which are a part of the “Application Logic”.

The task of this chapter is to define and rationale a system architecture, which allows to implement the found functional requirements. It needs to be discussed, which kind of backend architecture suits best in order to provide access to the (maturing) services, so that knowledge maturing is supported well for a particular context. Furthermore, additional non-functional requirements are derived in the discussion about the LME approach in section 4.4.1.

4.2 Backend Architecture

For realising a landscape of loosely coupled tools in a Web 2.0-manner, which support knowledge maturing, cf. (Mature Consortium, 2007), a client/server architecture is required, where the server-part is referred to as the backend in this context. The main requirement for the backend is the provision of adequate services in a way that at least does not hinder, and if possible even supports knowledge maturing. Therefore, the suitability of two different approaches to backend architectures is discussed. This section will introduce first the Service Oriented Architecture (SOA) approach followed in the MATURE project. Its strengths and weaknesses are considered and subsequently a rather lightweight alternative is discussed. Furthermore, an Inter-Widget Communication (IWC) solution is presented, which allows inter-application data exchange. This is a lightweight, fast and flexible communication platform and can serve the instantiations as a Graphical User Interface (GUI) gateway to the backend.

4.2.1 MATURE Architecture

The MATURE reference architecture consists of three building blocks (cf. figure 4.2).

- Buildtime Environment
- Runtime Environment
- Evaluation Environment

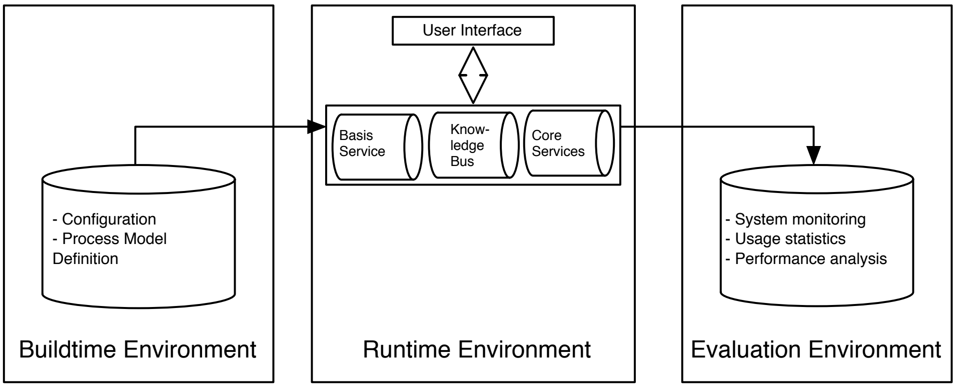


Figure 4.2: *A simplified representation of the MATURE architecture. Adapted from (Mature Consortium, 2009d, p.20)*

The *Build Time Environment* mainly holds functionality for configuring the system by means of a model driven approach. The *Evaluation Environment* serves for monitoring the system's performance and indicators for knowledge maturing, on which basis services or user interfaces might have to be improved. Both blocks are important for the system to run but do not directly serve to support knowledge maturing for knowledge workers using the MATURE software.

In this section, the main focus lies on the middle block, the *Runtime Environment*. This building block itself consists of three parts, the basis services, services of the Knowledge Bus and the core services.

4.2.1.1 Basis services

Basis services are services, which are essential for the system to run and which are mostly used by other services. These are considered to be context and configuration independent[1]. One MATURE specific service is the *Data Access - Semantic Repository Service*. Similar to database management systems, it provides the functionality for storing and retrieving data. The semantic add-on implements the opportunity to store ontological relations and metadata. So, for example, not only a tag is stored that has been saved for a resource but also metadata about the context behind it, e.g. the user. Core services can use this information e.g. for further data mining processes. However, the development of a semantic repository needs a well defined environment, as it needs a comprehensive metadata description of resources. This description comprises standards regarding the vocabulary, an ontology describing the relation between resources and a kind of logic framework for data mining mechanisms on the overall relationship between resources and their metadata.

Furthermore, logging and security services are provided. The logging services provide a standardised interface for all services allowing to save atomic activities, e.g. of users or the software itself. The security service is implemented by means of Shiboleth[2], an open source framework that provides authorisation and authentication methods in distributed environments. This is especially helpful for a SOA based approach, as web services might be distributed on several servers and organisations.

> "This enables cross-domain Single Sign-On and removes the need for content providers to maintain user names and passwords. Identity providers supply user information, while service providers consume this information and get access to secure content." (Mature Consortium, 2009d, p.30)

4.2.1.2 Knowledge Bus

The *Knowledge Bus* is a middleware and the main "acting" instance, which actually manages the services used, and makes them visible to the outside world. The part *Service Management* consists of the registration, repository, annotation, discovery, orchestration and enactment, cf. figure 4.3. The registration allows to bind new services to the system. A description of these services is hold in the repository. This description consists of syntactic

[1] Actually all services that can be related to the OGSA framework form the basis services, cf. (Carl Kesselman, Nick, & Tuecke, 2002; Mature Consortium, 2009d).

[2] http://shibboleth.internet2.edu/, last access 13.02.2012

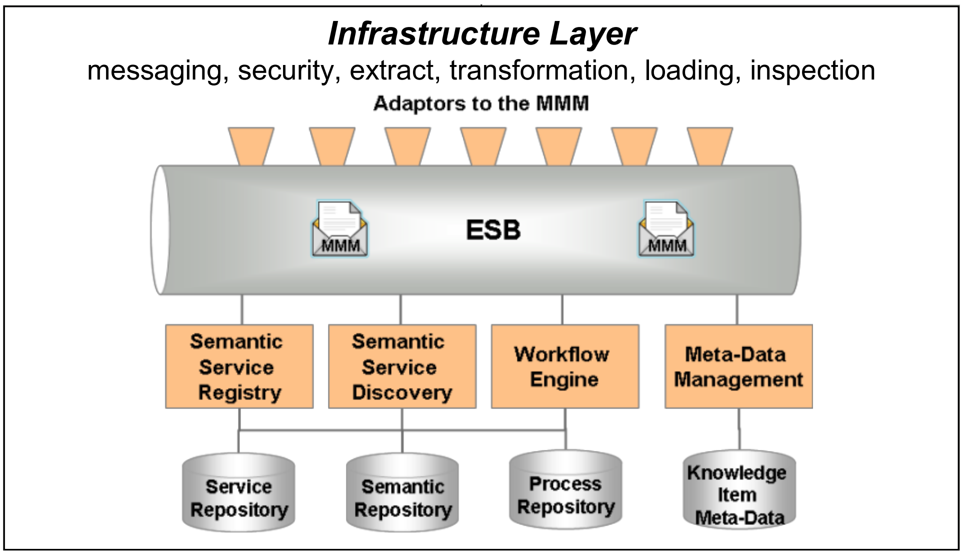


Figure 4.3: *The basic infrastructure of the Knowledge Bus. Taken from (Mature Consortium, 2009e, p.66)*

data (WSDL) and semantic data provided via annotations. The annotation module is for describing services by means of textual and tag based descriptions, which are used by the service discovery. Registered services can be discovered during runtime through search requests by other services or the user interface. The discovery module is responsible for selecting the correct service based on the requests. A workflow engine is used for the service orchestration, which is well known for the SOA approach. The orchestration is proposed to link services in order to create new functionality. This orchestration or a single method call is invoked after identification by the enactment module. It is also responsible for passing output data along the corresponding workflow to another method or return it if the workflow has finished.

The *Knowledge Bus* also uses a messaging component, which is supposed to enable data communication between services. A classical implementation of this is an event-management-based approach following a publish/subscribe pattern (Mühl, Fiege, & Pietzuch, 2006). However, in terms of configuration and agility in the implementation process, this is not an ideal solution. For each change, the server configuration, which describes the producer-consumer-link table needs to be adapted. Thus a server-runtime configuration is not possible and thus the barrier for agile development or free inclusions of new software is increased. During the project, another communication system has been developed, which allows to send and receive messages to connectors with one or many other clients or services. This intercommunication infrastructure is also referred to with IWC, which is described in section 4.2.2 and essential for major parts of the instantiation development.

4.2.1.3 Core Services

> "MATURE Core services represent utility services, which are a reusable and useful piece of code that is mostly very generic and can be easily consumed by other services" (Mature Consortium, 2009d, p.32)

It is mainly the class of *Maturing Services* that falls under this category. These services are essential for supporting knowledge maturing in the different instantiations. Their specific definition and a discussion about the general notion of independent and flexible maturing services is presented in section 4.3.

4.2.1.4 Summary and Critics

The MATURE reference architecture is profoundly designed and provides a very elaborated backend based on a centralised SOA approach. The *Knowledge Infrastructure* mainly represents the technical focus of the system design. It contains the *Knowledge Bus*, which mainly provides the service management, including semantic discovery and a workflow engine for orchestrating services. These services can be basis services, which are mainly context free and maturing services, which support knowledge maturing directly or indirectly (cf. section 4.3). However, though this architecture has many advantages, two points of criticism need to be discussed:

1. Typical limitations of a (central) SOA architecture.
2. The actual support of knowledge maturing and the applicability in (very) agile environments.

A centralised SOA architecture, as the one presented here, including the *Knowledge Bus* as the central integration layer[3], increases costs and harms

[3] This layer is typically referred to as an Enterprise Service Bus (ESB)

the system flexibility (H. Li & Wu, 2009). It increases the costs due to the implementation complexity of the bus system and moreover, due to the necessary maintenance as this design may introduce a single point of failure (Leusse, Periorellis, & Watson, 2007). This specific kind of bus architecture impedes the system flexibility as applications are developed directly against the integration logic instead of applying a standardized semantic message type for decoupling services and applications from the bus (Leusse et al., 2007). Additionally, technique based drawbacks need to be considered that have also influence on the applicability in agile environments, as it is found for SMEs or even freelancers. A major issue is performance and scalability. The SOAP based Web Service (WS) approach aiming at interoperability has to face several performance lacks. Main impact on the performance XML messages, as they are 10 to 20 times larger than binaries. Furthermore, the interaction protocol, managing the access to the UDDI[4] service, any intermediary processes (e.g. use of workflow engine) and the possibly locally distributed provision of services increases network communication. It may introduce a major drawback on service response times (O'Brien, Merson, & Bass, 2007). Based on these problems, the scalability of the system is highly influenced. Especially architectures like the here presented ESB-design suffer from the single point of access, which shifts the responsibility for good scalability at high request numbers to the quality of the hardware. That is to say, the more requests have to be processed the faster the hardware has to be. Rather distributed SOA approaches would tackle that problem better (H. Li & Wu, 2009)[5].

However, agile environments firstly do not have a large set of standardised processes that can be represented in a workflow engine and secondly need new services to be incorporated on-demand and very context specific (Krogdahl, Luef, & Steindl, 2005; Jammes & Smit, 2005). Thus, though well structured and implemented, the MATURE approach causes several problems:

1. A huge overhead of necessary work for configuring and implementing the existing workflows.

[4]Universal Description, Discovery and Integration (UDDI)

[5]Although, scalability strategies exist, like the usage of stateless services, the problem can not be neglected, especially compared to lightweight but inflexible connections of applications and backends as typically used in web based solutions.

2. The necessary purchase of cost intensive hardware for setting up the architecture.

3. The (cost intensive) creation of a supporting position in order to maintain the backend and its configuration.

4. The possible creation of problems regarding the response time of the software, leading to unsatisfied users, and a slow down of productivity.

In a nutshell, for many contexts which are also addressed by this work on knowledge maturing, using the MATURE backend is like breaking a fly on a wheel. In agile environments, fast developed and quickly deployed services are important. This can be achieved by using REST-full services (Hao, 2004). The REST-approach[6] allows clients to deal with arbitrary resources in a uniform way (Fielding, 2000).

> "REST's foremost concern, unlike SOA, has always been distribution: it focuses primarily on ensuring that distributed hypermedia systems can scale and perform well, by explicitly constraining important aspects of their architectures [...]" (Vinoski, 2007, p.84)

These constraints include the uniform interface, which prescribes the same interface for each client, independent of the underlying set of resources and services. This especially makes the distribution a lot easier. Compared to the use of SOAP calls, the whole overhead of parsing, validation and transformation of an incoming message is avoided. Scalability and performance is also addressed by the constraint of statelessness, which means that neither resources nor services are aware about the clients' state. Thus, each service request has to carry any session information. Moreover, caching and resource naming and representations are key factors of REST.

However, the disadvantages of this approach are also well known, and it is a cost trade-off whether it is more appropriate than the ESB approach. For example, in REST architectures, like the Web, services and contents are mostly statically connected, which limits the reusability of services (Schroth & Janner, 2007). Moreover, due to a fixed service interface, developer defined semantics are introduced to the messaging without data typing, which

[6] Representational State Transfer

increases error rates, especially in very complex systems. Especially, the management of the URI namespace can become cumbersome in complex applications (Muehlen, Nickerson, & Swenson, 2005). Therefore, for the implementations for the application partners, we felt confirmed in the decision for a widget based approach. It allowed us to reduce the application complexity by providing independent widgets. The inter-connection is realised on the communication layer and thus decouples it to a certain degree from the application logic. Hence, the problems of a REST approach could be somewhat reduced. Security issues are tackled easier and more holistic in a SOA approach using SOAP as not only the transport level can be secured (with REST via HTTPS) but also the message level (Widmann, 2009).

For a web based implementation, often several independent services are implemented or mashed up, probably from different providers. Thus, the backend architecture yet should be able to provide SSO mechanisms such as OAuth[7]. Moreover, especially for the lightweight mashup of services and user interfaces as it is provided e.g. by iGoogle[8] or Netvibes[9], a communication infrastructure for inter-service or inter-widget communication has proved to be helpful (Laga, Bertin, & Crespi, 2009). Such an infrastructure aims at allowing data exchange between user interfaces or also between backend services and user interfaces. The main aim is to reduce server load by replacing server polling with a push message mechanism and by providing an easy to implement solution for communication. The solution developed in MATURE is described in the next section.

4.2.2 Inter-Widget Communication

While there are well established techniques for queuing and orchestrating backend services, allowing to provide data from one service to another, only limited solutions exist that provide an efficient implementation of bidirectional communication. As it will be described in section 4.5, one of the implementations of the MATURE system was realised by following a widget based approach. Thus, for using widgets a bi-directional data exchange was implemented, called Inter-Widget Communication. An application is shown

[7]OAuth is an open and standardised protocol (RFC 5849) that allows a secure API authorization from desktop- and web-based applications.

[8]http://www.google.com/ig, last access 13.02.2012

[9]http://www.netvibes.com/, last access 13.02.2012

in a second implementation in 5.2. The following subsections will present the client/server based IWC solution for intercommunicating widgets. This software has been developed during the MATURE project lead by the author of this thesis. The results were previously presented in (Nelkner, 2009).

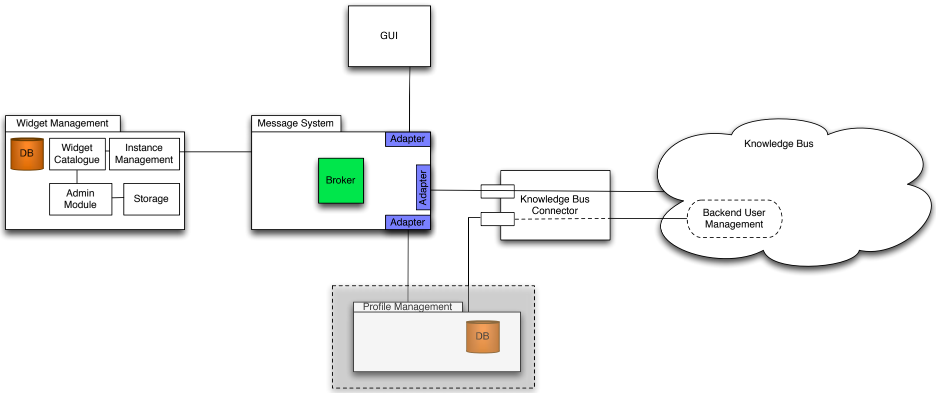


Figure 4.4: *The architecture for widget inter-communication.*

Figure 4.4 depicts the architecture of the IWC solution. The main component is the message system for the communication activities, furthermore it contains a management part and a user management. Additionally, a so called *Knowledge Bus Connector* was provided in order to allow an implementation as a UI gateway for Knowledge Bus infrastructures. The specific value added is that the service enactment is realised for widget requests through that connector. However, without using this connector, the IWC server can also be integrated as stand-alone solution in REST-style architectures. Widgets call their (maturing) services independently. The architecture is explained in more detail in the next sections.

4.2.2.1 Application Scenario and Objective

The term widget is the short version of „window gadget“ and has been applied during Project Athena (Arfman & Roden, 1992). A widget is usually a window the user can interact with and it provides a small set of functionality. Widgets are nowadays well known and used in very different contexts like in a WeBlog to aggregate a RSS feed or for weather information on the operation system like in Windows Vista or Mac OS X. However, during work processes also more complex tasks have to be fulfilled by the user and therefore need to be supported by LME. Bringing the mashup concept of widgets and the requirements of a work integrated learning environment together, intercommunication between widgets or more generally between user interfaces, is a possible solution to build more efficient, interactive and immersive software systems. Exchanging data enables two or more widgets to create more sophisticated functionality by linking the output of one widget to the input of another one. Apart from the widget scenario, such a solution is useful for establishing a fast reacting intercommunication between user interfaces of different implementation techniques and platforms. Thus, a server solution was developed that allows a simple broadcast communication between the different connected clients. Furthermore, it provides a sophisticated peer and group communication, so that a message is only received by a predefined set of connected clients.

4.2.2.2 Related Work

The most trivial approach is a publish/subscriber model as implemented in the knowledge bus of the MATURE architecture. This is a working but not very efficient solution for the kind of problem considered here. Clients need to poll the blackboard for new information regularly. Depending on the client technique this can be problematic in terms of performance and efficiency.

Within the EzWeb/Fast EU funded project (Lizcano, Soriano, Reyes, & Hierro, 2008) a SOA based environment has been created that allows the composition of mashups of widgets by providing them in a special repository. The EzWeb composition environment is a user interface that allows connecting widgets graphically in order to create intercommunication by linking the output of one widget to the input of another one. In the backend, this connection results in an orchestration of webservices. The architecture presented here is based on the idea of providing widget communication facilities and it does not matter in which environment they run, nor in which programming language they are developed. A minimum of overhead in administration shall be achieved. Moreover, widgets shall not only be visualisations of data but may also realise business logic, depending on what the developer wants to provide to the user. It is not the aim to link the underlying data or logical services. They shall remain independent.

Another approach is the Wookie server, a result of the TenCompetence EC co-funded project (Wilson, Sharples, & Griffiths, 2008). The Wookie server allows hosting and instantiation of widgets and provides a proxy server that allows access to different kind of services and therefore also to backend services. The Wookie implements a blackboard approach to which each widget has access to. This allows the group wide use of data (for example for a chat widget) but does not allow direct communication in a point-to-point manner.

Apart from these client-server based approaches, several mere client-based approaches for web applications exist (Wilson, 2011). These are restricted to browser implementations.

4.2.2.3 Requirements

As described before, the most important requirement is the provision of intercommunication between widgets. A communication system allows widgets to get data and events from other widgets. This can be either realised through a peer connection but also via broadcasting to all widgets that are interested in a special data set of another widget. Apart from that, it was considered to be useful to prepare the access to a certain backend. This connection serves as a proxy between widgets and for example a workflow engine with dedicated webservices. Thus, a uniform interface to a backend for storing, retrieving and analysing data, mapped through the messaging could be provided. Such a backend system can be a middleware like the Knowledge Bus concept (cf. 4.2 or (Hinkelmann et al., 2007)) but also a set of fix services provided by a certain system. Moreover, as widgets were the initial primary types of clients, a widget repository should be provided. The widget repository serves the user as a kind of catalogue for finding widgets she/he likes to mashup. Therefore, it provides an upload and download functionality, where especially the upload is enriched with validation tests on the widget. Obviously, a user management is necessary in order to provide user bound persistence services as profile management or configuration settings.

4.2.2.4 Architecture

According to these requirements a server has been built that meets the expectations and requirements (cf. figure 4.4 above). The server is divided into the four parts of Widget Management, Message System, Profile Management, and Knowledge Bus Connector that will be explained in detail in the following.

Message System The Message System is used for widget-to-widget and widget-to-server communication. The Message Broker supports point to point communication as well as group based communication models. Groups are created automatically by the Instance Management, either because of the input and output parameters of loaded widgets or according to the users' configuration. All external entities like widgets, an administration frontend or the backend system have access to the server via adapters. The used adapter concept is flexible and allows the connection of all kinds of systems as long as an adapter can be developed that works as a translator between certain programming languages and JAVA.

Widget Management The Widget Management package of the server contains all modules dealing with the issues of the widget repository mentioned above. This includes hosting, adding and managing the currently running and but also inactive widgets. Especially the Widget Catalogue needs a database to save metadata about hosted widgets. As an external backend system is not necessarily available (see explanations regarding Knowledge Bus Connector), this database is not outsourced but under the control of this package. The Widget Catalogue holds a collection of the currently available widgets, for example a Weather Widget, Chat Widget, etc. These are then instantiated and executed in the user's client. In addition to this, the catalogue also keeps track of each widget's preferred run-time environment. It is thought to be queried by the user's client and provides a list of available and fitting widgets according to the client's runtime environment (e.g. web, Java, Flash, etc.). This is important especially to include mobile devices with their special requirements on performance, display size etc. The Instance Management is the most important component of the widget management package of the server. It keeps track of all running instances of widgets in all connected workspaces and automatically purges widgets that have become inactive. It is always the most up-to-date source on the current global state of the widget server. Messaging and administration functions depend on it. As well as keeping track of running widgets, it also manages the state of their communication, for example the information which widgets are connected to communication units. The messaging system uses this information to distribute messages correctly. The Admin Module performs management functions for the widget management component, usually working on the catalogue. It provides options for catalogue maintenance, widget upload, widget deletion and other administrative functionalities. It is intended to be accessed via internal messaging or an authentication-enabled web frontend. The Storage Module stores widget files, such as Flash, Flex, HTML and JavaScript files. This is basically a shared and protected directory or drive from which the hosted widgets are being loaded via HTTP. This is transparent to the user.

Profile Management The Profile Management module is conceptualised for managing server-bound user data that is absolutely necessary for the widgets to work. This includes data that is only used to provide essential functions of the widget system and does not necessarily need to be stored in the backend. It includes for example user authentication, default widget positions, saved environment configurations (if available), possibly third-party logins and others. Especially the user management led to the possibility of intercommunication between widgets of different users. This allows to develop communication and collaboration facilities. Because of its special relevance this module is part of the server. The backend system is not necessarily available and not important for the server and the hosted widgets to run. As long as a backend system is integrated in the server, it makes sense to use this module as a stub and to provide the used database as a backend service. Because of this conceptual duality the package is greyed in the image. Compared to the integration in a Knowledge Bus approach, the responsibility for the user data persistency lies at the IWC server. As it can be seen later on again, this has an influence on the implementation of a SSO solution (cf. 5.3.2). This is easier when using the Knowledge Bus infrastructure for the actual profile management.

Backend Connector The Backend Connector is responsible for providing the access to appropriate services. It is unimportant if this is a middleware encapsulating several services or only one service. All requests and responses are transferred through this connector which translates the requests to the backend in the specific calls. The connector has to be adapted according to the respective backend system. Widgets not necessarily depend on the existence of a backend as long as storing or retrieving data from a certain database system is not relevant.

Graphical User Interface The GUI is the users' client on which the widgets will run. This GUI is connected to the server via an adapter providing access to the communication system. As the adapter is also the broker between different programming languages, the widget developer can choose the one she/he is familiar with, which simplifies widget development enormously and decreases barriers working with the server. Moreover, it does not matter if the widgets run standalone in a browser or if they are encapsulated in a closed environment where that is responsible for mapping messages to the certain widgets. Nor is it irrelevant if a widget is running as a desktop client as long it is connected to the server. Consequently it is possible to link browser widgets and desktop widgets interacting with each other. It only depends on the adapter and can be accessed via different techniques, e.g. JMS[10], DWR[11] and others.

Relation Between Modules In order to provide a clearer picture of the interaction between these modules a use case based example of how the server manages the certain requests is shortly presented. A calendar widget and a weather widget are loaded by including them into iGoogle. They interact with each other and with the backend system. Using widgets in iGoogle is easy as it only contains a link to the Storage in the Widget Management package. After the browser has loaded both widgets, the server authenticates them at the Profile Management. Then a message is sent to the Message System for registering the widgets in the Instance Management, the pool for all running widgets. Furthermore, they are registered at a communication group that allows them to talk to each other. This is either realised by connecting widgets automatically according to their input and output format or manually by the user in a configuration. If the user now creates a calendar entry with a certain place, the calendar widget sends a message to the server that distributes it to the common group. The weather widget gets this

[10] Java Message Service, http://www.oracle.com/technetwork/java/index-jsp-142945.html, last access 13.02.2012

[11] Direct Web Remoting, http://directwebremoting.org/dwr/index.html, last access 13.02.2012

message, checks if it can interpret the message and updates the display. By creating the new entry, the calendar widget also sends a save request to the widget server. This is translated into a backend save request in order to store the calendar dates. The widget server only transfers this message to the backend connector which calls the specific web service or backend system.

4.2.2.5 Summary

With this messaging server, the intercommunication between different user interfaces could be realised in the MATURE project. It serves as interface gateway and allows to improve the usability of mashed up systems a lot. Apart from the here focused widget context, this messaging has also been proved as useful in integrating a web application with a Java based application, as described in section 5.2.

4.2.3 Conclusion

Depending on the context, a SOA architecture may fit better to an organisation than a REST based and vice versa. However, due to the application partners of the MATURE project and the experiences with the developed software solutions, a lightweight and REST based solution even fits much better for an LME architecture. The according architectural description are presented in section 4.5. The software instantiations that have been developed and the outcome of the evaluation is presented chapter 6. However, the following paragraphs will briefly justify the decisions by forestalling some details of the software instantiations. Three software instantiations will be considered, which are called SIMPLE, Demonstrator 2 and SOBOLEO. A more detailed presentation for all three is provided in the following chapter 5. It includes a more specific view on technical implementation details and on the SSO approach as well as on the service enactment and on the persistency solution.

SIMPLE This software is a client/server based desktop application. It requests resources including its metadata from a backend architecture, which provides the maturing services. Furthermore, it is implemented on the base of the ADOBE AIR framework[12]. The framework allows a rapid development of

[12] http://get.adobe.com/air/, last access 13.02.2012

rich internet applications and desktop applications. The desktop applications apply a similar technology as JAVA. They run in a sandbox environment with restricted but possible system access.

During the software development, it turned out that the use of Web-Services on a SOAP base is incredibly underperforming. This might be the result of a combination of several reasons. Firstly, the implementation of the handling of SOAP messages in the AIR framework might underperform. Secondly, due to the nature of the data that need to be transferred, many small blocks of data are encapsulated in XML, which leads to a high overhead of the data to be sent. Thirdly, a triple store is used in the backend which is itself requested by many different services and might have also led to a drawback in performance. Though this is explicitly not a SOA-rooted problem, it also needs to be compensated.

The technical problems are intensified by the particular application context. The application context was a career guidance scenario with Personal Advisers (P.A.s) in a very mobile working context. The P.A.s had laptops available that were administered by an IT administrator. These laptops were quite old, so that the impact of SOAP message processing was even higher, apart from a generally slower running software. Moreover, P.A.s got internet dongles that allowed them to access the internet while they are at schools. Obviously, the access speed via the mobile phone network is even slower per se, thus multiplying principle technical problems. Furthermore, due to the IT administration policy, the distribution of new clients was very problematic, which could only be approached to by a flexible widget technique, allowing to distribute functionality via remotely loaded widgets (cf. explanation in section 5.3.3).

Summarising these findings, it can be said that especially performance issues disapprove a SOA based approach in this scenario. One point is the slowness of the client machines, another point is the slow network access. Due to the MATURE project structure, the real service distribution would have been as depicted in figure 4.5. The client (located at “A”, England) accesses the knowledge bus hosted at a partner in Austria (“B”). The bus has to discover the correct services, which are itself hosted in Austria or Germany (location “C”, “D” or “E”). Moreover, the IWC infrastructure is hosted in Germany (“E”). Apart from this aspect of geographical distribution,

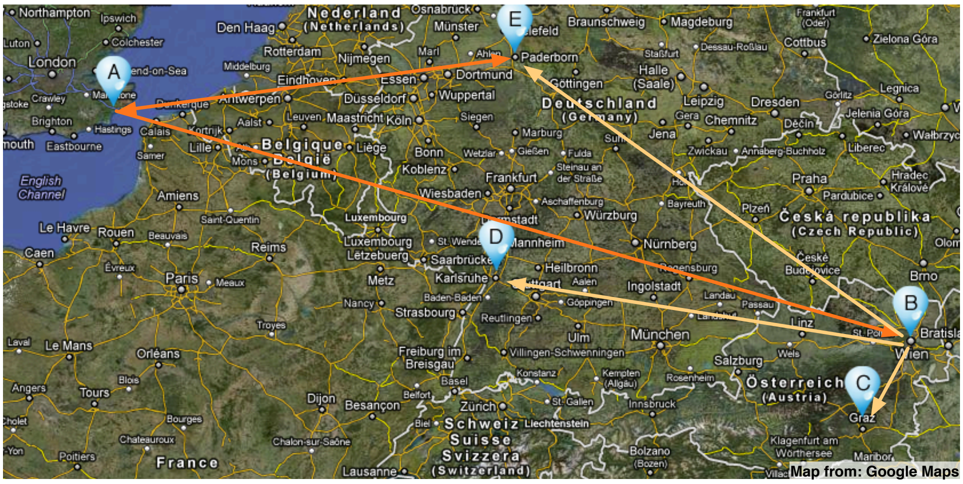


Figure 4.5: *The services distribution.*

the application of an orchestration engine (e.g. workflow engine) for a job, which is culturally conditioned very informal can hardly serve as a model.

Demonstrator 2 This software prototype consists of a web-based service called SOBOLEO for collaborative ontology creation was connected to a desktop-based JAVA tool developed to support constructive discussions, InterLOC (cf. section 5.2). Hence, the idea was to enrich the ontology maturing process by means of negotiation processes. From a technical perspective, the main objective was to establish communication between both applications in order to allow firstly the initiation of negotiation processes from within SOBOLEO and secondly provide the discussion threads back to SOBOLEO. The latter is a typical use case of service workflows, where InterLOC would call a method on the knowledge bus, which provides the data to a SOBOLEO backend method. However, initiating the process in that way is not a typical use case, as a communication between user interfaces has to be established. This could be realised by a publish/subscribe pattern, where InterLOC regularly polls the server but which has been solved much more elegantly by the client/server architecture that has been built for message exchange between different concise applications, as described before in section 4.2.2. It realises a push service to react on certain messages. On the one hand, the scenario could be quite a feasible use case for the SOA-based architecture due to the data oriented service connection. But on the other hand, the effort and overhead of implementing the services, the polling of the server, modeling the workflow, setting up the environment etc. exceeds the actual solution to such an extend that one can hardly opt for a heavy-weight architecture. One may argue that a transfer of existing backend services to the knowledge bus might increase the value added. However, InterLOC is a chat tool using the XMPP protocol[13]. Thus it relies on push messages rather than on polling the server. It simply does not make sense to transfer this into passive web services, the performance would decrease considerably.

SOBOLEO One specific application case of SOBOLEO is people tagging, rather than concentrating on resources (cf. section 5.1). However, technically it is only the SOBOLEO system, a coherent and consistent application that has been built for this purpose. There is no need for a particular SOA architecture, especially as the application context is also a career guidance scenario, within an even more restricted Citrix-based [14] IT landscape. Only a web-based application is a feasible solution for this environment, as organisations' IT security policy typically demands a complex process of certification for newly installed software and this process might have to be repeated for each update.

However, not for its own, but for the purpose of integration, SOBOLEO and all other applications would benefit from an SSO solution in order to reduce complexity of usage of distributed services. Here, a SOA based architecture may provide the most holistic support via standardised approaches like implementations for Security Assertion Markup Language (SAML), as Shiboleth does for example (cf. 4.2.1) (Schlager & Ganslmayer, 2007). Dispersed web-based services can only rely on external services providing for example the OAuth protocol.

Without going into detail, one prototype exists that really profits from the SOA approach, as it serves complex processes with different services in different cases (Mature Consortium, 2010b). The demonstrators discussed above, do not profit from it. None of the prototypes mentioned above is bound to and used in formal organisational processes. This leads to the following hypothesis:

[13]Extensible Messaging and Presence Protocol (XMPP), cf. http://xmpp.org/, last access 13.02.2012

[14]Citrix is a company, which is specialised on developing application- and terminal server environments. On user computers typically a thin client runs, which allows access to the organisational services or to remote terminals running arbitrary software remotely; http://www.citrix.com, last access 13.02.2012.

> *A SOA approach is best implemented in organisationally characterised learning and maturing environments, which are (deeply) embedded in formal organisational processes. A lightweight REST approach is rather suitable for a personally characterised learning and maturing environment supporting learning in a rather informal work context.*

This might remain unanswered in this thesis and is open to further research. However, it refers to a non-technical decision that has to be taken with respect to the application context prior to any implementation.

In terms of knowledge maturing, no indication can be observed that the architectural approach itself can contribute to knowledge maturing directly. Of course, wrong technical or strategic decisions limit the user experience and might decrease users' motivation (Davis, Bagozzi, & Warshaw, 1989; Venkatesh et al., 2002). In this sense, the architecture is only one aspect of the whole and a suitable decision might at least not hinder knowledge maturing. However, no evaluational data is available and it would be hard to isolate its influence on knowledge maturing in tests.

4.3 Maturing Services

This section will shortly introduce and explain the conceptual background of Maturing Services and its division into three different classes. The potential influence on the support of knowledge maturing, including the related role of knowledge maturing indicators (cf. section 3.3.3.2) is discussed subsequently. In conclusion, it will be investigated, which knowledge maturing activities (cf. section 3.3.3.1) can be directly or indirectly supported. As figure 4.6 shows, the services derived in chapter 3, can be divided into Maturing Services and rather general services. As it will be described in the following paragraphs, Maturing Services represent rather those services, which can make use of Knowledge Maturing Indicators and which may serve to make aware of knowledge maturing processes and status by means of data mining methods. General services may also support knowledge maturing, for example by means of proper visualisations of data or by providing the possibility to search for digital resources. However, due to the specific characteristics of Maturing Services, both classes should be considered conceptually separated.

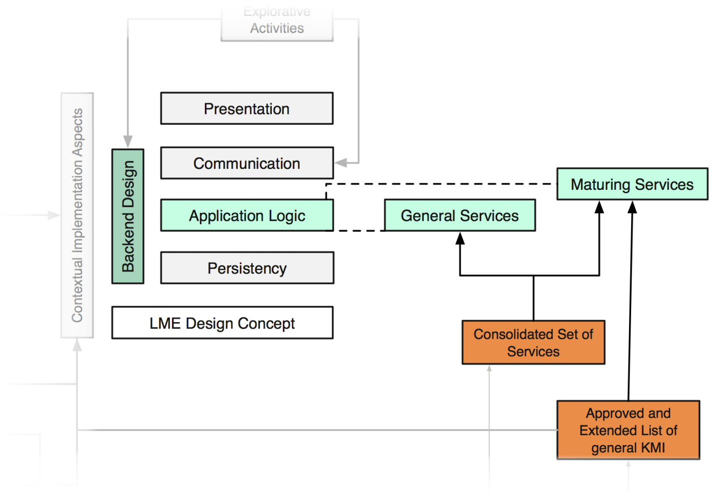


Figure 4.6: *Classification of the consolidated set of services developed in chapter 3. Irrelevant aspects for the aspects discussed in this section are blanked.*

4.3.1 Introduction

Maturing Services build a set of backend services (representing *Core Services* in the MATURE infrastructure, cf. 4.2), which should help to determine and support (directly or indirectly) knowledge maturing by means of the services represented in the following classes (cf. figure 4.7) (Mature Consortium, 2011c):

- Representation Services: It is distinguished between three types of knowledge representation: *content*, *usage*, and *structure*. Representation services enable the storage and analysis of data.

- Modeling Services: Services, which use representation services in order to build models of the type *user*, *resource*, and *process*.

- Reseeding Services: Awareness and recommendation services, which try to drive the knowledge maturing process with respect to artefact based knowledge and people knowledge.

These three pillars of service classes depend on each other (not mutually). The model services depend on representation services, the reseeding services mainly depend on the model services, but also on the representation model

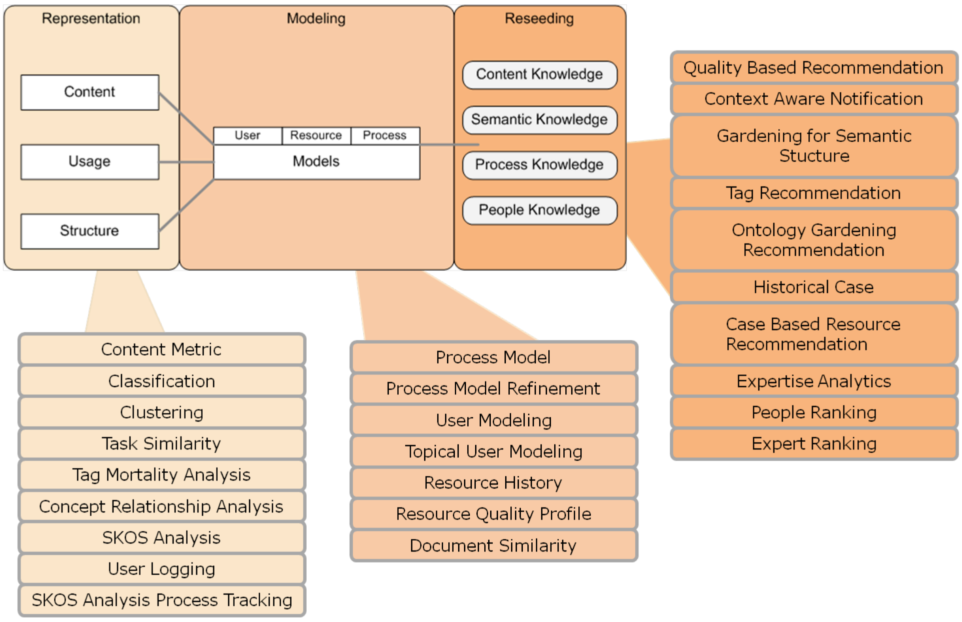


Figure 4.7: *Three main pillars to separate types of maturing services. Graphic taken from (Mature Consortium, 2011c)*

directly. The Flesch-Reading-Ease[15] index for example is computed by Representation service. The value could then be used by a reseeding service in order to raise awareness for the readibility. Or, less trivial, a keyword extraction on a document is performed and the results are used by a resource model service in order to characterise resources by means of a weighted term vector. A reseeding service may use this information to suggest topic-dependent resources to users. In this way, services can be used in very different combinations. The next subsections will describe the different types in more detail.

4.3.2 Representation Services

Representation services work on externalised representations of knowledge of different structure. The main idea is to apply certain services on user generated data in order to compute or infer new information, which can be used by modeling services or reseeding services, e.g. a readability index. Different types of representations are considered:

[15] The Flesch-Reading-Ease score represents a readability and comprehension difficulty measure based on a weighted relation between the total number of words, sentences and syllables a text contains, cf. (Flesch, 1948).

- Structure: Semantic structures are investigated with respect to conceptual knowledge and process knowledge.

- Content: Artefacts are investigated in order to try to derive necessary supportive actions for the artefacts or for information recommendation.

- Usage: The usage of a software system is represented in traces of user activities and stored in an ontology in order to try to deduce the users' state of knowledge, interests or characteristics.

4.3.3 Modeling Services

Modeling services are used to build models of the different entities *user*, *resource*, and *process*. These services collect data by means of representation services, transform them with regard to their representation and enrich them typically with abstract model descriptions. Building a user profile for example, consists of several data, including the number of created documents, a calculated expertise, or related persons. The number of created documents can easily be counted by a representation service searching the database. The calculated expertise may be deduced by analysing Knowledge Indicating Events (KIEs) (S. Lindstaedt, Beham, Kump, & Ley, 2009). Thus, a value added is generated by enriching collected data with predefined measures. Related persons may be gathered by considering those persons who have already worked on the same resource for example. Thus the implicit underlying assumption that people might know each other because they touched the same document leads to a certain model instantiation. Similar ideas are applied to process model services (Riss, Cress, Kimmerle, & Martin, 2007) and resource model services (Mature Consortium, 2011c). Shortly characterised, these three service types have the following underlying ideas:

- User Model Service: Based on the idea of KIEs, a model of system users (only users, not all related persons) is calculated by making use of usage traces, person-resource dependencies and social network analysis.

- Resource Model Service: The resource model service allows to create a model that provides an enhanced view on single resources and resource relations. It makes mainly use of representation services that apply natural language processing techniques.

- Process Model Service: By means of process mining techniques and task pattern recognition, process models are built.

4.3.4 Reseeding Services

Reseeding services shall support knowledge maturing of contents, semantics, processes and people. Knowledge maturing of these four types is understood as follows (Mature Consortium, 2011c, 2007):

- Contents: Represent mainly declarative knowledge externalised in digital artefacts.
- Semantics: Represent knowledge about the relationship between entities (e.g. artefacts, persons, terms) and is necessary for example for people to communicate on the same abstraction level, with a similar/same focus or with the same vocabulary.
- Processes: Represent procedural knowledge about how to carry out a certain process or task.
- People: Represent knowledge about people (system users). This is helpful for any expert recommendation or awareness mechanism.

This class of *Reseeding Services* highly depends on the other two main classes but is the one, which directly generates an output for the users, not an intermediate result anymore. Therefore, at this stage the mere technical *service* definition, in SOA terms a backend module (Jones, 2005) becomes inapplicable, as it is partly merged with a (contextualised) user interface. Providing awareness for something is hardly possible without a proper GUI design, no matter how relevant the information is.

4.3.5 Discussion

In a nutshell, it can be said that representation services work on a static datasets with a one dimensional outcome. Each operation on the dataset will return the same result until the algorithm has changed. Model services may take into account dependencies within the whole database of available knowledge. Furthermore the dynamic model status itself may be an input parameter for the calculations of models. Reseeding services aim at initiating further learning processes of the user, by providing resource awareness or expert recommendation for example. Thus, maturing services may determine knowledge maturing but also influence and initiate knowledge maturing. Therefore, two important issues need to be discussed, the role of KMI and the question, which knowledge maturing activities can be supported by means of maturing services.

The KMI derived from the ethnographically-informed study and from the Representative Study (cf. section 3.1 and 3.3) can help to operationalise knowledge maturing. In that way Knowledge Maturing shall be quantified, and made detectable as well as measurable. KMI are not use cases, thus it is not the purpose to support KMI, but software needs mechanisms to detect appropriate ones and services that translate them by means of models. Figure 4.8 shows the necessary process based on the three main service classes. It needs representation services in order to detect KMI, which return

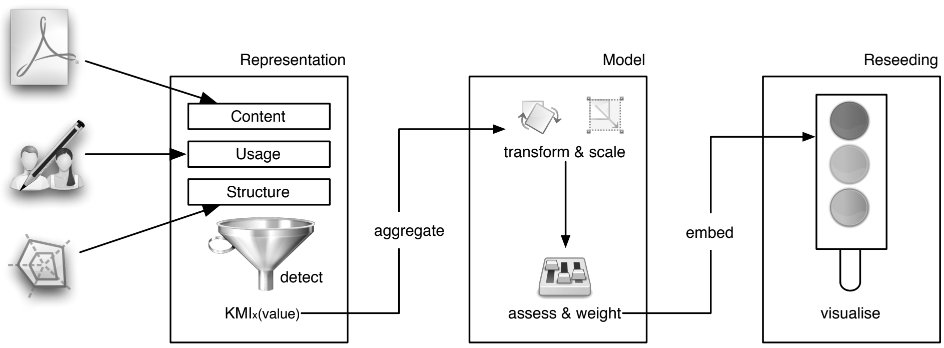


Figure 4.8: *Making use of Knowledge Maturing Indicators within the maturing services.*

some kind of quantified measure. Afterwards, it needs some kind of model service (or algorithms as part of a particular model service, e.g. resource model service), which can assess, weight, and aggregate it with other KMI values (it needs typically more than one indicator to allow a statement about knowledge maturing, cf. section 3.3.3.2). The reseeding services may then somehow visualise the result appropriately, in order to induce a knowledge maturing activity. For example, an LME might aim at supporting knowledge workers in improving the quality of organisational artefacts. A visualisation of the maturing status of documents might help here. Therefore, representation services exist, which determine the user rating, readability, how often a document has been read or changed and probably other indicators. The according model service aggregates these values and allocates them, as the user rating might be valued higher than the readability value. The reseeding service can make use of the model service's value and shows something like a traffic light, with green, orange and red, indicating the maturity status of the resource. This example clearly shows a practical value for the use of KMI, though making a sensible quantification and assessment is obviously a huge problem. Another problem is the possible induction of knowledge maturing activities and the question, how far maturing services (including the use of KMI) can help here.

Two additional aspects can be drawn from the document maturing example above:

1. Reseeding services can not be clearly separated from user interface functionality. According to (Mature Consortium, 2011c) it is an aggregation of backend service functionality and visual representations.

2. Though the quantification and scaling of the maturing indicators would result in perfect values, there is no guarantee that people react to it, in a way, that knowledge maturing activities are induced.

The blur between backend services, which can be technically implemented easily in other contexts (including necessary model adaptations), and the user interface should be avoided. According to (Fischer, 1996; Fischer et al., 1996) reseeding not only needs technical support but also requires an organisational agenda and a culture that supports reflection cycles. Thus, software has to fit the non-technical, cultural constraints. This can be partly solved by an appropriate user interface design, by using a contextually fitting vocabulary or graphical design for example. Services should be technically decoupled from that, as they might be useful in other contexts too and accessed by other user interfaces. The whole system of contextualised user interfaces and maturing services may support reseeding by inducing knowledge maturing activities. The notion of *reseeding service* however is rather misleading and should be avoided.

The second point listed above is also very strongly bound to the inter-organsiational culture. Reconsider the example above and assume that the maturing services returned perfect fitting values for a resource, which result in a red light, saying the document is not in a good shape. People have two choices then: ignore or improve. In terms of knowledge maturing activities both could be supported. Ignoring the resource could be supported by a deleting function representing the activity *Reorganise information at individual and organisational level*. Improving the resource can be supported by an editing functionality representing *Create and co-develop digital resources*. The software needs to provide the possibility of applying one or both strategies but it should be conform with the organisational culture and, moreover, it should provide and show immediately a value added. This, again, leads back to the argumentation before, that the user interface should provide a contextually fitting access to the organisational database. Maturing services return data that may be used to induce knowledge maturing activities (such as *Communicate with people*, *Reflect on and refine work practices or processes*), sometimes they can even be supported (e.g. *Find relevant digital resources*, *Find people with particular knowledge or expertise*). Thus, they play an invaluable role for the design of an Learning and Maturing Environment.

The MATURE deliverable of year 3 (Mature Consortium, 2011c) describes an overall set of 27 maturing services. Sixteen of them are representation or model services. The remaining eleven are reseeding services, which have already been contextualised and may directly support users' knowledge maturing activities. As stated above, representation and model services can only indirectly be used to support knowledge maturing activities. Table 4.1 shows the list of reseeding services ordered according to the knowledge maturing activity each of them supports.

Consequently, this list extends the list of services, which may support knowledge maturing and which has been described previously in chapter 3.

4.4 Non-functional Requirements

4.4.1 PLE Approach

A learning environment can be understood as the overall complex of a system (arrangement), which supports learners in learning processes (Wagner, 2003). It includes for example learning tasks, -materials and the place. This is not necessarily a digital environment nor is it limited to formal learning settings (Ballstaedt, 1997). But from this point of view, a learning environment can be every situation and context where learning takes place. However, considering the historic development of personal learning environments and the according literature it becomes clear that the PLE concept is closely

Table 4.1: *Reseeding services ordered according to supporting Knowledge Maturing Activities. Service short descriptions taken from (Mature Consortium, 2011c)*

Knowledge Maturing Activities	Service Name	Service Short Description
Find relevant digital resources	Quality Based Resource Recommendation Service	This service provides a set of ranked resources. The selection and filtering of resources is based on the qualitative status of the resource and quality requirements of the user.
	Case Based Resource Recommendation Service	The service suggests resources based on resource-use in historical process executions.
	Context Aware Notification Service	Provides information about activities related to particular artefacts.
Keep up-to-date with organisation-related knowledge	Expertise Analytics Service	This service provides an aggregated overview and comparison of available and requested expertise based on tag assignments and search query analysis within a certain timeframe.
Reorganise information at individual or organisational level	Ontology Gardening Recommendation Service	This service provides recommendation for improving a SKOS ontology based on the ontology itself and information on its application. Priorization, types of recommendation and scope (either whole ontology or single entities) is configurable.
Reflect on and refine work practices or processes	Historical Case Service	The service searches for historical cases in processes based on a given input. They give information about how the tasks and processes have been performed in the past and also offers an additional basis for decision making.
Share and release digital resource	Keyword Recommendation Service	Provides a list of synonyms and hyponyms for tags.
	Tag Recommendation Service	During the annotation process of a document, a user is supported with appropriate tag recommendations to achieve a consistent personal and organisational tag vocabulary. The goal of this service is to provide cognitive plausible recommendations.
Find people with particular knowledge or expertise	Expert Ranking Service	Based on past tag assignments (user-document-tag triple marked with a timestamp), this service recommends knowledgeable colleagues working on a specific topic.
	People Awareness Service	Based on a user/person's profile, this service recommends other persons with a similar profile.
	People Ranking Service	Provides a ranked list of people that are relevant for a given topic.

related to technology enhanced learning and virtual learning. Therefore, discussions about PLEs out of this context do not seem to be very helpful and rather misleading.

The concept is shortly treated from a linguistic point of view. The supplement *personal* refers to the learner within the learning environment. According to Longman's Dictionary of Contemporary English, *personal* means

> "belonging or relating to one particular person, rather than to other people or to people in general" (*Longman's Dictionary of Contemporary English (DCE)*, 2005)

Personal can also refer to private areas of life (asking personal questions), fierce criticism ("Don't get personal!") or to the body (personal appearance). However, referring to an object, *personal* means it is the possession, property or belonging of a specific person. There is some tendency in scientific discussions towards exchanging *personal* by *personalised* in order to point out that a PLE can be adjusted to the learner's needs. *Personalised* includes the notion of the fact that someone else can adjust it in a way she/he thinks it is useful, which might actually not be the case. In some specific contexts this renaming might be useful but in general it is rather not. The fact that something belongs to someone (that it is personal) is the basic precondition that she/he can and is allowed to change and adapt it according to particular contexts.

Apart from those aspects of individual belonging and the idea of self-regulated learning, the PLE concept is mainly about connecting people in order to create, share, remix, repurpose, pass along and discuss contents (Downes, 2005). Conversations do not any longer conclude only words, people can use multimedia, including images and videos in order to convey a message or pass information. Supporting workplace-integrated learning is one of the major issues of the PLE concept and an inherently social activity. A PLE is supposed to fit in with the contextual needs of learners and it should provide them with the ability to take responsibility for their own learning processes (Attwell, 2007a). It should provide free access to the social network and information using open and standardised protocols or leightweight proprietary APIs (Wilson et al., 2007). Beyond a rather technical view on this concept, it is often referred to as a new approach to learning beyond closed and restricted Virtual Learning Environments (VLEs). However, actually it addresses knowledge workers (Attwell, 2007b). Nowadays, the main tool for a knowledge worker is a computer. Consequently, the PLE is manifested in computer software. Thus, the aim of providing open and personal learning environments raise pedagogic questions regarding an effective implementation.

Regarding the technical non-functional aspects, it can be summarised that the following issues need to be considered (cf. Wilson et al. (2007))

- The combination and linkage of a heterogenous set of services and applications is facilitated.
- A reduced view on contextually relevant users and resources is provided.
- Incorporate existing VLE systems and according learning processes into informal learning processes.
- A personal and global scope should be supported.
- Foster the creation of open content, covered by according license models.
- Design a software based on open standards and lightweight proprietary APIs.

In conclusion, many scientific discussions often raise the impression that the mere provision of a technical flexibly configurable software system that provides open access to contents and people results in shaping the learning processes of its users (Fiedler & Väljataga, 2010). This is not the case. The main issue is (and that is the difference to VLEs) that the provided software needs to be adapted to the user context. Moreover, the users are responsible for that and not an external expert, tutor or coach. Consequently, users need to develop the willingness and competence which enables them to accept this responsibility. They do not have it per se. Fostering this process should be part of further research.

4.4.2 LME

Compared to the PLE concept, the concept of a Learning and Maturing Environment (LME) focuses clearly stronger on informal learning in organisational contexts. MATURE's *Description of Work (DoW)* distinguishes between a *Personal Learning and Maturing Environment* and an *Organisational Learning and Maturing Environment*. The development of each of them was a major objective of the project, such that for each environment a work package was defined. These objectives were described as:

> "
>
> - *OBJECTIVE 2:* a [...] [PLME], embedded into the working environment, enabling and encouraging the individual to engage in maturing activities (comprising content, process and semantic aspects) within communities and beyond
> - *OBJECTIVE 3:* an [...] [OLME], enabling to analyze and to take up community activities (comprising content, process, and semantic aspects), to reseed innovation processes and to apply guiding strategies
>
> " (Mature Consortium, 2007, p.12)

A PLME was supposed to consist of loosely coupled tools that integrate seamlessly into the knowledge workers' work environments. This approach can be traced back to the idea of PLEs. As mentioned before, a PLE is tackling the need for a personally adaptable software that can be integrated into individual learning processes and contextualised in the work environment (Downes, 2005). The OLME concept was derived as a kind of counterpart to the PLME, and is tackling the need for organisational guidance and monitoring of knowledge maturing, as well as driving community activities.

However, it turned out to be complicated to describe the difference between a PLME and an OLME. At first glance, it was thought that a separation could be found on a different level of abstraction or in a different perspective on the context both types of software might provide. The PLME for example is used by individuals who fulfill a particular task and thus need a particular view on the knowledge base. On the contrary, the OLME is rather used to drive processes and link the different people relevant for different tasks. On the one hand this separation makes sense, but on the other hand it is not a practical decision. Having a look at the particular peculiarity of the software, one has to admit that every kind of software can support and drive individual learning processes, although they might be embedded in organisational processes. As knowledge maturing is an inherently social (learning) process (cf. section 2.2), both kinds of *Learning and Maturing Environments* will support the individual.

Nevertheless, a difference could be made with respect to the kinds of supporting actions. Let us assume that an LME can be easily divided into functional modules, each of them supporting a certain knowledge maturing activity. Then, a difference between PLME and OLME activities exists with respect to

1. the formality of work-integration of these activity modules
2. the degree of ownership of the content
3. the transferability of content between contexts.

Especially the first point is considered to be the main difference between rather personally- or rather organisationally-characterised environments. Assume a larger organisation that has strictly implemented formalised processes. These determine how tasks are performed. The used software is supporting the knowledge workers in sticking to the processes and fulfilling all necessary tasks. Such a software system can be considered rather as an OLME, because the work-integration is very formalised, although it obviously addresses also individuals and might foster individual learning processes. Moreover, the contents aggregated in such a system are probably rather centrally organised. Thus, the knowledge worker does not possess these contents and she/he can not move into another context and re-create her/his working environment. Hence, the knowledge is useless outside the current context, except for illegal activities like economic espionage.

Assume for example, a software developer who has just learned a new technique, e.g. dependency injection in Java. She/he has aggregated material and examples about that. She/he possesses this material and her/his LME should support her/him to keep it and access it when changing the job. In this case, it is valuable for the developer in another context. This can be entirely different to an employee in the Human Resource (HR) department who is co-responsible for job advertisements and hiring interviews. Although, an OLME should support her/him in aggregating the necessary job information from the department leaders and might help her/him in creating contextualised advertisements, these contents are more or less untransferable to and not usable in a different context (regardless the personal experience condensed as tacit knowledge).

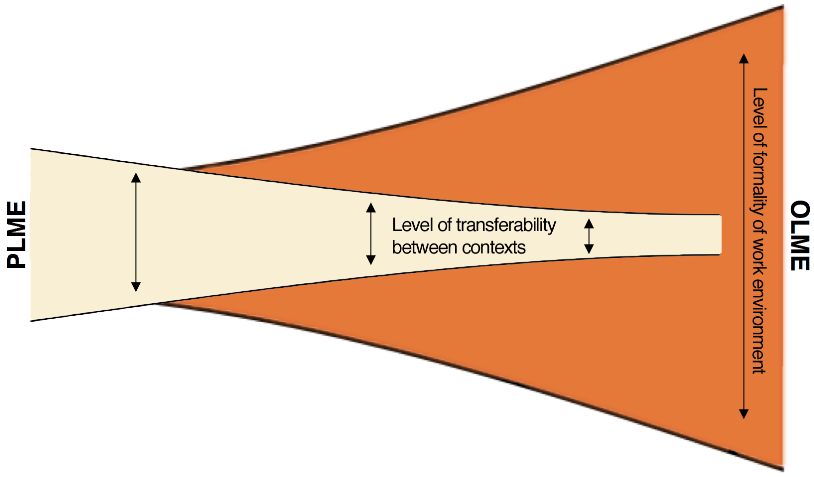


Figure 4.9: *When the formality of the work environment increases, the level of transferability of knowledge and resources decreases. PLME styled application is implementable in rather informal contexts, as opposed to the OLME.*

Thus, there is very well a difference between the idea of a PLME and an OLME. It does not exist so much from the developers point of view, but rather from the application contexts' perspective. It depends on the (necessary) degree of formality of the work processes, the software should support and in which it is embedded. Figure 4.9 visualises this aspect. This view on the difference of both approaches is rather abstract as it is not quantifiable.

In conclusion, it is the degree of formality of work-integration that defines whether an LME is characterised more organisationally or in a rather personal way. Rather informal work environments can be supported quite well with the personal one and vice versa. However, it should be requested that software developers who are approaching an LME, carefully decide to which degree the implementation of a PLME is possible in order to maximise the knowledge workers' individual responsibility for and identification with their learning and maturing environment. The general system design is unaffected from that differentiation and will support both.

4.5 A PLME Framework Architecture

This section focuses on the formal architecture description. It rationales the 4-tier division represented in the green block in figure 4.10

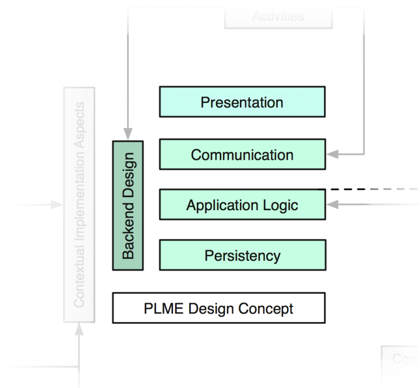


Figure 4.10: *Focus on the architecture design. Irrelevant aspects for this discussion are blanked.*

According to the findings described above, regarding the backend architecture, the intercommunication infrastructure, the maturing services and the PLE/PLME requirements, a framework architecture as described in figure 4.11 should be the structure of choice for a PLME. It describes a four-tier architecture with the tiers *Presentation*, *Communication*, *Application Logic* and *Persistancy*. The architecture is open enough in order to allow an arbitrary addition of new PLME components but also confined enough in order to stick to the objectives of organisational learning in a probably restricted environment. The different tiers are described subsequently:

- **Presentation:** The presentation tier comprises the Graphical User Interface, which allows and defines the possible user interaction with the system and visualises any system responses. It might be divided into different PLME components, such as widgets. Technically it is up to the developer to create it as a desktop based environment (e.g. by using Java) or a browser based variant (e.g. HTML with AJAX) or a mixture of both. These components can be connected to the communication tier in order to establish an inter-component communication. This inter-communication also allows a lightweight integration of components rather on the user interface level than on the service

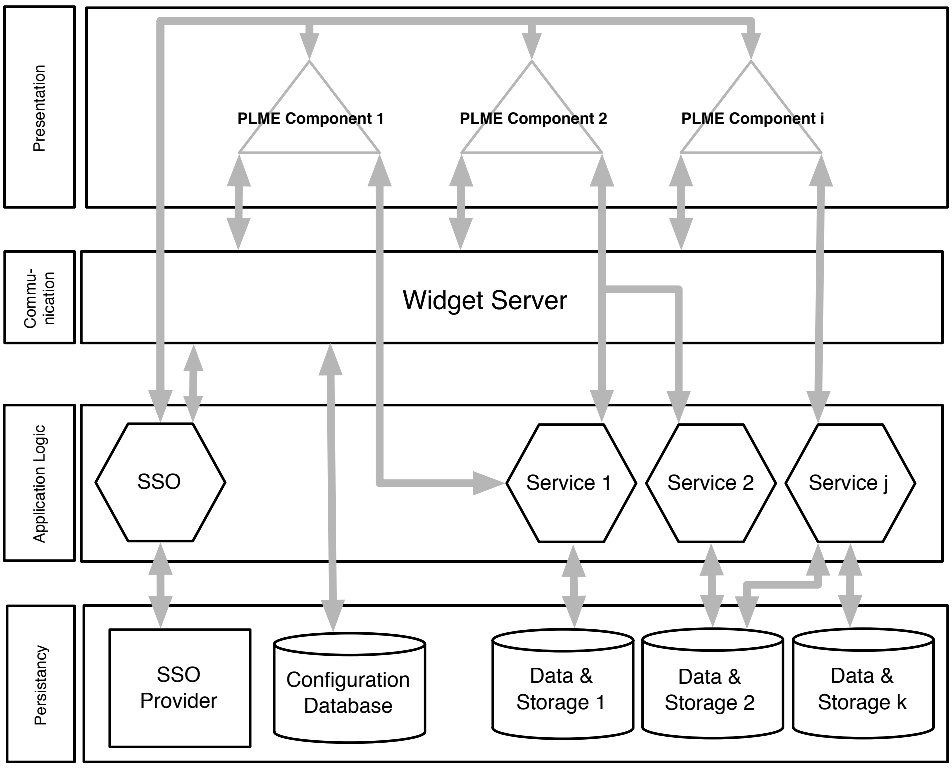


Figure 4.11: *The architecture of an ideal PLME framework.*

level. Though, this might reduce the reusability, it is developed and deployed quite quickly, so that the time-to-market can be reduced. In order to reduce the barriers at this level of integration, a Single Sign-On provider needs to be accessed via a particular service on the *Application Logic*-tier. In order to provide the needed functionality, the PLME components access the services on the same tier. Components might use one, two or more of them, depending on the particular objectives. However, this way of service access reflects the lightweight architecture needed and also allows to incorporate externals services or even UIs.

- **Communication:** The communication tier implements the inter-client communication, for example a client/server based solution as described in section 4.2.2. Such sophisticated solutions need a kind of user management and configuration in order to control the message flow. This is stored in a database which is directly accessed and thus has a connection to the persistency tier. Moreover, in order to be implemented seamlessly as part of the PLME component landscape, it also needs access to the SSO provider.

- **Application Logic:** This tier holds the services needed to serve the particular objective. These can be either hosted within the organisation but might also incorporate external services. The (security) decision whether this is allowed or to which degree this is allowed in an organisation needs to be taken on a management level and not on a technical one. However, the services typically need a database in the backend in order to work. This independent collection of services is the base for the implementation of such a lightweight architecture, as complex coordination and orchestration processes can be omitted.

- **Persistency:** The persistency tier holds the databases, which are necessary for the different services. Furthermore, the inter-communication solution and the SSO provider use it and need access to it. Apart from providing storage and retrieval of data, it should also provide a sustainable access, which means that a kind of backup solution needs to be considered.

In conclusion, by using this architecture concept the objective of providing a PLME implementation can be fulfilled. Moreover, this can be done independently from the technique used. The application services can be connected to the backend via a socket connection, where the different components in a PLME can be connected to the services via REST and the components themselves might be web-based or desktop based or even run on a mobile, at the same time. However, in such technically heterogenous scenarios, especially on the presentation tier, it needs a careful design of the overall PLME solution in order to avoid the introduction of media disruptions. This can also be seen as one of the major outcomes of the MATURE's prototype evaluations. The next chapter will introduce and describe the three MATURE prototypical instantiations, which follow (at least partly) the definition of a personally characterised LME. They do not follow completely the architecture described above but the approach can be found, though the flexibility got lost to some degree. This simply happened due to a missing formal architecture plan and furthermore due to contextual design decisions. These comprise application partner requirements and considerations of time and work load.

4.6 Conclusion

In this chapter the design of an architecture was described, which allows the implementation of a PLME. Therefore, it was discussed and elucidated that a complex SOA architecture based on SOAP, realised by means of a ESB component is not suitable for supporting flexible and individually arranged Personal Learning and Maturing Environments. Instead, a rather lightweight REST-style backend architecture was found to support the realisation of the PLME approach far better. Moreover, the Inter-Widget Communication was introduced, which allows a lightweight integration of different components on a GUI level. Furthermore, maturing services were introduced, which maybe enhanced by processing operationalised and contextualised Knowledge Maturing Indicators. The results can be used by UIs to provide better awareness, recommendations or other kinds of reseeding mechanisms.

Up to this chapter, the general term of Learning and Maturing Environment has been used. The discussion about the differences of a personal context and an organisational context however led us to distinguish between a PLME and OLME. The particular context has a huge impact on the characteristic of support the respective software is supposed to provide. Therefore, the following chapters, which comprise the prototype presentation, the evaluation case study descriptions, the related work and the conclusion will focus on the PLME approach.

Chapter 5

MATURE's Prototypical PLME Instantiations

The last chapter discussed the framework requirements, including the backend architecture, the service enactment, an integration approach and concluded finally in a conceptual description of a PLME framework. Within the MATURE project, five different software prototypes were developed, as depicted in figure 5.1. Three are PLME approaches, two of them implement

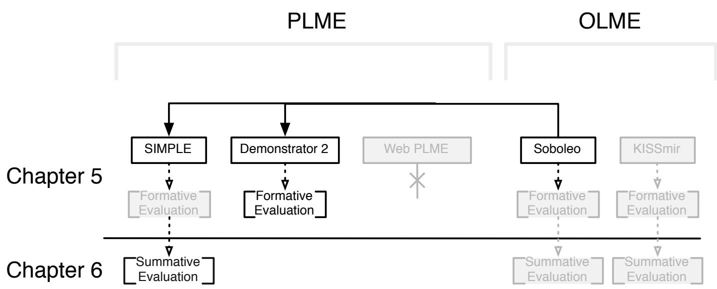


Figure 5.1: *The prototypes developed during the MATURE project and its relevance for this thesis.*

rather OLME approaches. The PLMEs are called *SIMPLE*, *Demonstrator 2* and *Web PLME*. The OLMEs are called *SOBOLEO* and *KISSmir*. SOBOLEO is integrated in SIMPLE and Demonstrator 2. The approach called *WebPLME* in figure 5.1 demonstrates the creation of a PLME by means of service orchestration via the Knowledge Bus Architecture. This was discarded early in the project as no use case could be found for this specific implementation, and application partners were not interested in it.

Furthermore, the research team, which was mainly involved in the PLME design was not convinced of the technical approach, with its known limitations e.g. from the WebEaz project (Lizcano et al., 2008). Especially the implementation of a heavy weight backend infrastructure described in section 4.2.1 was not considered ideal. *KISSmir* is an OLME approach, which has no relation to the PLME prototypes. All in all, this chapter describes briefly SOBOLEO, and then the PLMEs Demonstrator 2 and SIMPLE.

For all prototypes the figure also shows whether they were examined in a formative and summative evaluation. The evaluation activities for the OLMEs are marked grey in the figure as they are not discussed in this thesis. Those of KISSmir do not have an impact on the PLME design at all. Those of SOBOLEO have a small impact, the text will mention if design decisions base on these activities. The formative evaluation of SIMPLE and its implications on the PLME design was already discussed during the presentation of the participatory design process, cf. 3.5. The formative evaluation of Demonstrator 2 is discussed in this chapter, as it only marginally provides insights into knowledge maturing and as it is not comparable to the case studies presented in the following evaluation chapter.

The description of the prototypes is separated from the case studies for the following three reasons:

1. This chapter can focus on technical details and gives a rationale of how the software aims at supporting knowledge maturing. The formal process of evaluation can be described more concise in the next one.

2. The prototype SIMPLE was evaluated in three different case studies, thus the technical details should be introduced beforehand.

3. SOBOLEO is used in both PLME prototypes. However, evaluation activities are not of such great importance. For the sake of a clear structure, SOBOLEO should be described separately, too.

First SOBOLEO will be described as it is a common part for the other two. It can be referred back to it when necessary. Afterwards the two prototypes which make use of SOBOLEO are introduced.

5.1 SOBOLEO

SOBOLEO is the acronym for Social Bookmarking and Lightweight Engineering of Ontologies. It is a web based tool that uses AJAX technologies and provides possibilities for social and semantic bookmarking, people tagging, and collaborative ontology development. Figure 5.2 depicts the SOBOLEO system architecture. It has a similar design as the PLME framework de-

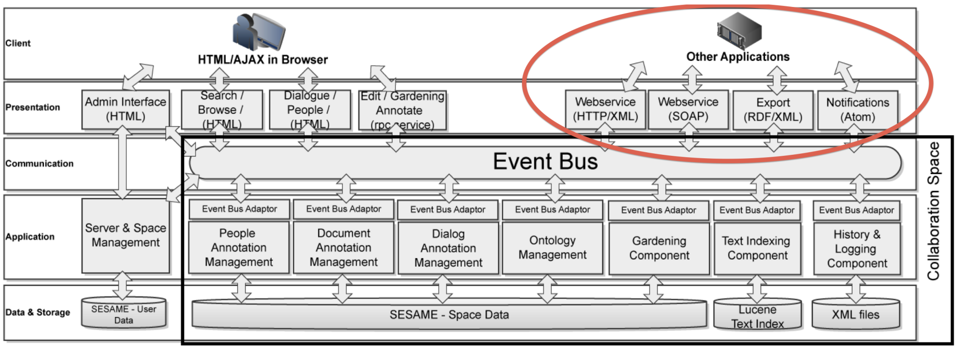


Figure 5.2: *The SOBOLEO system architecture. Taken from (Braun, 2012, p.127).*

scribed in section 4.2. However, the red marked area in the figure shows, how other applications can access the SOBOLEO services.

5.1.1 Social Semantic Bookmarking

With SOBOLEO users can annotate and bookmark web pages collaboratively and search for them in the SOBOLEO space (cf. figure 5.3). The bookmarking is realised via the tagging activity. The tagging activity is supported by means of the collaboratively created ontology and can in turn also support the ontology creation. Let us assume a user bookmarks a webpage by annotating it with a new tag that has not been used before. In this case, the new tag is simply added to the root of the ontology. In case a user wants to tag a web page with a known tag, then SOBOLEO also suggests the broader and narrower relations of that tag by means of a recommendation list.

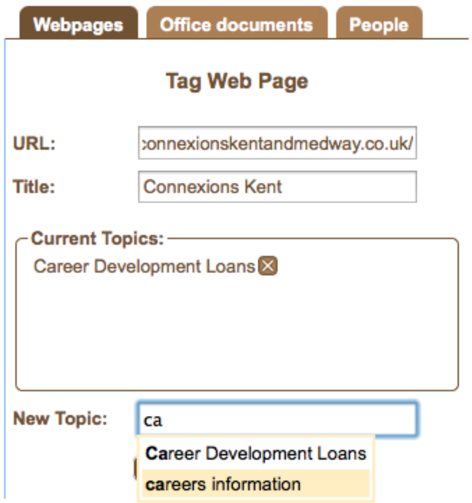


Figure 5.3: *SOBOLEO's tag window which gives the option to annotate web resources with tags.*

Figure 5.4: *SOBOLEO's entrance to people tagging by providing an email address.*

5.1.2 People Tagging

In case of people tagging, two different situations need to be distinguished. The person to be tagged is not necessarily a user of the system and is thus not necessarily represented by an email address, but rather by web page such as a business social network link as LinkedIn[1]. Thus, the user has to decide whether she/he wants to tag a person or a web page, if possible tagging is done via an identifying e-mail address, cf. figure 5.4.

[1]Browser based professional network. http://www.linkedin.com/, last access 01.03.2012

However, the tagging activity as such is quite similar to the web page tagging (cf. figure 5.5). The general purpose behind the people tagging

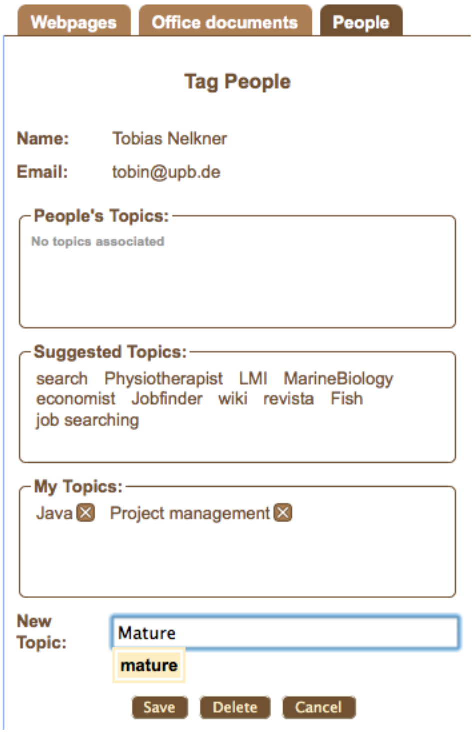


Figure 5.5: *SOBOLEO's people tagging window, which makes aware of people's topics, suggests new topics and shows assigned tags.*

approach is the implementation of a bottom-up collaborative competence management system (Braun et al., 2010; Braun, Kunzmann, & Schmidt, 2012). Depending on the target organisation, some properties need to be changed in order to meet the organisation's cultural needs. One can for example see who has provided a tag or not. Tagged people might want to delete a tag for themselves, etc. (Braun, 2012). However, for the users, the huge benefit is, that they can search for expertise and thus have a possibility to get in contact with people who might be able to help them for a task at hand. Expert search and expert ranking is the benefit that is generated for the single users and which is one of the main reasons why SOBOLEO was (partly) integrated especially with SIMPLE (cf. section 5.3).

5.1.3 Collaborative Ontology Creation

The ontology that is created by using new tags assigned to resources, initially has a flat structure as these tags are added to the root of the ontology. It needs gardening activities in order to create a real ontology out of that and to manage it. Figure 5.6 shows the ontology editor, which is used to structure the vocabulary. In the notion of SOBOLEO tags are not simple

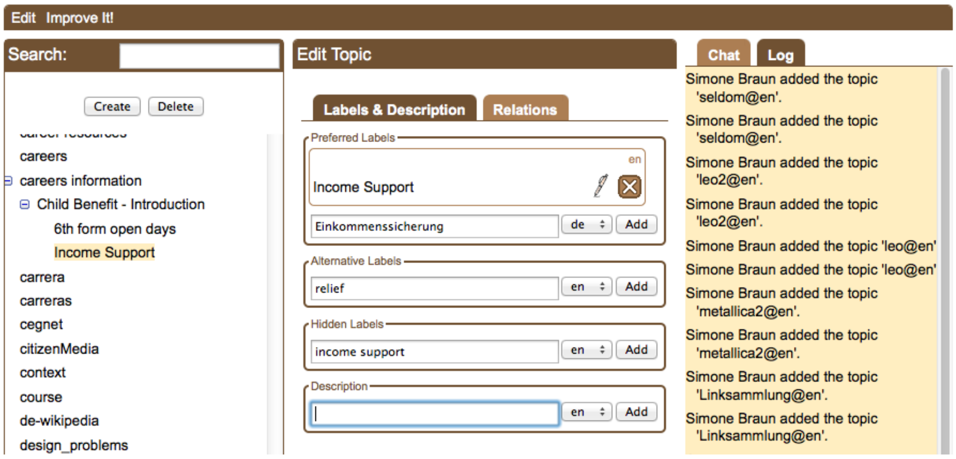


Figure 5.6: *SOBOLEO's ontology editor. The concept hierarchy is on the left, the concept metadata in the middle and an additional log and chat board on the right hand side.*

and flat keywords but they are concepts. They are enriched with metadata, ontology relations and other semantic information. This contains broader and narrower relations in order to represent the ontology. Furthermore a description can be assigned, language translations, synonyms and hidden labels with orthographic mistakes. These ontology management activities are also referred to as gardening activities. That means, that the tag space or the vocabulary needs to be reassessed, cleaned and restructured if necessary. As an outcome of an evaluation case study it will be clear that these activities are requested by users, though it needs an evolving culture around those activities. This includes questions like who is allowed to change, are changes fixed or reversible by others or should they be argued and discussed (Braun, 2012)

The ontology editor furthermore provides a logging board, which presents a history of user activities that allows to track and comprehend changes in the ontology. The implemented chat functionality is important as people need the ability to discuss about changes that were done (Ravenscroft et al., 2010). This was the motivation of the prototype described in section 5.2.

5.1.4 Conclusion

SOBOLEO provides social semantic bookmarking connected to a collaborative approach to ontology creation. Derived from the bookmarking concept, people tagging was introduced. This allows a bottom-up competence management in organisations but also for example expert recommendation mechanisms in CoP. The particular support for learning is described in detail in (Braun, 2012). The way, how the single parts of SOBOLEO are supposed to support knowledge maturing is described in the context of the two prototypes in the following sections.

5.2 Demonstrator 2

The *Demonstrator 2* is an integration approach of SOBOLEO and InterLOC, a tool for critical and structured discussions. The naming is caused by the different development strands in the MATURE project after year 1. At that point in the project rather prototypes were developed and it was not absolutely clear how to proceed with the PLME and OLME development. These prototypes were formatively evaluated. In case of *Demonstrator 2*, a further development was discarded after the formative evaluation. On the one hand, interesting results were gathered through the formative evaluation, which led to the impression that it was finally clear that the software can support knowledge maturing (Mature Consortium, 2010d). On the other hand it became clear that quite some effort would still have been necessary to go a big step further. However, as resources had to be bundled, this could not be accomplished.

Demonstrator 2 addresses the need to discuss and reflect critically about gardening activities in order to create a shared meaning (Ravenscroft et al., 2010). The creation of a shared meaning by means of structured discussions lies at the point of the intersection between PLME and OLME. Discussions are necessary to accomplish work tasks successfully but they are not necessarily formally embedded in work processes. Moreover, the collaborative creation of ontologies is not solely organisationally oriented, it also clearly shapes the personal understanding of the relationship between concepts and helps to create a common vocabulary that could also be applied in a different context (Braun, 2012).

From a technical point of view, it instantiates to a certain degree the conceptual PLME design described in section 4.5 (cf. figure 5.8). *Demonstrator 2* is an example of an integration effort merely on the user interface level. By means of the *WidgetServer* as IWC service, discussion and reflection activities are initiated. There is no cross-service usage between the systems.

In order to introduce this prototype, first the application context will shortly be explained. Afterwards, InterLOC and the technical integration is explained and it will be shown how the prototype is supposed to support knowledge maturing. In conclusion, a summary of results of the formative evaluation will be presented. All insights, including the lessons learned from the formative evaluation are included in this chapter. Due to the minor complexity of the software, fewer results regarding knowledge maturing and a not comparable procedure to the summative evaluation case studies presented in chapter 6, the description is put completely in this section.

Parts of this work have already been published in (Ravenscroft et al., 2010). The author of this thesis was highly involved in the development of *Demonstrator 2* by adapting InterLOC to the application context.

5.2.1 Development Context and Scenario

The application partner for *Demonstrator 2* was Structuralia, a provider for e-learning and blended learning solutions based in Madrid, Spain. Structuralia provides e-learning courses mainly for the construction sector. Therefore, the development context and scenario is built around a course for Classic Roman Civil Engineering. This

> "is currently built up with alumni students of a Structuralia e-learning course on this topic and together with the course trainer as community moderator. The aim is that the community collaboratively develops a shared understanding of this domain by collecting and critically discussing (controversial) information - especially information in the internet about Classic Roman Civil Engineering is often erroneous - and developing a common multilingual vocabulary - as there is a lot of information in different

> languages relating to Classic Roman Civil Engineering." (Mature Consortium, 2011b, pp.59)

As Structuralia and all clients are Spanish, the software had to be localised to the Spanish language. The formative evaluation was then accompanied by a Structuralia representative on site.

5.2.2 Technical Concept and Integration

InterLOC was designed and deployed as a "web-enabled" application. It is a Java application that can be started via Java Webstart. It could not be found an actual reason that explains why InterLOC has not been developed as full featured web application on the presentation layer. The most probable reason is the fact of the hardly sufficiently developed JavaScript libraries for the XMPP protocol (Saint-Andre, 2004a, 2004b; Saint-Andre, Smith, & Tronçon, 2009) and (Friedrich et al., 2011). This is used for the chat functionality.

InterLOC is a tool to "promote critical and creative discussion, reasoned dialogue and collective inquiry within the digital landscape" (Ravenscroft et al., 2010). Figure 5.7 shows a typical discussion as it is displayed by InterLOC. Dialogues are organised as threads, i.e. one can respond specifically to particular comment. However, really characteristic and specific is the way to enter the comments and answers. Participants have to choose the opener of their comments from a drop down box. For example, if someone simply wants to comment on a statement, she/he can chose between openers like *I think*, *I read that*, *Let me explain* and many more. In that way, a certain discussion culture that supports learning should be encouraged (Ravenscroft et al., 2008).

> "Essentially, these dialogue games realise engaging and structured rule-based interactions that are performed using pre-defined dialogue features (such as dialogue moves and a model of turn-taking) that are specifically designed to foster thinking and learning in ways that are popular with users." (Ravenscroft et al., 2008)

The architecture of this demonstrator is an example of an integration approach merely on the user interface (UI) level. Figure 5.8 shows that

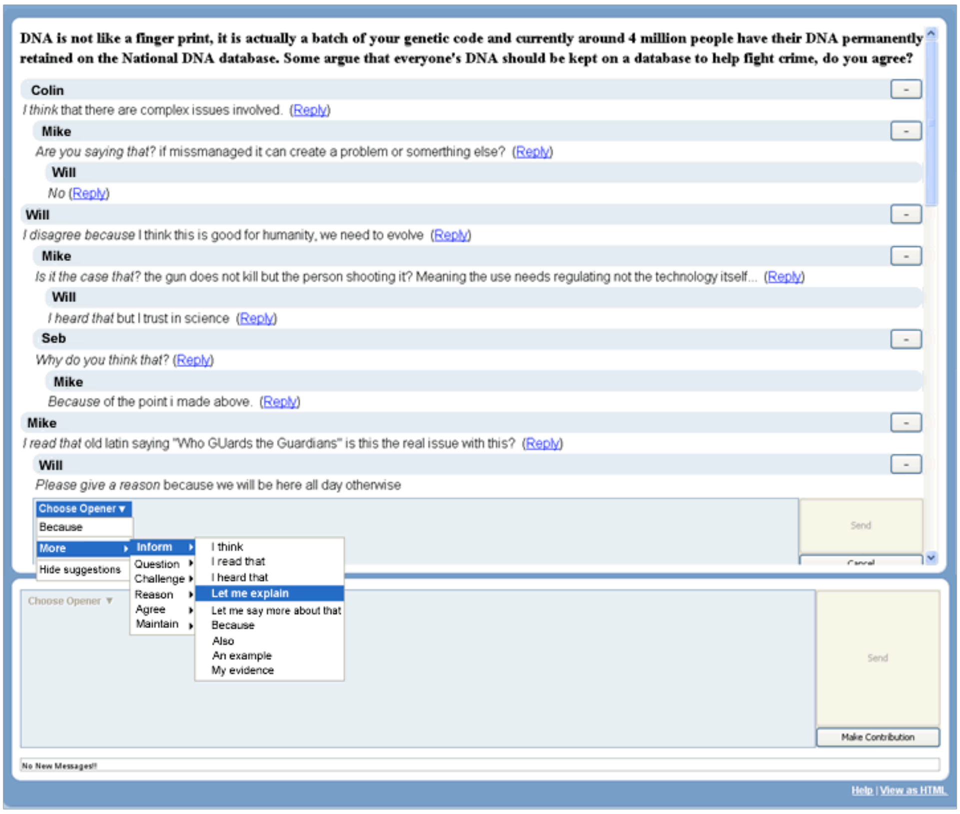


Figure 5.7: *InterLOC, showing a typical discussion, including some openers. Taken from (Mature Consortium, 2009b).*

SOBOLEO and InterLOC are working in parallel, exchanging data only via the Inter-Widget Communication (IWC) infrastructure. Users could initiate and start InterLOC from within SOBOLEO. However, they had to login to SOBOLEO and after they had started InterLOC, they had to provide their credentials again there. Each system is storing and managing its data itself and only uses services provided by the own storage layer. In case of SOBOLEO, this is a self developed backend. In case of InterLOC this is OpenFire, an open source XMPP server, as InterLOC is working on that protocol.

The users' work processes with both systems was as follows. Changes to the ontology are realised by the users with the ontology editor as described before in section 5.1. When users felt it was necessary to discuss changes in the ontology, they started to discuss critically in InterLOC (cf. figure 5.9). There, they could contribute to existing discussions or started new ones in the

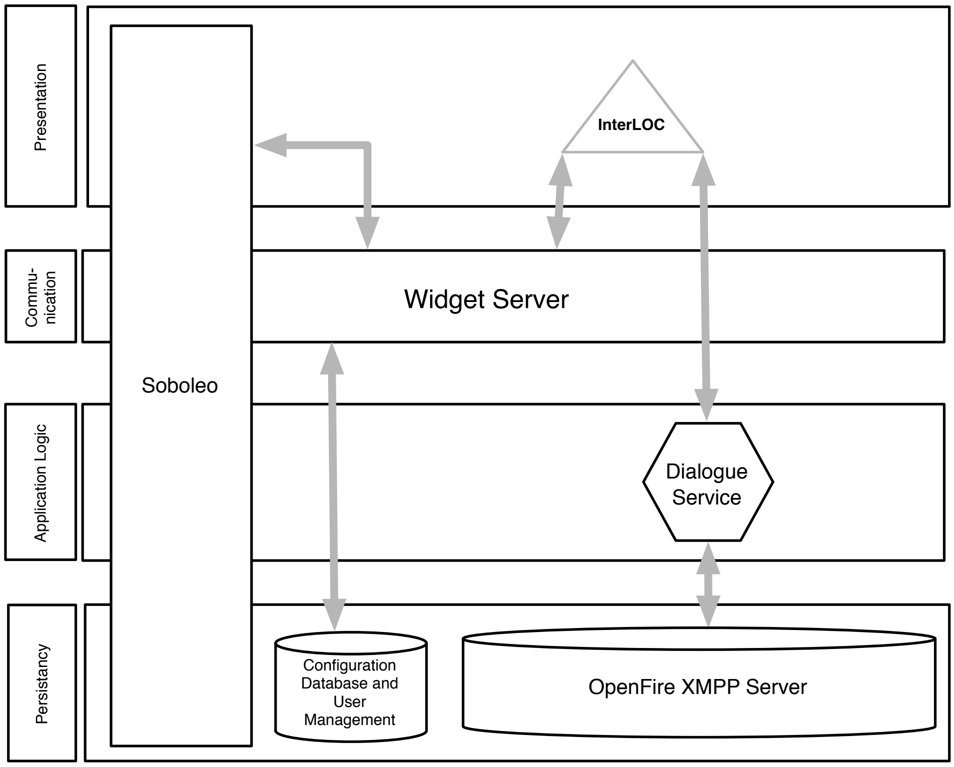


Figure 5.8: *The architecture design, showing the parallelism between SOBOLEO and InterLOC.*

InterLOC specific way. After finishing the discourse, the results were fed back into SOBOLEO in order to make them persistent for a later processing to create an index and thus make it available for the internal search. Moreover, the discussions could be viewed easily from within SOBOLEO and regarded as a kind of a reflexible record.

5.2.3 Discussions and Conclusion

The prototype was deployed in a formative evaluation in the given application context, described in (Mature Consortium, 2010d). In a small Communities of Practice of 7 people the software was introduced and provided for around three weeks. Quite natural, some insights regarding the software introduction and usability were found. Thus, on the one hand people found SOBOLEO quite unnatural and a bit complicated, which can be tracked back to the unusual kind of work, especially the ontology creation. This needs a more sophisticated introduction and probably a longer running test period.

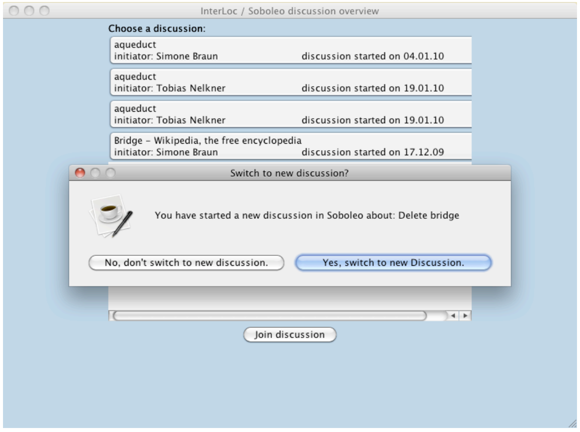


Figure 5.9: *Screenshot of InterLOC when a new discussion is initiated. Taken from (Ravenscroft et al., 2010)*

On the other hand, people found it also unusual to be guided by a tool (with the openers) when discussing with others. Hence, users experienced discomfort with SOBOLEO in developing the ontology, which increased when they were asked to discuss about it with InterLOC. The feedback on the general usability was quite positive. However, several things were disturbing the experience. Especially, two things should be mentioned. Firstly, the media disruption between the InterLOC Java-based desktop application and the browser based SOBOLEO was found problematic. Secondly, the need to enter the user credentials twice was annoying, SSO solution would have been preferred (cf. architecture requirements in section 4.5).

In terms of knowledge maturing activities, the demonstrator supports directly the activities *Reorganise information at individual or organisational level* and *Communicate with people*, as this is the main purpose of both tools. Apart from that the software might also support rather indirectly (as it depends on the context and the specific usage of the tools) the activities *Reflect on and refine work practices or processes*, *Assess, verify and rate information* and *Find people with particular knowledge or expertise*. Reflection might occur when people talk about a topic and discuss things. The discourse and the search for compromises may be a result of reflection. Moreover, as part of the reflection process, the concepts are discussed and the arguments assessed and verified. Finding people with particular knowledge or expertise is supported as each dialogue is saved and related to a concept. Thus, people might be found, who have a particular knowledge in the field the discussed concept describes.

With respect to the support of Knowledge Maturing Activities (cf. section 3.3.3.1) and to the services, which were derived in the persona and use case analysis (cf. 3.1.3.3 and 3.2), the following services were (at least partly) implemented by means of the demonstrator:

- **Maturing Dialogue Service:** InterLOC represents a maturing dialogue service
- **Resource Ontology Service:** SOBOLEO Ontology Editor and semantic bookmarking
- **Entity Assessment Service:** Discussions can be used to assess resources
- **Feedback Service:** Threads in discussions allow direct feedback to comments
- **Artefact-Actor Services:** SOBOLEO relates resources to discussions of persons, which allows to see who has an expertise in which topics
- Experience Reflection Service: The dialogue game, which is mainly represented by the provided moves and openers, foster people's reflection

It could not be found a clear evidence that Demonstrator 2 supports knowledge maturing. This is not very surprising due to the short period of time of the user tests. Differentiated into the artefact, sociofact and cognifact layer some more details can be exposed. Artefact maturing could be observed especially at the dialogues.

> "As the contribution to structured dialogues was observable, these dialogues underlied a maturing process. [...] Apart from the dialogue aspect, the contribution to the ontology structure itself by adding and labelling as well as relating concepts to each other, a maturing process could be shown. The artefacts developed from new concepts to annotated, discussed, related and substructured entities, which provide the possibility to reflect its developments." (Mature Consortium, 2010d, p.55)

Although, this can be regarded quite positive, sociofact maturing and cognifact maturing is rather less distinctive and observable. Discussions alone do not prove the existence of sociofact maturing, though this is an inherently social activity. Only few contributions (8 to 17) for each seeded topic and dialogue were provided. Moreover, no newly created dialogues, no patterns, process or long lasting changed behaviour could be attested.

> "However, whether from the log data or from the interviews, sociofact maturing could be observed. The rules for using InterLoc are given by the software itself, users have to structure their dialogue entries with the given moves and openers. As SOBOLEO was used to a lesser extent, it was hard to observe a maturing of patterns of usage (some kind of rule) there." (Mature Consortium, 2010d, p.55)

Cognifact maturing could not be observed in the interviews, which were led subsequently to the experience and people did not report about it. It might be possible that the reflection process during the discussions might have helped them and led some kind of cognifact maturing. Unfortunately, SOBOLEO was not used as much as expected and thus it could not be observed whether the discussions in InterLOC could have led to a change in the ontology, which would have been a quite meaningful indicator. However, real cognifact maturing is hardly measurable.

Nevertheless, this demonstrator provided us with important insights regarding the relevance of dialogues for building a shared meaning and proved the relevance of an integration in software that aims at supporting knowledge maturing. It might not be a feasible solution to mix up browser-based applications with desktop based. However, this lightweight integration approach proved to be helpful for context specific solutions that need a fast development and deployment.

5.3 SIMPLE

This section introduces SIMPLE. It is the main PLME based approach that has been developed during the MATURE project and which was designed by means of participatory design methods (cf. section 3.5). In the following subsections it will be shortly reviewed for which application context SIMPLE was developed. Afterwards, it is presented, how the system instantiates the conceptual PLME architecture design (as presented in 4.5) and which software components were developed. Furthermore, it will be described exactly the configuration was implemented in MATURE's summative evaluation. Improvements, which were deemed necessary and useful, are either a result of the summative evaluation or were theoretically based and known before but could not be implemented due to the trade off between research interests and application partner needs. The most important improvements and lessons learned are discussed in section 6.4.2 after presenting the evaluation results.

SIMPLE was developed as a widget based approach. For each widget, firstly, a general description is provided, including interface screenshots and technical details. Secondly, it is described how each widget aims at supporting knowledge maturing. This includes a reference to the supported knowledge maturing activities and lists the services, which are implemented, referring to the list of services developed as part of the persona analysis in section 3.1.3.3.

5.3.1 Development Context and Scenario

The software was developed together with application partners working in the context of career guidance. These are Personal Adviser (P.A.), who are specially trained and based in schools, colleges and at specific access points. Particularly, we worked together with P.A.s from Connexions Kent (CK). Connexions Kent advertises and describes itself on its homepage with

> "If you are between 13 and 19 then we can offer you free confidential information, advice and guidance on learning, living and working.
>
> We also support young people up to the age of 25 who have a learning difficulty or disability.
>
> We can help if you
>
> - need advice on your subject choices
> - are thinking about your career options
> - are looking for a job

- want to find out more about courses and training opportunities in your area
- have something on your mind and would like to speak to someone in confidence - this could be health, money, housing or relationship issues
- are thinking about volunteering

" (http://www.connexionskentandmedway.co.uk/, 19.04.2012)

In order to have a concrete scenario as a basis for discussing the relevant requirements among the developers and in participatory design workshops, we used the following fictional story as a kind of boundary object:

> "The Personal Adviser (P.A.) at the centre of this fictional scenario is recently qualified and new to this region of the country. He works in[sic!] a school that is located near Sittingbourne [...]. The young person featuring in this scenario is one of many young people who have been referred to the P.A. by the careers co-ordinator in the school that the young person attends. She has been referred for a one-to-one interview. This particular young person is 15 years old (in Year 11 in her school) and does not wish to stay at school to undertake any higher level qualifications, beyond the compulsory school leaving certificate (General Certificate in Secondary Education), usually taken at age 16. She tells the P.A. that she wants to go into the construction industry, to train to become a plumber. Her dad has told her that plumbers get paid lots of money and she wants to do a job that is practical." (Mature Consortium, 2009b, Appendix A)

In four workshops with P.A.s, we iteratively presented and discussed recent system features, which might support knowledge maturing in the given scenario and are coincidently supporting the P.A.s in their daily work (Mature Consortium, 2010b, 2011b, 2010d).

5.3.2 Architecture and Used Systems

The architecture design of SIMPLE is to a certain degree an instantiation of the conceptual PLME architecture described in section 4.5. Figure 5.10 shows the design.

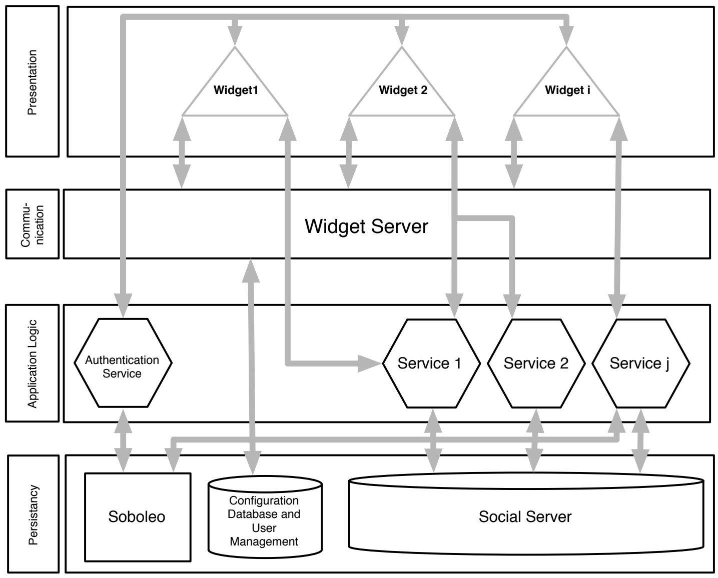


Figure 5.10: *The architecture design of SIMPLE is basically an instance of the PLME framework.*

SIMPLE integrates SOBOLEO with a widget based PLME approach. The widgets access different services, which are almost all provided by the *Social Server* (cf. 4.3). However, a few services also access SOBOLEO. Some are data services, e.g. for duplicating new tags in order to allow the collaborative creation of an ontology.

Another very important service is the authentication service. Instead of using a standardised SSO service, it was decided to embed the authentication in SOBOLEO, for the sake of simplicity and for saving resources. The authentication procedure is depicted in figure 5.11. After the successful authentication at SOBOLEO it returns a hash key that is provided to the

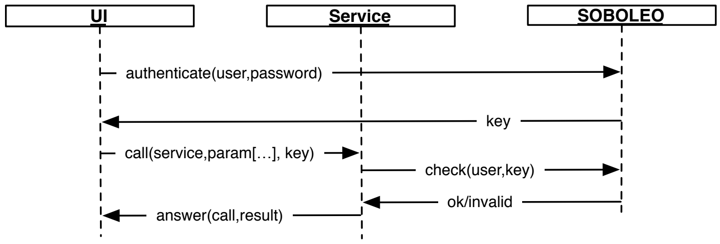


Figure 5.11: *The authentication mechanism for SIMPLE. SOBOLEO serves as user management system.*

services with each method call. A service running on the *Social Server* is validating this hash key at SOBOLEO and in case of success, the original call can be executed. Otherwise, the authentication has to be initiated again.

Most of the widgets are furthermore connected to the WidgetServer (cf. 4.2.2), which provides the IWC infrastructure. On the persistence layer, the WidgetServer uses its own user management and configuration database. Although, the WidgetServer is generally designed to use an external authentication server, the relevant module which establishes the connection was not implemented in order to save resources. Therefore, the WidgetServer could not be connected to SOBOLEO's authentication service. It is the only component, which does not use this authentication method. This is clearly a weakness of the implementation. However, in the evaluation it did not play a role as the developers administered the user accounts and who made the second login procedure as transparent as possible.

Apart from that, the *Social Server* uses its triple store to save the data and the relations between them. Of course SOBOLEO's persistence layer is also represented on this layer. The access to all functionalities was provided by the data access and maturing services represented on the application layer.

The overall system implemented is based on the Adobe Flex SDK[2], compiled for the Adobe AIR runtime environment. The widgets are using an API, which accesses the server via a socket connection. Although this requires a specifically defined connection protocol and has some drawbacks regarding the effort for maintainability and extensibility, it is substantially faster than SOAP-based services, as the XML overhead burdens the connection and the data throughput.

Although not supporting knowledge maturing, by using the IWC infrastructure, SIMPLE implements the service *Inter-tool communication service*, which was derived from the results of the persona analysis, discussed in section 3.1.3.3.

5.3.3 Activity Based Sidebar

The *Activity Based Sidebar* is the main desktop application, which needs to be installed on the target machine. It is an Adobe AIR application, which

[2]http://opensource.adobe.com/wiki/display/flexsdk/Flex+SDK, last access 01.03.2012

runs in the according runtime environment. The name has evolved during the different development steps, at the beginning the screen orientation was vertical and the window was placed on the right or left hand side of the screen. Actually, the sidebar may not fully deserve its name anymore as the bar is now at the bottom of the screen. The reason behind that was simply the idea to save horizontal screen space and to make it inconspicuous.

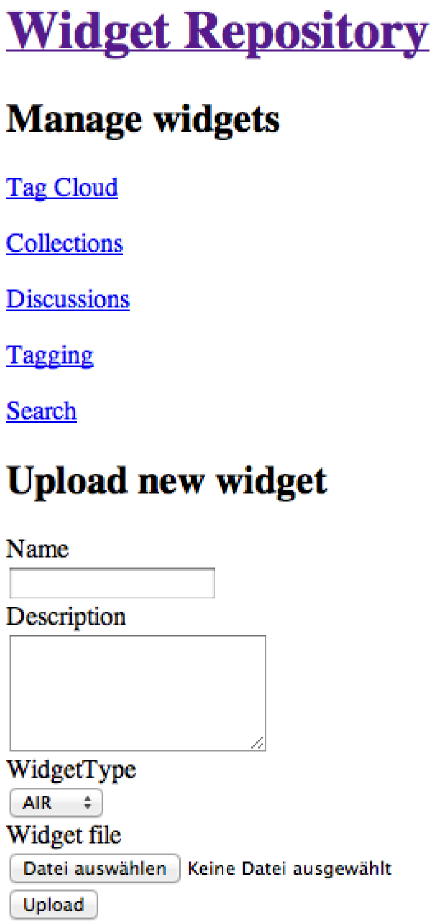
It was aimed at providing an application which enables knowledge workers to create their PLME independently and contextually fitting. Moreover, the prefix *Activity Based* refers to the possibility users have, to classify and group a subset of their used widgets into activities according to individual tasks. This will be explained in more detail later on.

As a widget based approach was chosen (cf. section 4.4.1), the main functionality for the sidebar is:

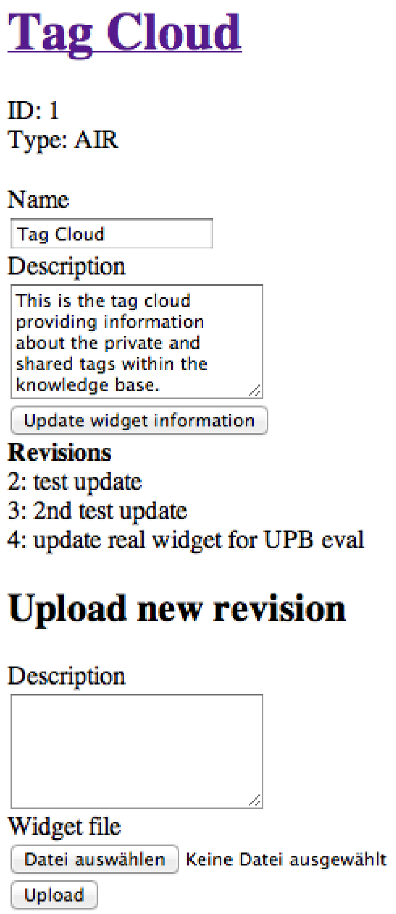
- Widgets need to be added and instantiated
- Users are enabled to group and start widgets according to their tasks and hence build activities
- For an easy deployment, an update mechanism for widgets is important

Widgets are deployed by means of a web-based widget repository. The widget repository has two very important tasks. Firstly and most obviously, it has to allow for the upload and management of widgets and the different versions. Secondly, uploaded widgets need to be certificated with the particular certificate of the sidebar, in order to allow an instantiation by the sidebar. Figure 5.12a shows the very simple overview page of the repository and figure 5.12b the versioning and upload interface. This was implemented very conveniently without a focus on usability in order to save resources. It was clear beforehand that it would never be part of any evaluation activity. In principle, the widget repository is also prepared to handle Java based widgets, however this has never been a serious use case and was of no practical use.

The sidebar loads the widgets in a list of all widgets selected by the user. Therefore, the user clicks on “add widget", which opens the dialog shown in figure 5.13. For each widget, a description, a screenshot and the author is shown. By downloading a widget it is added to the list shown in figure 5.14, represented as a button. This list is the initial entry point to use widgets.



(a) Widget Repository and its the overview over all widgets.



(b) A particular widget, including name, description and versioning comments.

Figure 5.12: *The Widget Repository which is used by the* Activity Based Sidebar *for downloading its widgets.*

By clicking the button, the widget window opens. In order to classify and group widgets according to the individual tasks, users can create activities, cf. figure 5.15. They provide a name and drag the widget button into that window. By clicking the button in the sidebar below, named with the activity, all widgets within that activity are opened and re-placed according to the prior position they had when it was closed the last time. By clicking another activity, the currently opened widgets are closed and the new ones opened. There can also be an overlap of widgets.

When the user starts the sidebar, the current widget list at the widget repository is requested. Beside a description of each widget, this XML based

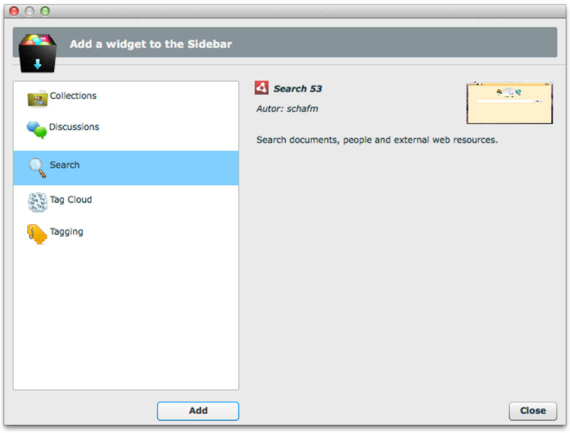


Figure 5.13: *Dialog to add a widget from the repository to the sidebar.*

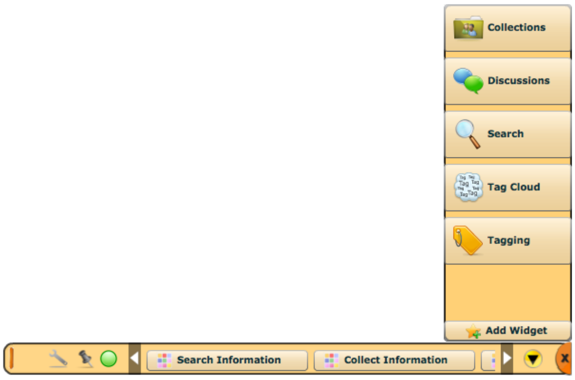


Figure 5.14: *The widget list shows all downloaded widgets available for the user.*

list contains the path to the widget for download, a path to an icon, the version number of the most current version on the server and some other information. Thus, an update mechanism was implemented, which easily allows the sidebar to provide the most recent versions of a widget. Due to the very non-technical context of development at career services it was decided to do the updates automatically, without asking the user.

The other buttons numbered in figure 5.16 serve to

1. Open a configuration dialog which allows to enter the user credentials and some server information

2. Keep all windows on top, independent from the window which actually has the input focus

Figure 5.15: *Task dependent activities can be created by dragging the widget button in the activity.*

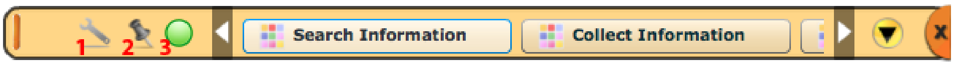


Figure 5.16: *Options of the* Activity Based Sidebar.

3. Prevent widgets from popping up, when they receive a respective message of the IWC infrastructure. This is experimental and turned out not be very useful, as windows only popup as a reaction on messages users intentionally triggered (e.g. by clicking on a button).

In general, the sidebar can load each widget developed as Adobe AIR module, which is certified correctly. However, in order to increase the ease of use and the general usability, a sidebar related particular interface has to be implemented in order to make use of enhanced functionality. An aim was for example that a click on a tag in the tag cloud starts the search. The search itself is easily started via the IWC server, but the user probably only becomes aware of it when the widget becomes visible in these cases and pops up. Therefore, the surrounding application, namely the sidebar, needs to know about that. Hence, by implementing the sidebar specific interface, a widget can notify the sidebar to be made visible. Moreover, properties of the widgets can be recovered by means of this interface, e.g. height, width, position.

The next sections will describe the widgets, which have been developed in the context of the career guidance scenario and which have been evaluated in three different case studies.

5.3.4 Collection Widget

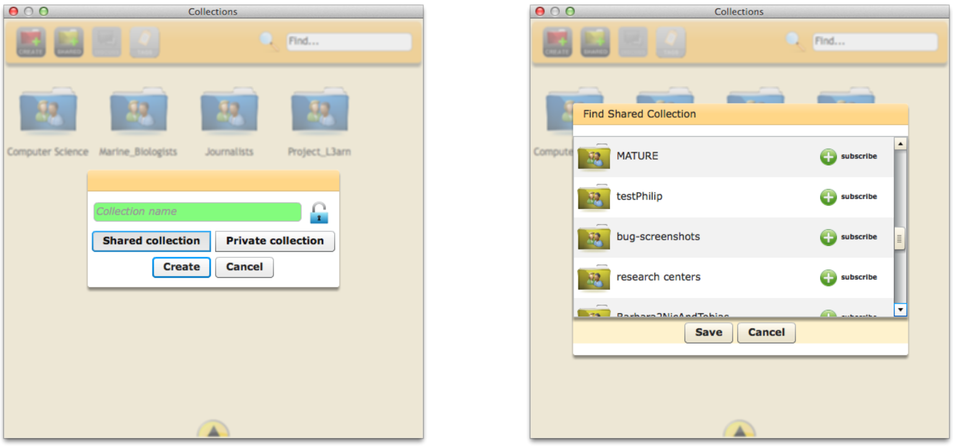
5.3.4.1 General Description

The collection widget allows users to collect resources of any kind in a flat folder-like structure. Collections are a means to aggregate resources related to a particular topic. Collections can be for private use or shared and collaboratively developed. The resources can be files or URLs. Figure 5.17 shows the interface. Users can create new private or shared collections (figure 5.18a) or they subscribe to an existing shared collection (figure 5.18b).

Figure 5.17: *The collection widget allows to create aggregations of resources.*

Resources are added mainly by drag and drop. Either a URL is dragged from the browser address field into the collection widget or from the desktop directly into the widget, which is then uploaded[3]. Compared to HTML upload dialogs, this makes it far easier to deal with local files and to share them from the desktop. This aims at reducing the barrier between desktop based applications and web pages by providing a seamless integration of

[3]The search widget also provides the possibility to add a search result directly into a collection, cf. section 5.3.7.

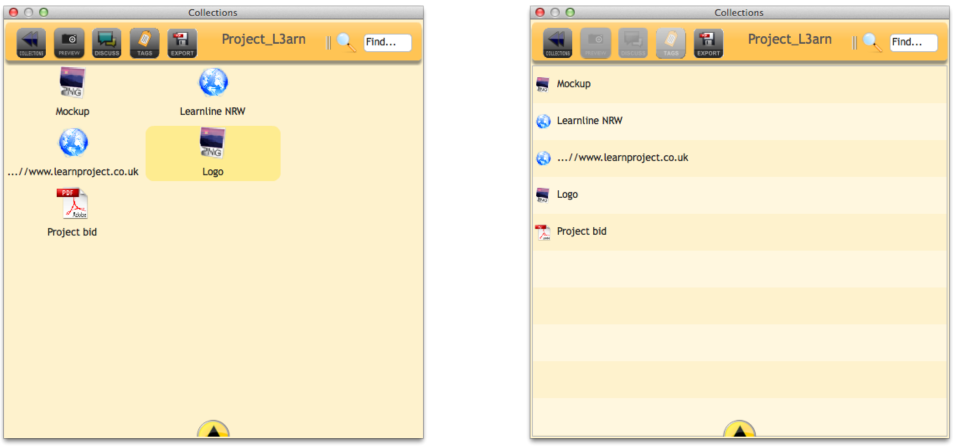


(a) A collection can be created private or shared.

(b) One can subscribe to shared collections from other users.

Figure 5.18: *Collections can be added in different ways.*

both. Resources are presented in an icon style (figure 5.19a) or as a list (figure 5.19b).



(a) Resources of a collection can be presented in an item grid view.

(b) Resources can be also presented as a list.

Figure 5.19: *Resources of a collection can be presented in different ways.*

The toolbar and a context menu provide access to the various options. A collection can be (partly) exported, such that a PDF file is created. This contains either the links to web addresses, or a link to local resources, which are provided after export in a subfolder on the hard drive. Pictures are directly included in the pdf. Moreover, the resource view of the widget provides a preview functionality. It allows to load web pages and PDF files directly within the widget, in order to get an impression what the resource was about (cf. figure 5.20).

Figure 5.20: *The collection widget provides a resource preview in order to get a quick impression of the resource's content.*

Apart from that, the widget allows to open the tagging widget and the discussion widget in order to annotate or discuss a resource or even a collection. It is connected via the Widget Server with the discussion widget, tagging widget and the the search widget. It sends data to the discussion widget and the tagging widget. It receives data from the search widget.

5.3.4.2 Knowledge Maturing Support

The collection widget specifically aims at supporting the knowledge maturing activities *Share and release digital resources* and *Familiarise oneself with new information*, and additionally but rather indirect the activity *Create and co-develop digital resources.*

By creating shared collections, which are then used to collaboratively aggregate resources, the activity mentioned first is obviously supported. Shared collections which are actively changed and enhanced (which mature) are a helpful and invaluable means for subscribers to get familiar with new information for a specific topic or domain. *Create and co-develop digital resources* may refer to "living collections" in the community, which is a rather trivial case. However, with respect to the co-development of artefacts such as documents or wiki pages, the collection widget can serve as source for those activities. Before starting to draft a document for example, sources could be collected and discussed and an initial understanding and consens may be achieved with the co-developers, which is the basis for the formulation of the document. Thus, the collection widget is very helpful for such processes without directly supporting the artefact creation process.

Considering the services, which were derived in the persona and use case analysis (cf. 3.1.3.3 and 3.2), the following were (at least partly) implemented by means of the Collection Widget:

- **Dissemination Service:** Resources can be disseminated be creating shared collections
- **Shared organisational and personal resources access service:** Realised through shared folders, which are publicly available
- **LMI provision service:** In the particular career guidance context for which the prototype was developed, collections can be used to provide Labour Market Information.

5.3.5 Tagging Widget

5.3.5.1 General Description

The tagging widget is a simple widget for tagging digital resources. The resource can be dragged into the address field but also transferred via the IWC infrastructure. Figure 5.21 shows the interface, which is divided into three columns, headed by the address field. The most left column presents tag suggestions, provided by a maturing service. The actual implementation of that maturing service changed several times and is described in (Mature Consortium, 2010c, 2011c). The middle column shows the shared tag of a resource, the most right column shows the private tags assigned to a resource.

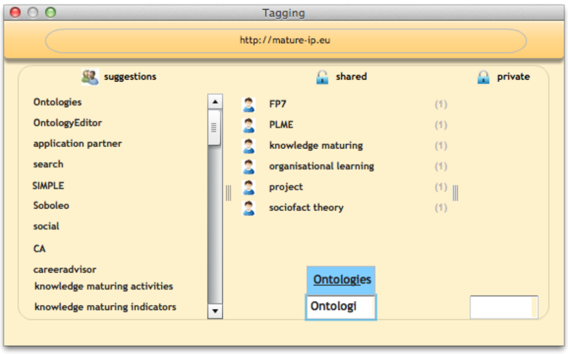


Figure 5.21: *The tagging widget with a column for tag recommendations, shared tagging and private tagging.*

A distinction of both was important, as tags like commands, or assessments, or even personal notes should be allowed but not visible to others. The input fields are below the tag presentation and provide a simple autocompletion method. The widget is connected via the IWC infrastructure with the collection widget and the search widget and can be started from both. Moreover, tags which are added to the knowledge base in the tagging widget, are also added to SOBOLEO as prototypcial concept, a new concept that is not yet related to the existing ontology concepts. They can be structured by means of the tag editor afterwards (cf. section 5.3.9)

5.3.5.2 Knowledge Maturing Support

The main knowledge maturing activity, which is aimed to be supported is *Embed information at individual and organisational level.* Tagging resources and thus contributing to the organisational knowledge base by means of using a (possibly) long-term evolved common vocabulary may support individual cognifact maturing but also sociofact maturing. Closely connected to this point is *Share and release digital resources*, at least in this context. By using shared tags, the tagged resources are visible for all others. It is an intention to foster that in order to contribute to the organisational knowledge base. Shared tagging provides a direct value added in order to *Find relevant digital resources* and *Assess, verify and rate information.* People often mainly use tags in order to find the resources faster when needed. Depending on the kind of tag, it may also provide some kind of classification, e.g. an assessment (Ames & Naaman, 2007; Panke & Gaiser, 2008).

Considering the services, which were derived in the persona and use case analysis (cf. 3.1.3.3 and 3.2), the following were (at least partly) implemented by means of the Tagging Widget:

- **Resource Tagging and Annotation service:** Tagging is obviously realised with this widget
- **Topic or context dependent information and resources gathering and aggregation service:** By means of tagging, several resources can be aggregated and gathered for a particular topic

5.3.6 Tag Cloud Widget

5.3.6.1 General Description

The tag cloud widget is a small widget representing all visible tags or all private tags in a weighted tag cloud, cf. figure 5.22. Visible tags are all

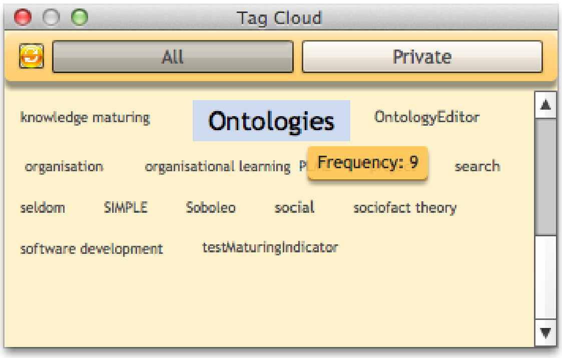


Figure 5.22: *The tag cloud widget presents tags with the font size depending on their relative frequency.*

shared tags brought together with all private tags, denoted with "All" in the interface. "Private" refers to all privately created tags. As well known from tag clouds, the tags' font size is varying according to the relation of the number of occurrences of one tag to all tags. This results in larger font sizes for tags, which are used more often than others and implicitly refers to a higher relevance of those tags in the overall knowledge base (Schrammel, Leitner, & Tscheligi, 2009). Although a value added in terms of (organisational) learning or an economic value should be seen critically, it gives at least an impression which terms are used and which kind of resources are shared most often.

The tags are ordered alphabetically in order to support the orientation, which was a request from a participative design workshop. By clicking a tag in the tag cloud, the search widget is opened, which reveals all documents that are tagged with it. This is the only connection to another widget.

5.3.6.2 Knowledge Maturing Support

The tag cloud widget does not support knowledge maturing activities directly. It should work rather like an initiator or engine, which motivates people to become active, by creating some kind of Cognitive Dissonance (cf. 2.4.2). If, for example, users see a tag that is very large compared to others they might get interested in the resources that are behind that and whether these are interesting for the individual tasks (*Keep up-to-date with organisation-related knowledge*). Moreover, gardening activities might be initiated after users have realised different spellings of the same tag (*Re-organise information at individual or organisational level*). They could then use the tag editor (cf. section 5.3.9) to harmonise the tags in SOBOLEO. Furthermore, *Find digital resources* is possibly be initiated.

In its role of providing awareness for available information in the knowledge base but also for possible errors or suboptimal conditions, the tag cloud is very important and might be very beneficial for knowledge maturing.

Considering the services, which were derived in the persona and use case analysis (cf. 3.1.3.3 and 3.2), the following were (at least partly) implemented by means of the Tag Cloud Widget:

- **Topic related resource awareness service:** Tags are a means to gather resources for a particular topic. A click on a tag start a search for it, which might make users aware of resources

- **Resource Search Service:** A click on a tag starts the tag-based resource search

5.3.7 Search Widget

5.3.7.1 General Description

The search widget is the main widget for finding resources and getting information about them. It allows to search for resources in the internal database and for web resources at different search engines. Figure 5.23 shows the interface. The internal search is divided into three parts. It consists of two

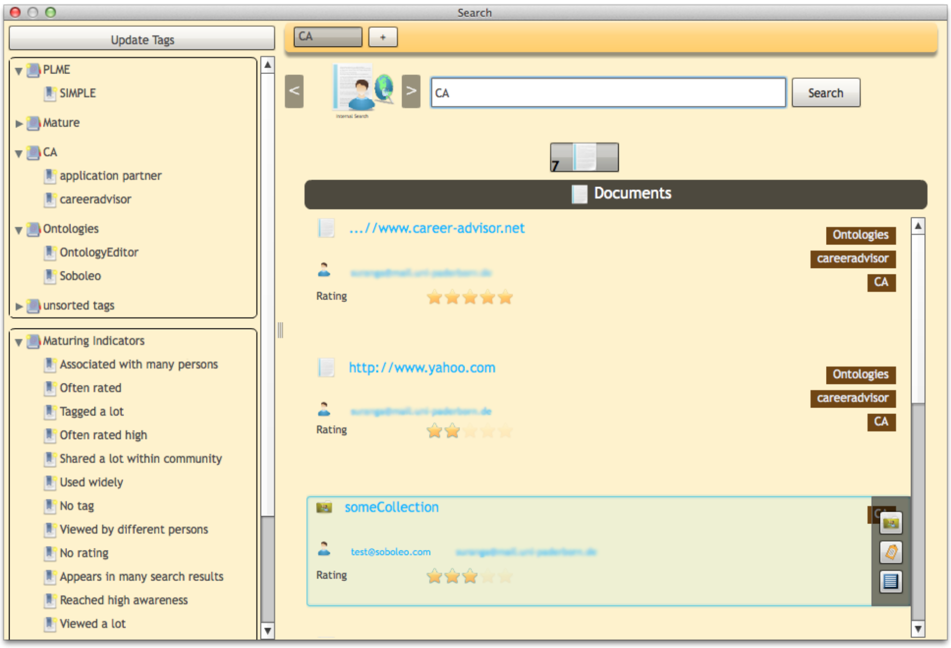


Figure 5.23: *The search widget main view, showing the facets on the left and the search results on the right hand side.*

columns and a header. Similar to tabbed browsing, the search widget allows a tabbed search. Hence, several search requests and the according results can be shown. The header contains the tabs, the search input field and a switch from the search on the internal knowledge base to the internet. Under the header in the column on the right hand side, the search results are presented. On the left hand side, the categories for a faceted search are shown.

The provision of a web based search via different available search engine APIs[4] (cf. figure 5.24) has two roots. Firstly, it is an application partners' request to easily integrate and search in different search engines (Mature Consortium, 2010b). Secondly, it should reduce the barrier to switch between the internal and external search. If a P.A. for example searches unsuccessful for study related documents in the internal database, it should by easy to start the same search in the external web without the media disruption of starting the browser. The web based search is itself divided into search for

[4]For example the Yahoo API, http://developer.yahoo.com/search/boss/, last access 01.03.2012

internet pages and for pictures. All search results can be easily opened in the browser but also integrated into the system via tagging or by adding to a collection.

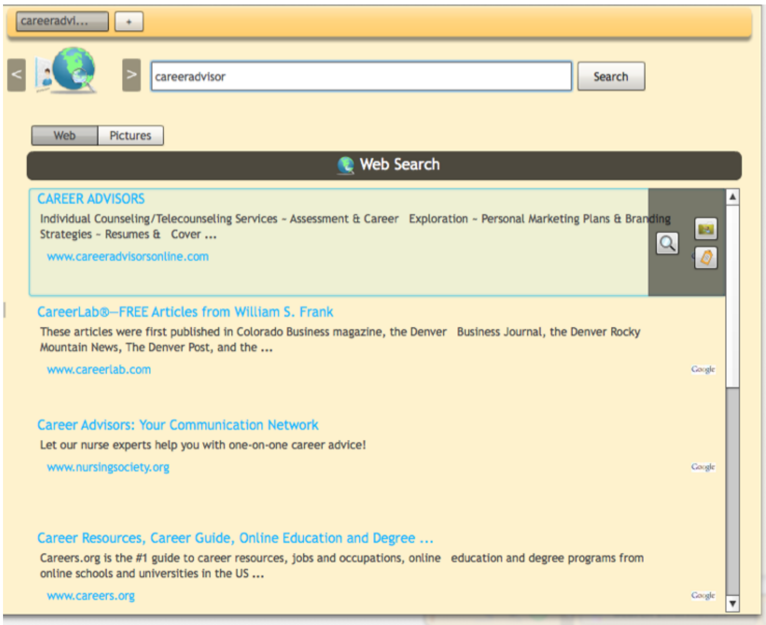


Figure 5.24: *The web search, showing results from an online search engine.*

Furthermore, the internal search offers the opportunity of a faceted search, which is shown on the left hand side.

> "Facets are metadata that can define alternative hierarchical categories for the information space. Unlike traditional categories, facets allow a document to exist simultaneously in multiple overlapping taxonomies" (Koren, Zhang, & Liu, 2008, p.477)

For the enduser, a faceted search reduces searching to a navigation through the facets over these taxonomies (Suominen, Viljanen, & Hyvänen, 2007). The faceted search could be integrated by means of SOBOLEO's ontology (cf. section 5.1.3). Two main facets are represented. One is showing the ontology, which is built up by means of the tag editor widget. The second represents a non changeable list of specific Knowledge Maturing Indicators. Although represented in and fetched from SOBOLEO, the list of maturing indicators is flat and does not have a structure. The KMIs are predefined by the consortium and represent an operationalised, specific instantiation of those found in the representative study (cf. 3.3.3.2 and (Mature Consortium, 2011b)). They are static and fix, and manually brought into SOBOLEO. They include for example: *is discussed a lot*, *is opened a lot*, *has been viewed by many people* or even *has no tags* (Mature Consortium, 2011c). These indicators shall serve as a search request input. Hence, users can search for resources with the characteristics that are reflected by the indicators.

The dynamic list of facet entries, changes, when the ontology changes. The overall functionality was achieved by integrating SOBOLEO services. The idea behind is the following: users find a resource and tag it. This tag is automatically added to the ontology as prototypical concept (cf. 5.1). Afterwards, she/he changes the ontology in the tag editor in order to integrate the new tag appropriately (cf. 5.3.9). The faceted search then allows to search for the resources assigned to the ontology's nodes, which brings up all resources of the specific node, all below and from that set, all related concepts which are not part of the broader and narrower relationships (Mature Consortium, 2011b)[5].

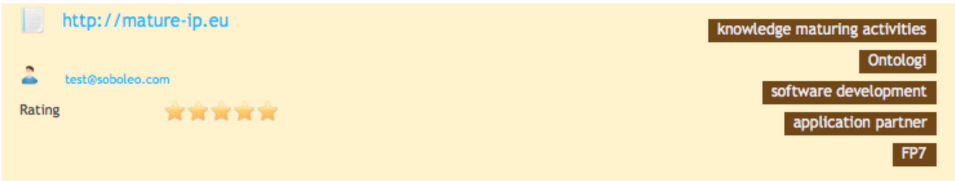


Figure 5.25: *A search result entry presents the resource name, type, all tags, the user rating and related people.*

In the right column under the header, the search result list is presented. Each result entry represents either a collection or a web page or a document. Figure 5.25 shows an example for this. Beside the name, the entry shows the user rating (which can be also changed ad hoc), a maximum of five tags, and the creator of a resource. When hovering the mouse over the entry field, an overlay menu is faded in, which allows to add the respective resource into a collection, and to tag it (cf. the bottommost search result entry in figure 5.23).

Hence, the search widget has an IWC connection to the collection widget, the tag widget and the tag cloud. The tag cloud serves as starting point for searches.

[5]Obviously, circles have to be considered while traversing the tree. However, this needs to be considered in the service design.

5.3.7.2 Knowledge Maturing Support

The search widget has two functions. It should support knowledge maturing directly but also serves as an engine that may initiate new knowledge maturing processes. *Finding relevant digital resources* and *Assess, verify and rate information* are activities which are supported quite directly. But at least of similar importance is the indirect initiation. The activities *Keep up-to-date with organisation-related knowledge*, *Share and release digital resources* and *Communicate with people* might be initiated by the widget. This widget provides users with an entry point to catch up with certain organisationally relevant topics. If they found useful results, they can support the distribution by assigning further tags or by aggregating them in new or existing collections.

Considering the services, which were derived in the persona and use case analysis (cf. 3.1.3.3 and 3.2), the following were (at least partly) implemented by means of the Search Widget:

- **Topic or context dependent information and resources gathering and aggregation service:** This tag-based search provides an aggregation of resources for a certain tag and each search result can be added to a collection

- **Resource Search Service:** Implemented by the search itself

- **Entity assessment service:** It is possible to rate resources with a 5-star rating

- **Topic related people activity awareness service:** For all resources, related persons are provided

- **Topic related resource awareness service:** Search results might make users aware of certain resources

- **Organisational resources access service:** The search service provides a specific access to organisational resources

5.3.8 Discussion Widget

5.3.8.1 General Description

The development of a discussion widget was motivated by theory and application partner needs. As the concepts of ZPD, CoP and TM suggest, it needs discussion opportunities in order to support knowledge creation and a shared meaning (cf. sections 2.4.3, 2.4.4, 2.4.5). Application partners also saw a clear need for a chat tool (Mature Consortium, 2010b). Consequently, this discussion widget was developed. The description of the *Demonstrator 2* prototype (cf. section 5.2) may raise the question, whether it could have been re-used for this purpose. As the *Demonstrator 2* was developed in Java it could not be integrated seamlessly into the AIR framework and as it was partly assessed as too complex, a new and rather simple implementation was necessary.

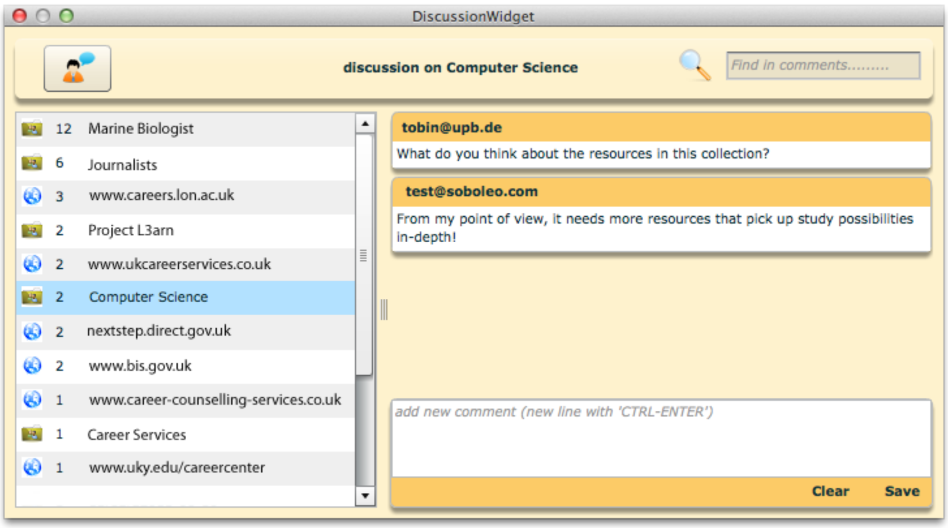


Figure 5.26: *The discussion widget shows on the left hand side the list of available discussions and on the right hand side the discussion entries.*

Figure 5.26 shows the discussion widget interface. It has a very simple design. It contains a header and two columns below that. The header holds the title of the current discussion and a start button for new discussions. The left column shows the list of discussions, the right one the plain list of discussion entries. In contrast to InterLOC, the discussion entries are not structured.

The discussion widget can be started from the collection widget. Discussions started from outside of the widget are always related to a resource. However, a new discussion can also be started from within the widget using the button in the header without any relation to a resource.

5.3.8.2 Knowledge Maturing Support

By means of the discussion widget, the knowledge maturing activity *Communicate with people* is obviously supported. Depending on the discussion culture, discussions might be also used to assess and reflect about resources, particular work processes or certain work practices in general. Thus, in specific situations, the activities *Reflect on and refine work practices or processes* and *Assess, verify and rate information* are performed by means of this widget, especially when a discussion is started with relation to a resource. As the process of co-developing documents for example always needs some kind of discussion, also the activity *Create and co-develop digital resources* is rather indirectly supported. Furthermore, the activity *Find people with particular knowledge or expertise* is addressed as the widget might also be used to find experts for a certain topic. It does not provide a particular search, but users can find More Knowledgeable Other in discussions (cf. 2.4.3). However, this depends on the overall amount of participations in discussions, on the general culture how the widget is used in a community (e.g. seriously, privately, etc.) and on the relevance of discussions for particular topics.

Considering the services, which were derived in the persona and use case analysis (cf. 3.1.3.3 and 3.2), the following were (at least partly) implemented by means of the Discussion Widget:

- **MATURE-enabled communication services:** MATURE-enabled, as discussions are related to resources and people in the triple store, which would allow further analyses and the provision of an enhanced value added, e.g. visualisation of the social network.

- **Experience reflection service:** Discussions foster reflection

- **Feedback service:** Resource related discussions allow to give feedback

- **Entity assessment service:** Resource related discussions allow to collaboratively assess resources

- **Collaborative social networking service:** Users may come in contact and start collaboration
- **Collaboration initiation support service:** Discussions may support the initiation of collaboration
- **People and expertise search service:** Discussions may allow to get an idea of the expertise or main topics of interest of participating people

5.3.9 Tag Editor Widget

5.3.9.1 General Description

The tag editor is an HTML frame for loading SOBOLEO's ontology editor. Figure 5.27 shows the widget, which focusses on the editor. The visibility

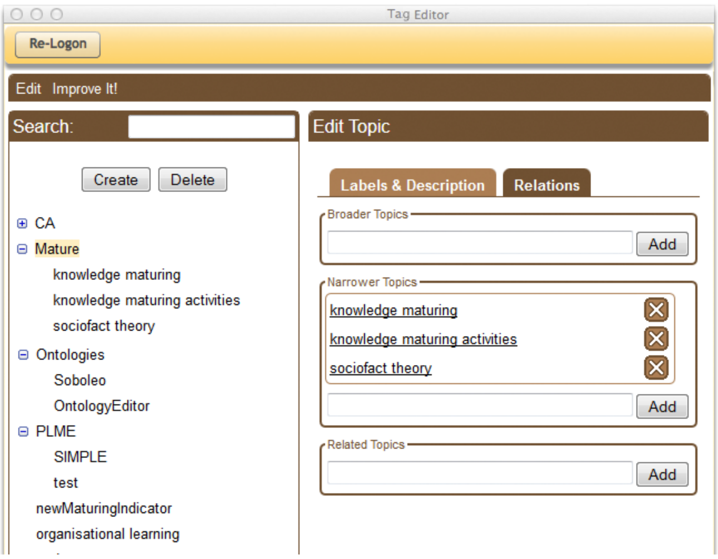


Figure 5.27: *The Tag Editor Widget shows the ontology editor of SOBOLEO, hiding some visual and control elements.*

of some visualisation and especially some control elements is disabled (e.g. log or menu bar). The objective was to integrate SOBOLEO seamlessly into SIMPLE in order to provide users the tag editor. It is supposed to foster the collaborative creation of a common vocabulary, represented in an ontology (cf. section 5.1.3), including changing and harmonizing the concept base. When a new tag is created by the tagging widget, it is also duplicated in

SOBOLEO. Initially, it was planned to feed back changes in the common vocabulary into the social server backend, so that changed labels of concepts are also visible in the tagging widget, which would have been a consequent and consistent integration work. However, due to the necessary implementation effort that accompanies resolving typical synchronization problems (Cho & Garcia-Molina, 2000), it was dismissed. Hence, usability problems and missing transparency of changes in the vocabulary were anticipated. Nevertheless, it was decided to deploy the widget.

The name *tag editor widget* was a result of application partners feedback, who requested a simpler name than *Taxonomy Editor* or even *Ontology Editor*. It has no IWC connection to other widgets. New tags are duplicated via backend service calls on the SOBOLEO system (cf. 5.1).

5.3.9.2 Knowledge Maturing Support

Knowledge maturing can be supported by allowing to *Reorganise information at individual or organisational level.* Creating a commonly created and agreed vocabulary may also indirectly support to *Find relevant digital resources*, as in this implementation concepts are related to resources and used to search for them. The structure was even represented in the facets in the search widget. The application partners definitively saw a need for administrating the vocabulary and could imagine that it might be helpful to structure them (Mature Consortium, 2010d). Nevertheless, the complexity of the ontology editor itself and the missing final integration steps were expected to become an issue during the evaluation.

Considering the services, which were derived in the persona and use case analysis (cf. 3.1.3.3 and 3.2), the following was (at least partly) implemented by means of the Tag-Editor Widget:

- **Resource Ontology Service:** The ontology editor allows to create ontologies with relation to resources

5.3.10 Mature Fox

5.3.10.1 General Description

The *matureFox* is a simple plugin for the Firefox browser[6], replicating the rating of the search widget and the tagging of the tagging widget. It is installed via drag and drop on the browser's address bar. It is displayed at the bottom of the screen. As figure 5.28 shows, it provides the opportunity to tag and rate a resource, and shows the overall rating of the currently displayed resource. Moreover, a tag overview over all tags assigned to that resource can be displayed in a small popup.

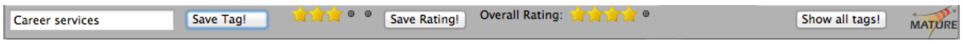


Figure 5.28: *The matureFox allows to tag and rate pages and shows the overall rating of the current page.*

Users first have to enter a tag or provide a certain number of stars of a five-star rating and then have to save that. The plugin calls a service on the social server in order to save the input. Apart from that, the plugin does not have a connection to the other widgets.

5.3.10.2 Knowledge Maturing Support

As this plugin is duplicating already known functionality, there is no additional maturing support. The two functionalities support the activities *Assess, verify and rate information*, *Share and release digital resources* and *Reorganise information at individual or organisational level* (as the according widgets). The main reason for providing this plugin was the improvement of the general usability of the prototype by reducing the media disruption when browsing through the web and searching for information. Users can simply tag or assess a web page without having to switch between the browser and the desktop application.

With respect to the support of Knowledge Maturing Activities (cf. section 3.3.3.1) and to the services, which were derived in the persona and use case analysis (cf. 3.1.3.3 and 3.2), the following services were (at least partly) implemented by means of the matureFox plugin:

[6]The Firefox browser is an open source browser developed by *mozilla* under a Creative Common license. http://www.firefox.com, last access 01.03.2012

- **Entity assessment service:** The plugin enables a five star rating
- **Dissemination service:** The tagging can be a means to disseminate resources within the organisation
- **Resource Tagging and Annotation Service:** Realised by the tagging functionality

5.3.11 Conclusion

SIMPLE is a widget based approach of a PLME. It implements to a huge degree the conceptual PLME design developed in section 4.5.

The deviations to the architecture design are:

- SOBOLEO is used as SSO provider, which is not standardised and should not be transferred into another context.
- The WidgetServer is not using the SSO provider.
- Some data is duplicated in SOBOLEO and the Social Server.

Although not a conceptual deviation, the usage of the socket connection based API introduced a barrier for re-usability in other environments. A solution based on the HTTP protocol might have been a more favourable one. However, with respect to the architecture, this is a lean architecture with a lightweight service binding. Due to the implementation effort, a full integration between the SOBOLEO services and the Social Server services could not be achieved. Especially the gardening activities could not be fully implemented. Hence, problems regarding user acceptance and engagement are anticipated for the evaluation.

The set of six widgets and the browser plugin aim at supporting 11 of the 12 Knowledge Maturing Activities verified in the representative study (cf. section 3.3.3.1), seven directly and four indirectly. The activity *Restrict access and protect digital resources* is not supported. The following activities were identified to be supported directly:

- Share and release digital resources
- Familiarise oneself with new information
- Embed information at individual and organisational level

- Find relevant digital resources
- Assess, verify and rate information
- Communicate with people
- Reorganise information at individual or organisational level

Moreover, the following activities are supported indirectly. This means, they might be initiated by using the widgets, though this can either not be represented by software functionality or was not intended to be supported directly.

- Create and co-develop digital resources
- Keep up-to-date with organisation-related knowledge
- Reflect on and refine work practices or processes
- Find people with particular knowledge or expertise

The empirical findings yielded a list of services, which might support knowledge maturing (cf. 3.1.3.3). The following services are at least partly implemented by SIMPLE.

- Dissemination Service
- Shared organisational and personal resources access service
- LMI provision service
- Resource Tagging and Annotation service
- Topic or context dependent information and resources gathering and aggregation service
- Topic related resource awareness service
- Resource Search Service
- Experience reflection service
- Entity assessment service
- Feedback service
- Topic related people activity awareness service

- MATURE-enabled communication services
- Collaborative social networking service
- Collaboration initiation support service
- People and expertise search service
- Resource Ontology Service

All in all, SIMPLE is a system that focusses on supporting knowledge maturing mainly on an artefact level. It provides a strong support for knowledge maturing with its possibility of collecting and aggregating resources, providing a knowledge base for creating resources, leading discussions and reflecting on resources, and providing a sophisticated access to find them.

However, the design of the widget set might raise the feeling that important developments are missing in order to provide a real cutting edge product. Actually, the development results are cutting edge technology, e.g. the flexible inter-widget communication, the services working on the resource and user models, the triple store of the Social Server as data backend, or the flexible widget based approach. The product delivered to the application partners however is conceptually lacking to a certain degree knowledge maturing support on the sociofact level. Expert recommendation, social network visualisation, using Social Network Analysis (SNA) technologies and more could have been emphasised during software development. Beside different research interests of the development partners, this has mainly the following reason. The initial SIMPLE prototype focused mainly on artefacts, text quality measurements, content-based resource recommendation and similar approaches (to a certain degree a follow-up of the APOSDLE project, cf. chapter 7). During the course of the project and with an improved understanding of knowledge maturing, we tried to concentrate our attention on both, the artefact level and the sociofact level. This has started too late for providing a sophisticated integration of both levels, which could be assessed in the summative evaluation. Nevertheless, a high degree of potential knowledge maturing support is presented by means of this research prototype.

Chapter 6

Evaluation and Implications

SIMPLE was deployed in three different case studies, each with a completely different context. One case study was conducted at Connexions Kent, which were the main application partners in the course of the software development. A second case study was conducted in the context of an e-learning course at another MATURE application partner, Structuralia. A third one was conducted at the University of Paderborn in the context of a seminar with students. It was our aim to find out whether the software has the potential to support knowledge maturing and to which degree this depends on the particular application context. Moreover, it was seen as a huge advantage to get quantitive and qualitative feedback from people with very different background in very different contexts of knowledge work.

The author of this thesis was actively accompanying all three studies by participating in workshops, or by supporting the participants in using the software and by doing or supporting the concluding analysis.

6.1 Case Study I: Career Services

This case study report is presenting the results of the evaluation activities, which were carried out together with the application partners from Connexions Kent (CK) in the career guidance context. The software was rolled out in three on-site workshops. The initial objective was to gather log data, and to ask users to complete a questionnaire and to participate in a guided interview. For several reasons, not enough people participated in the evaluation sessions and thus, only few and mostly meaningless log data could be gathered. The reasons for the low participation were:

- Initial technical problems demotivated users for further participation
- A generally low IT-affinity of end users led to problems in understanding the principles of the software and concepts behind it (e.g. tagging)
- For unknown reasons agreements to use and cascade the improved and running software between the workshops were not adhered to

Therefore, it was relied on the questionnaire and interview to gain insights regarding knowledge maturing support and usability feedback, as presented in the sections 6.1.3 and 6.1.4.

Thus, the structure of this case study description is as follows. First, the specific configuration of the deployed SIMPLE version is shortly explained. Afterwards, the series of workshops is described, in which the questionnaires were distributed and insights regarding the tool usage were gained. This includes on the one hand indicators for knowledge maturing and on the other hand feedback regarding the perceived usefulness and usability of the tool.

The third part consists of application partner feedback that was gained in a feedback session along an open interview guideline in the last workshop (cf. Appendix B.1). The case study description ends with a conclusion and discussion of implications.

6.1.1 SIMPLE Configuration

SIMPLE was deployed by installing the sidebar and the matureFox plugin on end users' laptops. The widget repository provided the following five widgets (cf. figure 6.1):

- Collection Widget
- Tagging Widget
- Tag Cloud Widget
- Search Widget
- Tag Editor Widget

The users were registered at SOBOLEO and the *WidgetServer* beforehand.

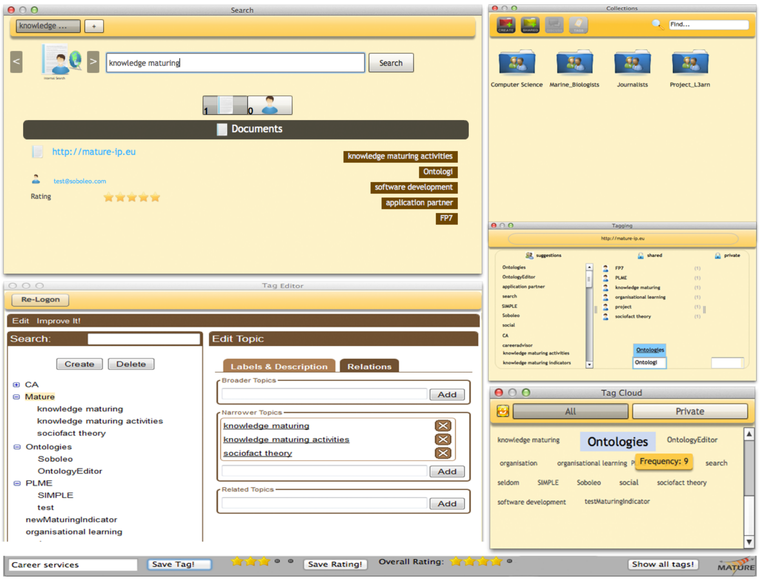


Figure 6.1: *The 5 widgets provided for the career guidance case study.*

6.1.2 Procedure

The summative evaluation took place between May and July 2011 in three work shops. The first workshop took place early in May, 2011. Eight Career Advisors of Connexions Kent and six representatives of the project joined the workshop. Users were guided through key elements of the system and topics were agreed for individuals to work on in the course of a Tagging Exercise with paper post-its. Due to technical problems, which initially came up in this distributed and real multiuser situation, not much data could be collected during that day. Therefore, although the system could be presented and introduced, the work on the system remained rather conceptually and technically problematic that day. A second workshop was set up for mid June in order to catch up on the data collection. A hands on workshop was organised which allowed to use the updated system as (technically) expected. Four Career Advisors and three representatives of the project joined the workshop. Based on the topics identified in May, users were re-introduced into the system successfully. During several sessions, they worked with it, collected data and made their individual experience. Finally, each Career Advisor chose an arbitrary topic she/he is typically in touch with and everyone agreed to collect information by means of the SIMPLE. This was supposed to help us in collecting log data and sophisticated feedback. Moreover, they confirmed to contact colleagues and present the system to them in order to cascade the usage. Additionally, a user guide for the software with step-by-step instructions was developed to respond to criticisms that the system was 'not intuitive' enough for newcomers. The third and concluding workshop was at the end of July. Five Career Advisors and three representatives of the project participated. Practitioners had the choice either to work on their own or to jointly use the system guided by particular tasks. One participant preferred the option to work alone, the others followed the guide. The session focused on reviewing individual progress with using the system, looking at the new user guide, and working on collecting resources in the system. Usage data could be collected. At the end of the workshop, a group discussion along a questionnaire was led. Its findings are described in more detail in section 6.1.4.

6.1.3 Pre- & Post-Questionnaires

6.1.3.1 Support of Knowledge Maturing Activities

In order to find out whether the software has the potential to support knowledge maturing activities in the P.A.s daily work, three questionnaires were provided to them. Two were handed out to the participants beforehand the workshop series and one afterwards. The pre-workshop questionnaires were answered by seven persons. The group consisted of one man and six women. The participants have on average almost 12 years worked as P.A.s[1]. They stated to spend around 48% of their working time using a computer[2].

The main idea behind the questionnaires was the following process:

1. Find out, which activities are relevant for the P.A.s' current practice (Questionnaire 1)

2. Find out, which of these activities need an improvement compared to the current practice (Questionnaire 2)

3. Find out, which of these activities are well supported by means of SIMPLE (Questionnaire 3)

Therefore, based on the twelve Knowledge Maturing Activities (cf. 3.3.3.1), a set of 17 context specific activities was formulated, which was thought to

[1] Mean = 11.86, Standard deviation = 7.559, range: 6-27 years
[2] Mean = 47.86%, Standard deviation = 16.79%, range: 20 - 65%

be probably relevant to the P.A.s' daily work. Participants could rate these activities on a four-point scale, distinguished in *Untypical*, *Rather Untypical*, *Typical*, and *Very Typical*. The results are presented in table 6.1. The original questionnaire included some paper-based activities. These are not considered in the result table, as they are not deemed helpful for the assessment of SIMPLE. The original questionnaire can be found in Appendix B.2.

The most typical activity was *I search on the internet for relevant information*. All say this is *very typical*. For the following three activities, still six out of seven say, that it is a *typical* or *very typical* one for them:

- *I take individual notes that I revisit at later points in time*
- *I store relevant results in collections on my desktop or laptop*
- *I discuss relevant resources with my colleagues*

At least five state the following activities as *typical* or *very typical*:

- *I search on my own desktop for relevant information*
- *I maintain my private collections and continuously add materials*
- *I share my private digital collections with colleagues*

Table 6.2 shows the results of the second questionnaire (cf. Appendix B.3). An enormous need for improvement for collaborative work and possibilities to share materials can be assumed. The following activities were assessed to need the most improvement:

- *Creating a common taxonomy/classification for tagging (or labeling) resources*
- *Sharing private digital collections with colleagues*
- *Maintaining common digital collections of information and materials with colleagues*

The following four activities work better and rather need some improvement as stated by six participants:

- *Storing relevant results in collections on my desktop or laptop*
- *Adding keywords or tags to my digital resources in order to find them at a later date*
- *Maintaining private collections and continuously adding materials*
- *Sharing my private notes with colleagues*

Still five state this for the activities *Taking individual notes that I revisit at later points in time* and *Making relevance judgements for digital documents*

Table 6.1: *Overview over current practices of knowledge work.*

Item	N	Un-typical	Rather un-typical	Typical	Very typical	M	Median	s
Rating		1	2	3	4			
I search for colleagues to ask for help	7	0	2	3	2	3.00	3.0	0.816
I search on the internet for relevant information	7	0	0	0	7	4.00	4.0	0.000
I search on my own desktop for relevant information	6	0	1	2	3	3.33	3.5	0.816
I take individual notes that I revisit at later points in time	7	0	1	2	4	3.43	4.0	0.787
I store relevant results in collections on my desktop or laptop	7	1	0	3	3	3.14	3.0	1.069
I add keywords or tags to my digital resources in order to find them at a later date	7	0	4	3	0	2.43	2.0	0.535
I make relevance judgements for digital documents in order to highlight the most interesting resources and find them at a later date	7	1	2	3	1	2.57	3.0	.976
I maintain my private collections and continuously add materials	7	1	1	4	1	2.71	3.0	0.951
I discuss relevant resources with my colleagues	7	0	1	3	3	3.29	3.0	0.756
I share my private digital collections with colleagues	7	2	0	5	0	2.43	3.00	0.976
I share my private notes with colleagues	7	2	3	2	0	2.00	2.0	0.816
My colleagues and I have a common taxonomy/classification for tagging (or labelling) resources	7	2	4	1	0	1.86	2.0	0.690
My colleagues and I maintain common digital collections of information materials	7	1	3	2	1	2.43	2.0	0.976

Table 6.2: *Overview over the perceived need for improvement of certain knowledge work activities.*

Item	N	Not crucial for my work	Works well	Needs some improvement	Needs a lot of improvement	M	Median	s
Rating		0	1	2	3			
Searching for colleagues to ask for help	7	1	2	3	1	1.83	2	0.753
Searching on the internet for relevant information	7	0	4	3	0	1.43	1	0.535
Searching on my own desktop for relevant information	7	0	3	4	0	1.57	2	0.535
Taking individual notes that I revisit at later points in time	7	0	2	4	1	1.86	2	0.69
Storing relevant results in collections on my desktop or laptop	7	0	1	5	1	2	2	0.577
Adding keywords or tags to my digital resources in order to find them at a later date	7	0	1	3	3	2.29	2	0.756
Making relevance judgements for digital documents in order to highlight the most interesting resources and find them at a later date	7	1	1	1	4	2.5	3	0.837
Maintaining private collections and continuously adding materials	7	0	1	4	2	2.14	2	0.69
Discussing with my colleagues about relevant resources	7	0	1	4	2	2.14	2	0.69
Sharing private digital collections with colleagues	7	0	0	4	3	2.43	2	0.535
Sharing my private notes with colleagues	7	0	1	3	3	2.29	2	0.756
Creating a common taxonomy/classification for tagging (or labelling) resources	7	0	1	1	5	2.57	3	0.787
Maintaining common digital collections of information and materials with colleagues	7	0	0	2	5	2.71	3	0.488

in order to highlight the most interesting resources and find them at a later date.

Table 6.3 shows the results of the questionnaire provided to the participants after the last workshop. Four participants completed it. Due to a late change in the development plans, the deployment of a real Rating Widget was discarded. Moreover, evaluators became unhappy with the implicitly assumed relation of a five-star rating and relevance judgements, thus the statement *Making relevance judgements for digital documents in order to highlight the most interesting resources and find them at a later date.* was removed beforehand.

Honestly and unfortunately, it has to be said that these results have not proofed to be really meaningful but rather indicate a tendency. For three statements, 2 of 4 people could not assess the question, for other five statements, 1 person dropped out. This has two implications. Firstly, for eight of twelve activities, one person does not know if the software supports the activity well or needs an improvement. This can be interpreted as: the users did not know how this should be realised with the software. Hence, a discussion about the complexity and introduction of the tool is necessary, which is is led in the conclusion in more detail. Secondly, it should be taken into account that for these activities a maximum of three participants judged the tool. However, the best result was stated for *Storing relevant results in the 'collections'*, where 3 of 4 assessed it as supported well. The following activities were also quite positively perceived as only a maximum of one person stated that it would need a lot of improvement:

- *Searching on the internet for relevant information*
- *Adding keywords or tags to my resources in order to find them later*
- *Maintaining private collections and continuously adding materials/resources*
- *Maintaining common digital collections of information and materials with colleagues*

In conclusion, it can be said that the results from the pre- and post-workshop questionnaires give at least some indication, whether the software might be able to support knowledge maturing. Considering the activities from both

Table 6.3: *The perceived support of different knowledge work activities by means of SIMPLE.*

Item	N	I don't know	Supports the activity well	Needs some improvement	Needs a lot of improvement	M	Median	s
Rating		0	1	2	3			
Searching for colleagues to ask for help	4	0	1	1	2	2.25	2.5	0.957
Searching on the internet for relevant information	4	0	2	2	0	1.5	1.5	0.577
Searching on my own desktop for relevant information	4	1	2	0	1	1.67	1.0	1.155
Taking individual notes that I revisit later	4	1	1	1	1	2.0	2.0	1.000
Storing relevant results in the 'collections'	4	0	3	0	1	1.5	1.0	1.000
Adding keywords or tags to my resources in order to find later	4	0	2	1	1	1.75	1.5	0.957
Maintaining private collections and continuously adding materials/resources	4	1	2	1	0	1.33	1.0	0.577
Discussing relevant resources with my colleagues	4	2	0	1	1	2.5	2.5	0.707
Sharing private digital collections with colleagues	4	2	1	1	0	1.5	1.5	0.707
Sharing my private notes with colleagues	4	2	2	0	0	1.0	1.0	0.000
Creating a common taxonomy/classification for tagging (or labelling) resources	4	1	0	2	1	2.33	2.0	0.577
Maintaining common digital collections of information and materials with colleagues	4	1	2	1	0	1.33	1.0	0.577

pre-workshop questionnaires, the following ones are stated as rather typical[3] for those, which need at least some improvement[4]:

- *Taking individual notes that I revisit later*
- *Storing relevant results in the 'collections'*
- *Maintaining private collections and continuously adding materials/resources*
- *Sharing private digital collections with colleagues*

As stated above, the second and the third activity are well appreciated and need at least not much improvement. Thus, these are activities which are typical, need only some improvement (compared to current practices) and which **are rather supported** by the software. Mapped to Knowledge Maturing Activities, they reflect *Embed information at individual or organisational level*, *Share and release digital resources* and *Familiarise oneself with new information.* Storing resources in collections is about sharing and embedding them at an individual or an organisational level and maintaining private collections with resources supports familiarising with new information. *Taking individual notes that I revisit later* is considered to be not well supported as the software hardly does support the creation of individual notes. *Sharing private digital collections with colleagues* was judged quite positively but only by two people. The other two did not know whether the software supports it.

Considering only those activities in the pre-questionnaire, which somehow need an improvement but are not typical, the following ones were mentioned additionally:

- *Adding keywords or tags to my resources in order to find them later*
- *Maintaining common digital collections of information and materials with colleagues*
- *Sharing my private notes with colleagues*
- *Creating a common taxonomy/classification for tagging (or labeling) resources*

The first two were judged quite positively as both only need some improvement or are supported well. The third one is also stated to be supported well but only by two people, while the last activity rather needs a lot of improve-

[3] at least 5 stated, the according activity is *typical* or *very typical*

[4] at least 5 stated, the according activity *Needs some improvement* or *Needs a lot of improvement*

ment and was obviously not well addressed. With respect to Knowledge Maturing Activities, *Maintaining common digital collections of information and materials with colleagues* also refers to the activity *Create and co-develop digital resources.* The first and third rather refer to *Share and release digital resources.* The last one can be mapped to *Reorganise information at individual or organisational level.*

In this configuration and context, SIMPLE shows the potential to support knowledge maturing mainly on an artefact level, although this could neither be observed nor could another evidence somehow be brought. However, it is indicated that several artefact oriented activities, which were stated to need an improvement compared to the current practice, were mentioned to be supported rather well by SIMPLE. Of course, this can not be generalised due to the low participant number, but should not be neglected as the feedback came from experts in their fields. The feedback session after the last workshop yield some more qualitative data, which will be discussed in section 6.1.4.

6.1.3.2 Usefulness and Ease of Use

Table 6.4: *Overview over the perceived usefulness of SIMPLE and its widgets.*

Item	N	Not useful at all	Somewhat useful	Very useful	M	Median	s
Item rating		0	1	2			
Search Widget (allows to search for documents and colleagues based on tags)	4	0	1	3	1.75	2.00	0.500
Collection Widget (allows to collect documents from the web and the desktop)	4	0	1	3	1.75	2.00	0.500
Tagging Widget (allows to tag resources)	4	0	2	2	1.50	1.50	0.577
Tag Cloud Widget (gives an overview of all tags in the system)	4	2	1	1	0.75	0.50	0.957
Tag Editor Widget (allows you to edit, re-arrange tags and to put them in a hierarchy)	2	0	2	0	1.00	1.00	0
Mature Fox (allows you to tag web pages while surfing)	4	0	1	3	1.75	2.00	0.500
MATURE Demonstrator as a whole	4	0	1	3	1.75	2.00	0.500

The participants assessed the system as a whole and each single widget according firstly to its perceived usefulness and secondly its ease of use after the last workshop. That was done in two different questionnaires, which have been created by MATURE's evaluation team.

Four P.A.s filled out the questionnaire. All of them were female.

For the interpretation of the results, the small number of participants was cautiously considered. Table 6.4 presents the results of the perceived usefulness.

The mean value shows that each widget was perceived as rather useful, although the median and standard deviation indicate that the Tag Cloud Widget was seen very critical. The most convincing pieces of software were the Search Widget, the Collection Widget, the matureFox plugin and (with reservations) the Tagging Widget. The Tag Editor Widget was only assessed by two of the participants and was perceived as *Somewhat useful*. However, the feedback regarding the system as a whole was quite positive, with 3 of 4 participants saying that it was very useful. The tag cloud was obviously perceived as less useful although it was thought to be an initiator for certain knowledge maturing activities, like finding resources. It seems, as if this intention could not be conveyed and as if the widget with its limited functionality was not properly integrated into the P.A.s's workflow. The tag editor was used in the workshops restrainedly, as it needed more time to introduce the general concept and workflow. Moreover, as stated in the system description, the integration of SOBOLEO with the prototype was not fully achieved, which could hardly be hidden (cf. section 5.3). This aspects become more obvious when we consider the ease of use.

As stated before, P.A.s were also asked to assess the ease of use of each widget and the overall system. Table 6.5 presents the results. It is not very surprising that the components with the least functionality (Tag Cloud Widget and matureFox) was perceived as the most easiest ones to use. It is very positive that those, which were judged to be very useful (Search- and Collection Widget, and matureFox) were also perceived as quite easy to use, although this seems to be very individual as represented by the high deviations. The Tag Editor was judged to be not easy to use at all and for the Tagging Widget it can be said that it was perceived as useful but not that easy to use. Consequently, the overall system needs improvements and was assessed to be only rather easy to use.

Table 6.5: *Overview over the perceived ease of use of SIMPLE and its widgets.*

Item	N	Difficult to use	Rather easy to use	Easy to use	M	Median	s
Item rating		0	1	2			
Search Widget (allows to search for documents and colleagues based on tags)	4	1	1	2	1.25	1.50	0.957
Collection Widget (allows to collect documents from the web and the desktop)	4	1	1	2	1.25	1.50	0.957
Tagging Widget (allows to tag resources)	4	2	1	1	0.75	0.50	0.957
Tag Cloud Widget (gives an overview of all tags in the system)	4	1	0	3	1.50	2.00	1.00
Tag Editor Widget (allows you to edit, re-arrange tags and to put them in a hierarchy)	4	4	0	0	0.00	0	0.00
Mature Fox (allows you to tag web pages while surfing)	4	1	0	3	1.50	2.00	1.00
MATURE Demonstrator as a whole	4	1	2	1	1.00	1.00	0.816

On the one hand these results are somewhat disappointing, on the other hand several different and to a certain degree very obvious reasons can be made responsible for that. They strongly relate to the following points:

- The way of actually implementing the participatory design process: As developers and end-users had only minimal direct contact between the workshops, it was hardly possible to establish a continuous process of improvement. The design would have been probably more accepted if short but monthly online workshops had been established. Developers could have reacted faster on user demands and users had probably not needed so much time to learn the interface again.

- The conflict between end user expectations with research interests: The application partners had a lot of ideas how the software could be adapted and improved. The research and developer team focused on knowledge maturing support. Hence, due to a certain priorisation, not everything the users wanted, could be actually developed.

- The choice of the application partner group with regard to their IT-affinity: Most of the application partners who were involved in the design process were not very IT-affine, some rather reluctant to use computers in their daily work. This is problematic as they had to learn new concepts (like tagging) and a new software approach, which is clearly a barrier.

These issues are discussed separately in the conclusion section.

6.1.4 Feedback Session

After the third and last workshop, all participants were asked to provide feedback. This feedback session was guided by questions that mainly aimed at finding out how P.A.s would use the software in their daily practice and how this is different to the way they do it currently. It brought insights how the software may change familiar and partly proven work practices. The feedback is summarised and structured according to main activities in the software. The focus is on the potential for knowledge maturing.

6.1.4.1 Collecting and Sharing Resources

One of the major advantages of the software was to improve the way of commonly collecting work relevant resources, independently from whether it is a web page or a Powerpoint presentation or something else. This especially comprises the collation of resources in collections and the tagging facility. Previously, P.A.s mainly used to keep hard copies in their office. Thus, by sharing and collaboratively collecting resources, they took a huge step ahead. Of course, colleagues were somehow used to share documents but firstly they experienced problems to reach all interested people and secondly, sometimes technical barriers blocked such activities. Distributing a powerpoint presentation for example was almost always a problem as the inbox of the e-mail account (previously the favored way of sharing resources) was too small. Having free access and the possibility to exchange resources, e.g. presentations, is a new way of working and was appreciated as the next consequent step. It was stated that the organisational local intranet is very confusing due to technique, structure, file naming or information reliability and thus was hardly used by people (according to the team leader 68% have never used it at all). However, there was still some resistance to share resources. It was commented with: "... in reality sharing maybe a challenge, as I have to attribute author, who updates information and who takes credit?"

They are unsure about the reliability and quality of such commonly collated resources. They see the potential for assessing and rating the resource, but ask for criteria to do so. They found it necessary to have a protocol for rating.

6.1.4.2 Categorisation

Tagging was appreciated as it allows to annotate files beyond some typical file naming strategies. The concept was new to them but as a quick value added they liked the opportunity to find resources easily at a later stage. However, they foresaw the problems that may arise when many people add tags. It will come to the existence of the same tag with different spelling, or to other words with the same meaning, etc. Thus, they stated they needed a tag gardening opportunity to change and maybe even categorise tags. However, again they were unsure about the quality of that and subsequently about who should be responsible. That this could be a collaborative activity was seen rather sceptical.

6.1.4.3 Identification of new Knowledge

The P.A.s did not see the potential to get aware of other peoples' interests, work or expertise. They stated that there was only limited knowledge about expertise across the organisation, mostly people only knew the colleagues in their own area. This was expressed as something really missing. In contrast, they absolutely saw the potential to increase their own knowledge faster or more efficient by means of the software than in traditional ways as it is easier to get access to domain relevant resources. Furthermore, one said: "It has got me into the habit of looking critically at resources before I rate and topic resources or webpages".

6.1.5 Summary and Implications

SIMPLE was provided to P.A.s of Connexions Kent in a series of workshops. They learned to use the system, had to fulfill some tasks with it and provided feedback by means of completed questionnaires and in a discussion session. The results were presented above.

The next two subsections provide the reader with some interpretations and implications regarding the software's potential for knowledge maturing support and usability.

6.1.5.1 Knowledge Maturing Support

The results of the questionnaires and the feedback session indicate that the following rather artefact oriented Knowledge Maturing Activities have been addressed quite successfully:

- Embed information at individual or organisational level
- Share and release digital resources
- Familiarise oneself with new information
- Create and co-develop digital resources

The software needs to catch up with the support of the following activities:

- Find relevant digital resources
- Reorganise information at individual or organisational level
- Assess, verify and rate information

These three activities have been already addressed but their support needs to be improved as the results show. For the search facility, the complexity and the quality of the results has to be improved. The necessary full integration of the Tag Editor has already been mentioned. Moreover, it has to be introduced carefully and properly due to the novelty of the concept. The rating opportunity was quite hidden as it was only possible from within the search widget. Providing this more obvious and prominent might already help in supporting the last activity.

In the discussions, a real need for an improvement of the sociofact level was revealed. Participants stated that SIMPLE did not help to find experts for particular topics. This can be improved by means of additional maturing services which make use of a more detailed and sophisticated user model from the usage activities. The results could be used in order to enrich certain awareness and search functionality. People Tagging (Braun et al., 2012, 2010) makes users and their expertise far more visible for other and could be therefore another approach. Apart from that, they indicated that it would be helpful to have a discussion opportunity. Although this was planned for development, it was not accomplished for these evaluation sessions at CK.

6.1.5.2 Usability and Development Process

In this paragraph, the impression of the perceived usability of the system is discussed. This is related to the four points identified in 6.1.3.2:

- The overall participatory design process.
- The conflict between end user expectations and research interests.
- The choice of the application partner group.
- The deployment process.

Different aspects need to be considered for the usability discussion in this context. Several standardised approaches to gain information about the usability of a software system are available. They can be used to assess the usability of an existing software but are hardly helpful as a proactive tool during the design and development process. The standard ISO 9241-110, called *Dialogue Principles* for example, defines different characteristics of the design of a software system, e.g. suitability for learning, suitability for the task, conformity with user expectations and more. Another example could be the usage of a standardised questionnaire, like the System Usability Scale (SUS) questionnaire, which allows to get findings on the users' comfort, the felt complexity and more. The advantage of such questionnaires is the comparability of the results of different user groups or development iterations. The disadvantage is that a minimal number of users is required to obtain a certain reliability of results, for the SUS at least 12 (Lewis & Sauro, 2009). Given the evaluation situation at Connexions Kent, a rather qualitative approach during the workshop and the following guided interview was chosen. This allowed us to gain a wide spread palette of insights about drivers and blockers, which users recognised during system usage. These comprise issues regarding external indicators influencing the usage of the system, functionality, and perceived ease of use. The general ease of use was perceived rather positive as only one person stated that the overall software was not easy to use (cf. table 6.5) and all appreciated the instantiation as very useful (cf. table 6.4). However, different aspects are comprised by the term usability that are also analysed or considered by standardised approaches and need to be discussed with the help of the individual statements of users. As we will see, not everything that has been reported with relation to the user experience, can be easily referred to usability and thus should be differentiated. The suitability for learning (ISO standard) or for the subjectively expected effort for learning to use the system (SUS) reflects that software should support the user in learning to use the system as fast and easily as possible. Two comments of users highlight typical conflicts in HCI research.

> "Unfortunately I find the programme has too many sequences, which are not my strength at all! I also feel that you have to be a good computer user to get the most from the product. I am often left feeling very confused, as I can't see connections very easily from one section to the next."

> "I really like the idea behind the process, but continue to struggle with the complexity. Thinking about encouraging other colleagues, I don't think I will ever be in a position to be able to explain how to use it to someone else. New IT for an existing group (over 30) should take account of prior knowledge and therefore less functionality that slowly develops would be the way forward."

With focus on complexity, both users seem to struggle with the opportunity provided by the widget-based approach to develop own strategies for usage. On the one hand, Keil-Slawik states that enforced sequentiality of usage should be minimised in order to facilitate the processing of tasks for users (Keil-Slawik, 1992). The modular widget-based approach is a perfect means and SIMPLE a good implementation for that. On the other hand, due to this reduction the overall complexity of usage might increase as users are less strictly guided by the software and this is what the people above are struggling with. Based on this evaluation group, more guidance by the software and during the system's introduction might have helped here. However, this is a general design conflict, which has to be solved in the particular application context. Furthermore, the guidance aspect is strongly related to another issue, the *conformity with user expectations* (ISO standard) or the subjective expected complexity of using the system (SUS). Users commented that the software should have been introduced by taking into account their specific computer literature and thus their expectations to use the system. The software's interface approach does not seem to take into account the different mental user models (as the ISO standard suggests). However, complexity and thus user expectations are influenced in different ways here. Moreover, the software's amount of functionality seemed to be new to some user.

The following comment refers more to the widget concept as to the way of using it is (obviously) new to her/him:

> "I still need to familiarise myself with some of the widgets, but overall it is working a lot better than before."

Here, two or maybe three things clash together. Firstly, the system does not look and behave as users would probably expect, which can easily be understood as the overall interface concept is quite new. Secondly, however, the software seems to have some weaknesses regarding the ease and suitability of learning the system. Thirdly, the users seemed to struggle with the sense and concepts underlying the given functionality, e.g. the tagging idea:

> "I don't understand how tags will be organised and 'tidied up' – if there are too many headings/tags people will not want to use the software. We haven't really covered this in our sessions."

Consequently, three issues have to be addressed for future development. Firstly, the interface needs to be improved taking into account what users might know. In this case for example, one would try to give it a 'Windows – Look & feel', with typical menus, buttons, labels and with windows located where they are used to it. Secondly, user expectations need to be managed better at the beginning of the process. For instance, time and resource issues should be highlighted, so that minor technical errors and a simplistic design are expected. Finally, training, which is important but typically more expensive should be considered. Hence, a weakness in the design process becomes clear. Unclear concepts (like tagging) should have been better explained at an earlier stage in order to shift the cognitive effort more towards the software during the workshops. However, the practice in the workshop showed that some people were more confident using the software than others and that there was a huge difference in perceived ease of use of the different widgets (cf. table 6.5). The Collection Widget was accepted far better than the tagging widget for example, which may have been the result of the users' understanding of the purpose of the collections. Individual statements mention improvements that would be really helpful, e.g.

> "Clearer language from some of the tools used in the demonstrator is needed, i.e. tag editor is unclear."

> "Copy and paste facility within collections, so that you can copy items from one collection to another."

> "Facility to hover over an item in a collection and see its full name or URL."

This is not a closed list and the developers' list is far longer. However, in different situations, strategic decisions with respect to time and resources caused us not to implement improvements like those mentioned above in order to concentrate really on specific issues of a learning and maturing environment, including the related maturing services and the aim at supporting knowledge maturing as a whole. Here, end user priorities and research priorities differed. In conclusion, it can be said that on the one hand, the evaluated software has some weaknesses regarding its usability in practice. This concerns principles of locality, language, or possibilities for individual adaptations (e.g. colour). The brief analysis above, with respect to standardised methods, also revealed strengths and positive aspects in using the system (e.g. flexibility, adaptation to work processes, less sequences). On the other hand, framing conditions and technical problems have influenced the overall experience of the software. Slow internet connections, out-dated hardware and bugs in the software made it difficult to provide the software satisfactorily. A browser based approach might fit better into that domain. Moreover, the workshop based software deployment was probably awkward. Software errors regardless of the effort to fix them, had a negative impact as users did not use the software between two workshops and thus bugfixes (though provided remotely and automatically) were not installed. Furthermore, changing user groups influenced the experience and sometimes changed expectations for further developments. The following comment for example, is in contradiction to a workgroup decision taken at the October workshop 2009 (cf. (Mature Consortium, 2010d)), where they explicitly stated that a deletion of collections should not be possible.

> "Currently I can't seem to delete a collection that I have created (only items from within a collection). This would be useful."

Finally, more training that may have helped not to overload users, should have been considered during the design process. Hence, different aspects of the software are not perfectly adapted to the end user group. Nevertheless, the questionnaire results clearly show that the idea and to a high degree its implementation were perceived very positively and thus allows to deduce that the overall usability was also perceived very positively. This includes the main software (Sidebar), but also most of the widgets itself. The messaging server is an important instance for improving the overall flow of usage as it allows to create a kind of interaction between the single widgets. The embedded Firefox plugin lowers the entrance barrier of using the system as it addresses a software (a browser) that people already know well. Finally, regarding the usability a satisfying result was achieved, keeping in mind that research interests are confronted with specific domain and context based interests, needs and abilities.

6.2 Case Study II: E-Learning Course

This case study took place in the context of the e-Learning provider Structuralia, which was a full application partner in the MATURE project. An e-learning course about the CAD software CYPECAD, a relevant design software for the construction sector in Spain, was provided. The students were asked to complete the course by means of SIMPLE. Additionally, they had to use Structuralia's own browser based software platform to complete exercises and the final exam and CYPECAD itself.

6.2.1 SIMPLE Configuration

SIMPLE was deployed by installing the sidebar and the matureFox plugin on end users' computers. The users did this themselves but could ask for help. The widget repository provided the following six widgets (cf. figure 6.2):

- Collection Widget
- Tagging Widget

- Tag Cloud Widget
- Search Widget
- Tag Editor Widget
- Discussion Widget

Figure 6.2: *The 6 widgets provided for the Structuralia case study.*

The whole software, i.e. the Sidebar, matureFox and all widgets were localised to Spanish. The users were registered at SOBOLEO and the *WidgetServer* beforehand.

6.2.2 Procedure

The course was limited to 75 students. 70 students were accepted to the course (depended on their pre-experiences in this area), 66 were attending the on-site training. Finally, 55 students finished the course.

All students were invited to an on-site workshop, which served for introducing the software at hand. This should ensure that people asked the presenters in case they had any questions or something was unclear. The workshop was held by Structuralia staff members. One of them was the main contact person (the "boundary spanner") for all students in case they experience any trouble, had questions or comments during the evaluation period.

Furthermore, the research team could contact her in case anything had to be conveyed. Apart from that, the on-site workshop served for seeding some collaboration between the course participants. Although, most of them had participated in a learning course at Structuralia before, they did not necessarily know each other. At best, this resulted in a stronger communication and co-operation between the participants.

After the introductory on-site workshop, the evaluation ran for almost two months, the planned time period for the e-Learning course [5]. During that time, students used the software in order to collect materials, and discussed questions regarding the course and the final exam.

After this period of usage, the participants were asked to complete three questionnaires. One was referring to Knowledge Maturing Activities, and two were related to Usability, implementing the SUS questionnaire (Brooke, 1996). For the sake of more clarity, the SUS was divided into two questionnaires, as students were asked to complete the whole SUS for all software components (overall 80 questions). Therefore, the SUS was translated into Spanish.

6.2.3 Questionnaires

6.2.3.1 Relevant Work Activities

After the experience, we asked the course participants to complete two questionnaires related to Knowledge Maturing Activities (KMA) and two questionnaires asking for usability (the latter two belong together but were divided for practical reasons).

The two questionnaires related to KMA were divided such that the first asked for 10 typical activities of the participants' current practice of knowledge creation and sharing. The second asked whether these 10 activities were supported rather well or whether the software needed an improvement. These are discussed in this section, the usability questionnaires are discussed in the next section.

Table 6.6 shows the results of the first questionnaire. 46 participants completed it. They were asked whether the stated activities were *Untypical*, *Rather untypical*, *Typical*, or *Very typical* for their current practice of knowledge work.

[5] September 16th to November, 10th 2011

Table 6.6: *Overview over current practices of knowledge work.*

Item Rating	N	Do not reply 0	Un-typical 1	Rather un-typical 2	Typical 3	Very typical 4	Median	s
Searching on the internet for relevant information	46	0	2	14	19	11	2.85	0.842
Storing relevant results in collections on my desktop or laptop	46	2	19	15	8	2	1.84	0.888
Making relevance judgements for digital documents in order to highlight the most interesting resources and find them at a later date	46	2	21	14	5	4	1.82	0.971
Maintaining private collections and continuously adding materials	46	4	16	12	12	2	2	0.937
Discussing with my colleagues about relevant resources	46	1	12	18	11	4	2.16	0.928
Sharing private digital collections with colleagues	46	4	14	16	11	1	1.98	0.841
Sharing my private notes with colleagues	46	4	15	18	7	2	1.9	0.85
Creating a common taxonomy/classification for tagging (or labelling) resources	46	4	27	12	2	1	1.45	0.705
Maintaining common digital collections of information and materials with colleagues	46	3	21	15	6	1	1.7	0.803
Adding keywords or tags to my digital resources in order to find them at a later date	46	5	23	12	5	1	1.61	0.802

For 30 participants *Searching on the internet for relevant information* is a very typical or typical activity. 15 say that for *Discussing with my colleagues about relevant resources* and 14 for *Maintaining private collections and continuously adding materials.* It is quite interesting to see that most of the asked activities are rather untypical. For 8 out of 10 activities, 30 to 37 (65%- 85%) of the participants state that they were rather untypical or untypical for their knowledge work, the only exceptions are *Searching on the internet for relevant information* and *Maintaining private collections and continuously adding materials.*

Table 6.7 presents the results to the question whether the activities that were asked to be typical for their knowledge work are well supported by SIMPLE or not. Participants could answer with *Do not reply*, *Works well*, *Needs some improvement*, *Needs a lot of improvement*, *Not crucial for my work.* 45 students completed the questionnaire, one less than before.

The overall results are quite positive. The mean value for almost all activities is between 1,49 and 1.88. Only the activity *Creating a common taxonomy/classification for tagging (or labeling) resources* was assessed to need rather more improvement. Considering the absolute numbers, the following activities were judged as *Works well* (*Works well* or *Needs some improvement*):

- *Storing relevant results in collection on my desktop or laptop*: 22 (35)
- *Maintaining private collections and continuously adding materials*: 22 (34)
- *Searching on the internet for relevant information*: 20 (35)

These are supported best. Moreover, participants obviously saw the potential for *Making relevance judgements for digital documents in order to highlight the most interesting resources and find them at a later date* but stated it needs improvement (24). *Discussing with my colleagues about relevant resources* was also perceived quite positive and assessed as *Works well* or *Needs some improvement* by 29 participants.

All in all, the results of the questionnaires allow us to deduce some indications regarding SIMPLE's support of Knowledge Maturing Activities. Considering the activities, which were mentioned to be typical for the participants' daily work and its support by SIMPLE, it becomes obvious that the following are under the three best supported activities:

- *Searching on the internet for relevant information*

Table 6.7: *Overview over the perceived need for improvement of knowledge work.*

Item	N	Do not reply	Works well	Needs some improvement	Needs a lot of improvement	Not crucial for my work	Median	s
Rating		0	1	2	3	0		
Searching on the internet for relevant information	45	2	20	15	8	0	1,72	0,766
Storing relevant results in collections on my desktop or laptop	45	4	22	13	5	1	1,58	0,712
Making relevance judgements for digital documents in order to highlight the most interesting resources and find them at a later date	45	6	13	24	1	1	1,68	0,525
Maintaining private collections and continuously adding materials	45	7	22	12	3	1	1,49	0,651
Discussing with my colleagues about relevant resources	45	4	14	15	9	3	1,87	0,777
Sharing private digital collections with colleagues	45	7	16	16	3	3	1,63	0,646
Sharing my private notes with colleagues	45	8	15	15	3	4	1,64	0,653
Creating a common taxonomy/classification for tagging (or labelling) resources	45	9	7	15	13	1	2,17	0,747
Maintaining common digital collections of information and materials with colleagues	45	8	12	17	6	2	1,83	0,707
Adding keywords or tags to my digital resources in order to find them at a later date	45	3	16	13	11	2	1,88	0,822

- *Maintaining private collections and continuously adding materials*

Moreover, *Discussing with my colleagues about relevant resources* is at least quite well supported, though with limitations. It seems as if SIMPLE was supporting artefact maturing quite well. However, although the results are generally positive, the more the activities are related to sociofact maturing the worse the results are. Where the internet search or the maintenance of private collections is supported well, sharing resources is worse, and the support of discussions or adding tags is even deal worse.

6.2.3.2 Usability

In order to get an impression of how easy it was for users to work with the instantiation, we asked them to complete the System Usability Scale (SUS) (Brooke, 1996). The SUS provides us with a comparable measure of the easiness of use of a system. It is valid and reliable (Sauro, 2011) and it needs at least 12 participants to become comparable (Lewis, 1995). It does not help to identify specific problems. However, several questions ask about usability in particular and specific aspects that are also reflected in the ISO standard 9241-110 (Dialog Principles), e.g. suitability for learning (Lewis & Sauro, 2009).

Table 6.8: *SUS scores for SIMPLE (sorted in descending order of mean value)*

	N	Min	Max	Mean	s
Collection Widget	36	15	100	66,94	18,899
Discussion Widget	30	23	85	62,58	16,433
MatureFox Firefox plugin	30	23	95	56,25	16,863
Overall System	38	13	93	55,13	19,425
Search Widget	36	20	83	54,31	17,905
Tag-Cloud Widget	34	0	93	51,84	24,389
Tagging Widget	29	0	95	47,07	19,663
Tag-Editor Widget	37	0	83	45,61	19,476

According to table 6.8, the mean values of the overall system, the matureFox and four of the six widgets are above 50 points. The Collections Widget and the Discussion Widget have a high value of over 60 points. In general, it shows us that the overall system conception was accepted differently. Users liked the focus on collecting, aggregating, sharing and discussing their resources but had obvious problems with the Tag Editor (ontology creation) and the Tagging Widget (tagging resources). Discussions with application partners revealed that the ideas behind them are typically quite new to people. Hence, they need introduction time for training in order to grasp the underlying ideas and the relevance (cf. formative evaluation reports in Mature Consortium (2010d) and Mature Consortium (2010d) or section 5.2).

The SUS score for the overall system shows a mean value of 55. Hence, people in general were happy with the software. However, they found, for example that the collection widget was really easy to use with a remarkably higher SUS score. In turn, the general system conception needs to be critically reflected with respect to ease of use. Table 6.8 shows that the other prompted entities (Tag Cloud, MatureFox, Search Widget) are all slightly above the median and thus show a positive but also critical ease of use with room for improvements. In summary, it can be said that two of the most important widgets were perceived very easy to use, which can clearly contribute to the maturing of artefacts (Collection Widget) and sociofacts (Discussion Widget). We had expected a more positive result for the Search and the Tag Cloud Widget, but compared to the other widgets, these two might either provide too many functionalities (search) or not enough (tag cloud). They are thus not perceived as very easy to use. It might help to provide training that shows how work processes can be approached and how the widgets can be integrated there.

6.2.4 Summary and Implications

SIMPLE was provided to a group of 70 participants of an e-Learning course, who worked with the tool over a timespan of 8 weeks. Afterwards, they were asked to complete questionnaires, which asked about the relevance and support of certain Knowledge Maturing Activities and about the standardised SUS. The following paragraphs reflect and interpret the results.

6.2.4.1 Knowledge Maturing Support

According to the results in 6.2.3.1, especially table 6.7, it can be said that the support of the following Knowledge Maturing Activities should be improved:

- Share and release digital resources

- Communicate with people
- Assess, verify and rate information
- Reorganise information at individual or organisational level

The following ones obviously need less improvements:

- Find relevant digital resources
- Embed information at individual or organisational level

As already stated, artefact maturing might be well supported, sociofact maturing rather less. As there was no concluding interview or any other qualitative data gathered, it can only be assumed that sociofact maturing is a real need. At least for *Communicating with people* there was an evidence that users want that. However, it did not show clearly, whether the people were really aware of the bottom-up approach following the Web-2.0 idea and whether they assessed this approach as helpful and thus considered it worth to be supported. Anyway, assuming, sociofact maturing might be important and is perceived as important, it clearly showed that the software needs to be improved regarding that.

6.2.4.2 Usability

The result of the SUS questionnaire reflected an ordinary usability. Some widgets were perceived to have definitively a better usability (Collections Widget, Discussion Widget) than others (TagEditor). However, for all widgets is much space for improvements. Especially, the interface for the Tagging Widget and the Tag Editor Widget should be considered here. The usability has several weaknesses which are known to the developers. Several design principles (e.g. locality) were neglected during development and should be improved.

It might have also been a problem that people only had the introduction workshop to learn to use the system. Afterwards they worked directly with the live-system or they had to contact the staff member of Structuralia. Both was probably an obstacle to get to know the system better. Additionally, the impact of technical issues should not be underestimated. As SIMPLE is a research prototype several issues came up. Although these were fixed immediately, it very likely led to a demotivation of users and a bad impression.

Nevertheless, considering all circumstances, including the fact that software was developed in a completely different context, that the introduction time for users was low and that the software concept was probably quite new to many users the results can be regarded as very positive. It was obviously quite easy to implement the software in that context as users only had to use collections, discussions and the tagging widget. Thus, it seems as if the widget based approach makes it easy to implement the tool in different contexts.

6.3 Case Study III: University Seminar

The third case study presented here was implemented in the context of a specifically designed university seminar. The students were asked to use SIMPLE for working out the details of presentations and to share the used and additional material with fellow students and to comment on their contributions. Our objective was to find out, whether SIMPLE, which was developed in a completely different context, can also be implemented successfully in this formal learning scenario.

6.3.1 SIMPLE configuration

SIMPLE was deployed by installing the sidebar and the matureFox plugin on end users' computers. The users did this themselves. The widget repository provided the following five widgets (cf. figure 6.3):

- Collection Widget
- Tagging Widget
- Tag Cloud Widget
- Search Widget
- Discussion Widget

Due to the missing finalised integration of SOBOLEO in the system, the Tag Editor Widget was not provided and the Search Widget was slightly adapted not to show the facets based on the taxonomy. It should be avoided to overload the students by introducing a new software and a new seminar concept as we were aware of the existing problems. The interface language was English, it was ensured that people understood it. The users were registered at SOBOLEO and the *WidgetServer* in advance.

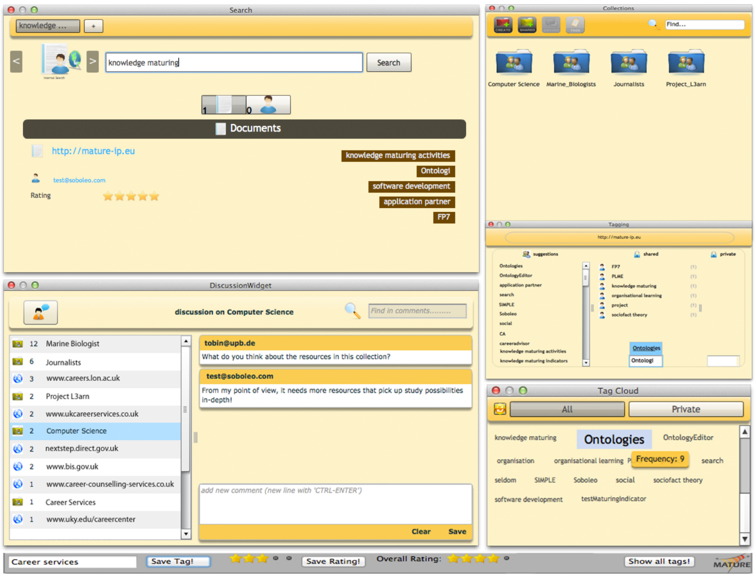


Figure 6.3: *The 5 widgets provided for the university seminar case study.*

6.3.2 Procedure

This case study took place in the context of a university seminar. The overall seminar concept was designed in order to embed SIMPLE into it and to test whether the software might be useful in such a context. Eight students participated in the seminar. The seminar was organised such that each of the students was asked to prepare one topic and to present it on a particular day to her/his fellow students. The topic should be prepared by means of SIMPLE. The lecturer seeded the preparation activity by initially creating a collection with basic material. Students were supposed to collect additional material for this collection and to tag it with relevant keywords. After the presentation and the related discussions in the group, all students were supposed to reseed the information base (resources in the collection and assigned tags) by adding additional material, tags and annotations or even start discussions with the Discussions Widget.

The case study ran for a whole semester, which is a timespan of four months. Afterwards, students were asked to complete a questionnaire, which was divided into four parts. They were asked about typical activities of their knowledge work and to which degree this could be improved by means of SIMPLE. These were the same questions as those provided to the participants of the case study at Connexions Kent (cf. section 6.1.3 and questionnaire in the appendix, D.1). Furthermore, some very context specific questions were asked regarding the particular seminar support and the question of ease of use of the software was addressed.

Additionally, two participants were chosen for an interview to discuss with us the overall concept, especially the implementation of SIMPLE in this context. One of the participants was chosen as she/he was very successfully participating in the seminar. The other person was chosen as she/he sometimes had problems with the software and contacted the lecturer several times and was generally very active and engaged. We expected to get very sophisticated and detailed feedback by this choice of interview partners.

In order to avoid the introduction of any barriers, the questionnaire was provided in German and the interviews were conducted in German as well. However, a translated version of each of the four parts of the questionnaire can be found in appendix D.1, D.2, D.3, and D.4.

6.3.3 Questionnaire

Table 6.9 shows the results, to which degree certain knowledge work activities, are typical for the students daily work. Eight students participated in the seminar and all completed the form.

It becomes obvious that for these eight individual artefact related activities are very or rather typical:

- *Searching on the internet for relevant information*
- *Storing relevant results in collections on my desktop or laptop*
- *Maintaining private collections and continuously adding material*

In contrast to that and somehow surprisingly, the following rather collaborative and social activities were described to be untypical or rather untypical:

- *Maintaining common digital collections of information and materials with fellow students*
- *Discussing with my fellow students about relevant resources*
- *Sharing private digital collections with fellow students*

The reason remained unclear. It might be that the related course tasks were too individual, or studying might generally be a rather individual activity

Table 6.9: *Overview over the current practice of knowledge work.*

Item	N	Do not reply	Un-typical	Rather un-typical	Typical	Very typical	Mean	s
Rating		0	1	2	3	4		
Searching on the internet for relevant information	8	0	0	0	1	7	3.86	0.447
Storing relevant results in collections on my desktop or laptop	8	0	0	1	2	5	3.50	0.787
Making relevance judgements for digital documents in order to highlight the most interesting resources and find them at a later date	8	0	4	4	0	0	1.50	0.535
Maintaining private collections and continuously adding materials	8	1	0	2	2	3	3.14	0.900
Discussing with my fellow students about relevant resources	8	0	1	6	1	0	2	0.0.535
Sharing private digital collections with fellow students	8	0	1	4	3	0	2.25	0.707
Sharing my private notes with fellow students	8	0	2	4	2	0	2	0.756
Creating a common taxonomy/classification for tagging (or labelling) resources	8	0	7	1	0	0	1.13	0.354
Maintaining common digital collections of information and materials with fellow students	8	0	7	1	0	0	1.13	0.354
Adding keywords or tags to my digital resources in order to find them at a later date	8	0	4	3	1	0	1.63	0.744

without much cooperation, or the listed activities are not of major relevance for studies or the students simply do not want to engage in such a kind of co-operation.

Additionally, we asked, which of these activities are supported well by the tool, for which activities the tool needs some improvement and for which it needs a lot of improvement (table 6.10). The results are interesting here as those activities which are rather individual artefact oriented as

- *Storing relevant results in collections on my desktop or laptop*
- *Maintaining private collections and continuously adding materials*
- *Maintaining common digital collections of information and materials with fellow students*

The following activities representing social interaction need rather more improvement:

- *Adding keywords or tags to my digital resources in order to find them at a later date*
- *Discussing with my colleagues about relevant resources*
- *Sharing my private notes with colleagues*

This is not very surprising, as the software was initially mainly developed with respect to artefact maturing support until it was recognised that the social layer had to be considered more thoroughly.

Apart from these questions, we presented four statements regarding the support of collaborative activities in the seminar (cf. table 6.11). We asked whether these statements apply, rather apply, do not apply or do not represent an application case. The results convey the impression that the software does not fit in with the seminar concept. For the statement *The collaborative collection of resources has helped to gain a better impression of the respective topic*, four people confirmed a support. The other three were not perceived as a helpful for the seminar. The tagging was almost not perceived helpful at all, the discussions were seen very indifferent.

Additionally to the first three statements the hypothetic question, whether a collaborative text editing tool would help the seminar work, was asked. As the collaborative creation of text is not a supported part of SIMPLE but students had to prepare topics pair-wise, it was an assumption that such a tool might be helpful. Four stated it rather applies or applies and three stated it would not apply. Hence, it is not quite clear to which degree digital-based collaborative work is helpful and necessary in the context of this seminar with

Table 6.10: *Overview over the perceived need for improvement of knowledge work.*

Item	N	No answer	Works well	Needs some improvement	Needs a lot of improvement	Mean	s
Rating		0	3	2	1		
Searching on the internet for relevant information	8	4	1	3	0	2.25	0.500
Storing relevant results in collections on my desktop or laptop	8	2	1	5	0	2.17	0.408
Adding keywords or tags to my digital resources in order to find them at a later date	8	1	2	4	1	2.14	0.690
Making relevance judgements for digital documents in order to highlight the most interesting resources and find them at a later date	8	2	1	5	0	2.17	0.408
Maintaining private collections and continuously adding materials	8	2	3	2	1	2.33	0.816
Discussing with my colleagues about relevant resources	8	3	0	3	2	1.60	0.548
Sharing private digital collections with colleagues	8	2	2	3	1	2.17	0.753
Sharing my private notes with colleagues	8	2	2	2	2	2	0.894
Creating a common taxonomy/classification for tagging (or labeling) resources	8	1	1	6	0	2.14	0.378
Maintaining common digital collections of information and materials with colleagues	8	1	4	3	0	2.57	0.535

Table 6.11: *The perceived support for the seminar provided by SIMPLE*

Item	N	Not an application case	Does not apply	Rather applies	Applies	M	s
Item rating		0	1	2	3		
Tagging of the resources has helped to summarise and reflect the seminar discussions	8	2	4	2	0	1.33	0.516
The collaborative collection of resources has helped to gain a better impression of the respective topic	8	2	2	0	4	2.33	1.033
The discussion widget has helped to prepare the seminar discussion session	8	4	1	2	1	2.00	0.707
A collaborative text editor had helped for the preparation and the follow-up of the seminar session	8	1	3	3	1	1.71	0.756

its particular concept. It seems to show that knowledge work is fundamentally different, depending on the particular context. SIMPLE was developed in the context of a career guidance scenario, an collaborative work was appreciated there. In the context of this seminar with its particular concept, it seems to be slightly different.

Table 6.12: *Overview over the perceived ease of use of SIMPLE*

Item	N	No Answer	Not easy to use at all	Rather easy to use	Easy to Use	M	s
Rating		0	1	2	3		
Search Widget	8	2	3	2	0	1.4	0.548
Collection Widget	8	0	2	3	3	2.13	0.835
Tagging Widget	8	1	1	2	4	2.43	0.787
Tag Cloud Widget	8	2	1	3	2	2.17	0.753
Discussion Widget	8	5	2	1	0	1.34	0.577
Mature Fox	8	1	4	1	2	1.71	0.951
MATURE Software as a whole	8	0	3	3	2	1.85	0.835

Finally, it was asked about the ease of use of the widgets and the system as a whole (cf. 6.12). The response is quite different. The Search and

Discussion Widget, the Mature Fox and the system as a whole were perceived rather not easy to use. The Collection Widget, the TagCloud Widget and especially Tagging Widget are are perceived rather easy or easy to use.

6.3.4 Interviews

As already mentioned, interviews were conducted with two persons, both quite engaged in the seminar course and using the software quite intensively, compared to fellow students. One of the two could not use matureFox plugin for some unknown reasons. However, both gave us interesting feedback. The interviews were led along a guideline, which can be divided into two parts. The first part was aimed at asking for Knowledge Maturing Activities and whether they are supported by means of SIMPLE. The second part asked about the overall perceived usability and ease of use. A version of the guideline translated into English can be found in appendix D.5. The interviews were led in German.

6.3.4.1 Support of Knowledge Maturing Activities

According to the feedback, it clearly turned out that the software was not supporting any knowledge maturing activities in this context as the software was not perceived as helpful. This has nothing to do with the software as such but it was stated that the seminar concept did not fit in with the software concept. The students had to read and tag seeded documents. The documents, however sometimes had a lot of pages and tagging was somehow very vague as it could not be related to specific pages. Therefore, students could not really use the tagging in order to prepare a class as they had to read through the document anyway. It was mentioned that the tagging might be helpful in this context if single pages could be tagged. That is to say, the students asked for the possibility to annotate documents and parts of it. This would provide them with possibility to share rather sophisticated reflections which goes beyond keyword tagging. Furthermore, such an initial database should be available to the course at the beginning of its next iteration. The participant might then benefit from tags without having read the documents in detail.

The collections were seen as quite helpful but still not integrated into their working processes as all documents were replicated in their known learning environment, which was consequently used. And although some contributed external links or documents to collections, as it happened after the group discussion, this was not used. Literally, the topic was "out-dated". Additionally, due to the topic itself, partly not many good and helpful resources were available in the internet for the seminar theme. In this case, the students were confined to the material provided by the supervising tutor.

The preparation of the topic presentation and discussion was rather done on-site, which was felt more to be natural, thus, the discussion widget was hardly been used.

The search widget was not used at all. In one case the student had technical problems, in the other case it was not useful as the student wanted to go through all documents anyway.

It can be concluded, within the context of the seminar, the software was only partly helpful for the students. It became clear that SIMPLE as well as the seminar concept need further adaptation in order to increase the value added for such a scenario. In the following fictional situation this might be better aligned. Let us assume, SIMPLE provides a collaborative editor (e.g. wiki) and a text annotation tool. Let us further assume the following seminar concept. Students are provided with an initial set of wiki pages, which contain valuable information. They are asked to collect additional resources in collections. These have to be summarised in a new wiki page, which has to be linked to available pages. For each week, two students have to prepare one topic in order to present it. In preparation to each seminar meeting, the fellow students have to read and annotate or discuss the topic beforehand. In that way, students still have to be very engaged in the seminar, but the kind of knowledge work supported by the tool and that demanded by the seminar concept is aligned far better.

6.3.4.2 Ease of Use

In contrast to the feedback of the Connexions Kent case study, the software was not perceived to be complex by both of the interviewees. They found the complexity very low and had no problems in learning to use the system. The basic idea was clear and each widget for its own easy to understand. One of the interviewees stated that she/he did not have problems with the use of the software and it was perceived as absolutely easy to use. The other student felt that the software was not integrating very well into the standard desktop interface as it does not fit into the used Windows Look & Feel. The bar containing the widgets is popping up from the bottom to the top, where Windows blends sideways. Furthermore, the colors of the software do not fit in with the personally configured Windows color scheme. The widget-windows as such do not look like standard Windows interfaces. The SIMPLE Sidebar itself seem to bother people only because of the place where it is put (bottom right of the screen).

The widget approach was appreciated by both interviewees. They know the concept and like to use it. However, it was mentioned that the widgets should be developed rather web based and should be embedded into the Windows' own Sidebar in order to improve integration.

All in all, it can be concluded that the perceived ease of use is very positive but due to bad integration in the overall Windows Look & Feel it was very inconvenient to use it. Interestingly, according to the interviews, SIMPLE was not considered very complex, quite contrary to the feedback in the career guidance scenario. This shows that the perceived ease of use is varying with individual precognition of the general concepts (e.g. tagging) and the software. Hence, regarding its implementation the context and scenario of knowledge work has to be considered carefully. Moreover, end-users have to be supported intensively and if possible already integrated in the design process.

6.3.5 Summary and Implications

SIMPLE was provided to a seminar course in an university setting over a period of four months. Afterwards the students were asked to assess to which degree the software had helped them to engage in the seminar and for its preparation and follow-up.

The sobering result was that the software simply did not fit in with the seminar concept. This could be anticipated only to a certain degree as it was not clear how students engage in collaborative and long-term processes. The questionnaires revealed that this had absolutely no priority. Furthermore, due to the specific situation, it could not be observed that knowledge maturing processes were supported or fostered by the software. Nevertheless, as SIMPLE is designed to be a PLME, the following conclusions can be drawn.

Strengthen individual activities SIMPLE hardly allows to create individual artefacts, which are necessary and often the base for further learning experiences. It mainly allows to collect existing artefacts, which can be additionally shared or released by tagging. In terms of the knowledge maturing phase model, the support of the individual creation of artefacts would strengthen the first two phases *Ia - Expressing Ideas* and *Ib - Appropriating Ideas*. Besides embedding new external information in a (shared) repository, the active work on artefacts (as external memory) is probably more important and was neglected in the software conception so far.

Support the transition between phase *I* and *II* Based on the prior conclusion, the transition from the rather individual phase *I* to the "collaboration-phase" *II* has to be supported. This could be done by providing much more functionality that helps to increase the awareness of members and especially improve the access to members of the social network. It could be visualised, which core areas of interest the students have. Resource recommendation might help to find additional learning materials. Moreover, resource quality awareness might motivate students to engage in collaboration activities. Activity streams, expertise topics, status awareness (online/busy/etc.) or expert recommendations are other examples. This might also be an approach to provide a direct value added for collaborative work in such an interactive seminar concept.

Usability Regarding the usability and ease of use it seems as if the software was not too difficult to use but rather did not integrate into normal work activities. In terms of size, technique and location on the screen the Sidebar seems rather displaced. A better visual integration in the system's standard Look & Feel would be very positive. As most operating systems provide a kind of dashboard for widgets, it was suggested to use these. We then consequently had to switch to an HTML approach which might anyway be even more flexible in terms of deployment and distribution. And as it can be expected that the HTML5 specification will be widely implemented by browsers in mid-term, many of the obstacles that have been a reason for not developing a web application will fall.

6.4 Conclusion and Implications

6.4.1 Conclusion

After considering the three case studies, a clear potential can be seen that the tool SIMPLE might lead to improved knowledge maturing processes. This could not be proofed due to the short-term studies and would rather need long-term observations. However, several positive indications but also blockers could be identified.

In all case studies it was asked whether and to which degree the tool supports the different particular knowledge maturing activities. In all cases, positive results were fed back especially with regards to individual artefact oriented activities, e.g. *Maintaining private collections and continuously adding materials*. Collecting resources and information either by aggregating them in collections or by tagging them was appreciated rather well in all case studies. In contrast to this, all collaborative activities were not that typical for the participants' daily work and mostly needed at least some improvements to be supported well by the tool. The latter might be influenced by weaknesses of the tools' usability. However, it seems that individual work is still preferred to collaborative work (at least in the case studies' context) and thus the software also has to address this aspect more thoroughly. Additionally, it seems as if the functionality which addresses rather social aspects, as discussions, rating, or even tagging has to be more strongly emphasised, in a way that motivates its use by giving a quicker value added. It seems to be an error to think that users are aware of and used to some concepts (e.g. tagging) and that they are able to incorporate new concepts easily into their work processes. It could be clearly observed that this depends on individual precognitions. Thus, such concepts need to be integrated more easily by simultaneously showing their value added more clearly. More particularly, sociofact maturing could be supported by providing improved functionality that increases the awareness for users, users activities, or users expertise topics, always with the possibility to contact them (e.g. via e-mail). The following section 6.4.2 presents some ideas, which address these issues and were developed after the official evaluation. Artefact maturing should be further supported by providing an opportunity to create individual notes and to start a complete authoring process. This should make it easier to distribute and discuss such artefacts. This could be achieved by providing a software, which can be integrated easier into the desktop, respectively into the daily work processes.

The widget-based interface concept of SIMPLE seemed to be difficult for some participants, while others said that it is not very complex. However, all had problems with certain usability aspects. The different components do not integrate very well in the system's standard Look & Feel. Having a small program like Sidebar, where each widget needs to be opened separately was obviously somehow cumbersome for many users[6]. Very interesting and positive was the feedback that the widget approach as such was not a huge problem for all. It rather seems that again the way of implementation was a problem. Hence, embedding the widgets in the standard widget dashboard of the most recent operation system or at least providing a more compact HTML version might be a solution here. Both solutions also had the advantage that widget windows were not so scattered over the screen but can always be at the same place with a fixed and possibly well known access to it.

The concept of this lightweight and REST-style backend architecture seemed to fit in perfectly well with all these studies and contexts. There was no indication that the more complex but probably more flexible bus-based SOAP architecture would have fit better. Especially due to the unforeseeable, very individual situations in the Structuralia context and the low internet bandwidth at Connexions Kent, it was very helpful to have a smart architecture, which allowed for a fast reaction in case of errors and provided a very fast data throughput.

Last but not least, one has to deal with the fact that some implemented concepts were new to many people, especially to those who do not have a high IT-affinity or share a passion for exploring new things on their Personal Computer (PC) or in the web. Thus, it would always lead to problems and blockades if such a software introduction would not be accompanied by management-driven measures, such as participative design methods, trainings and support.

[6]The activities concept was for some reason not accepted. The participants that could be observed have not used it for unknown reasons.

6.4.2 Approaches to Improvements

Especially regarding the support of sociofact maturing, but also regarding artefact maturing, different things were developed and tried out after the formal (summative) evaluation had been started or had already finished. This is a reaction to the experiences of the evaluation activities. The following paragraphs describe modifications to widgets or new widgets, which have already been developed and tested by the developers but which could not be evaluated formally.

Awareness Widget In order to get a better awareness of activities in the social network, the awareness widget was developed (cf. figure 6.4). Two ways of getting aware of activities are combined. Firstly, users may choose resources for which they want to get informed in case somethings changes, for example if a tag is added or a new discussion entry is available. Apart from that, there are several activities, which are generally displayed as one can not subscribe to them, for example if a new user is registered to the system, or a new discussion has started. In case, such an activity occurs, a small half transparent popup on the top of screen is displayed, which contains the message (top left in figure 6.4).

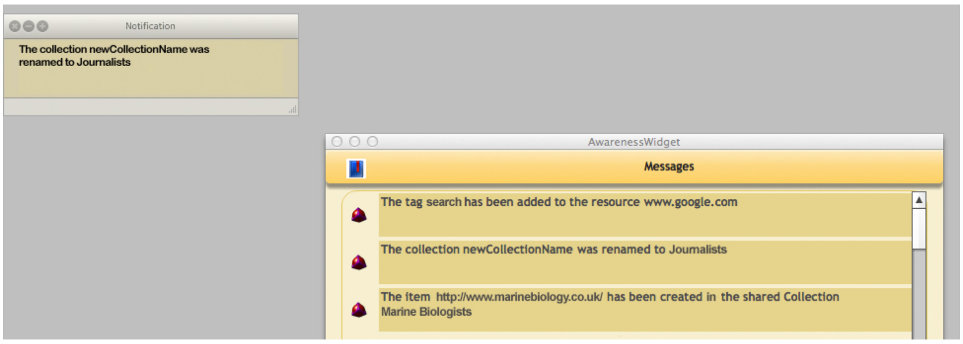


Figure 6.4: *The Awareness-Widget consists of 2 parts: a notification display and a main window.*

A critical design decision had to be taken here. On the one hand, such a widget might be ideal in order to support the awareness of activities of users within the social network. This could help to know for example on which topics others are working or which resources might be very interesting for other users. However, due to privacy concerns it was renounced to display activities, which may allow to derive personal interests, work or even private topics or other personalised stuff.

People List and People Tagging One of the Knowledge Maturing Activities, which are deemed very important but perceived to be supported poorly is *Find people with particular knowledge or expertise* (cf. 3.3.3.1). People Tagging can be a solution for two aspects. Firstly, it is a means of making users and even people (from outside of the company) searchable in order to find expertise and to be able to contact them. Experts are not necessarily declared persons in a particular topic but often simply topic specific More Knowledgeable Others (cf. 2.4.3). Secondly, people tagging can serve for collaboratively creating a kind of organisational competence map.

Technically, people tagging is already possible with the Tagging Widget provided in all case studies (cf. prototype description in 5.3.5). However, actually due to a missing service interface it was not possible to access the list of users in the system, thus there was no possibility to get the identifiers (e-mail address) into the Tagging Widget. This has been solved with the development of the People List Widget shown in figure 6.5. It is simply

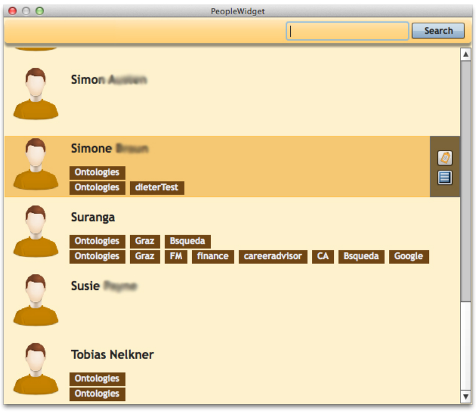


Figure 6.5: *The People List Widget lists all users of the system, their tags and provides access to the person summary view.*

listing all users in the system. From there, it is possible to tag people and to see a more specific summary. The tagging is realised by the known Tagging Widget. By click a button, the e-mail address is sent to the Tagging Widget by means of the IWC server. The people summary is shown in figure 6.6.

This person summary is supposed to raise even more awareness for certain

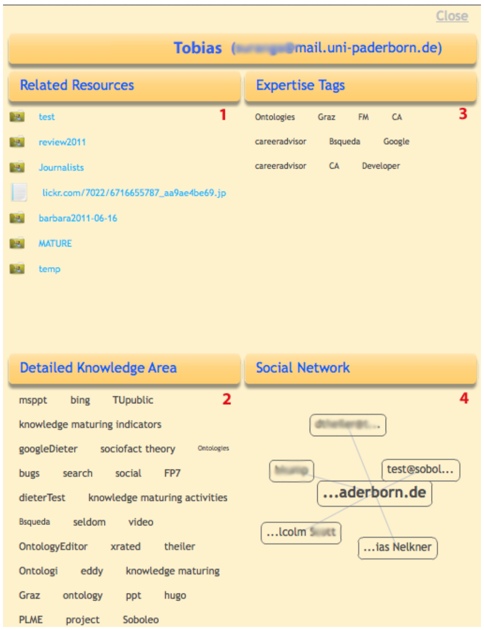


Figure 6.6: *The summary view of a People search result is divided into 4 areas.*

characteristics of a person. The window has four sections (numbered in the figure). The first one is showing related documents, web pages or collections. By clicking on the name, the resource is opened, either in a browser, or the Collection Widget opens or the resource is downloaded. The second part is showing automatically derived detailed knowledge areas. By means of an according Maturing Service, the resources the respective user has dealt with are analysed and certain topic areas are extracted in terms of keywords. The third area is showing all tags other persons have assigned to the user. The fourth area is showing the relations to other people in a social network visualisation. These relations are computed by means of analysing resources which are commonly viewed, collections to which users are commonly subscribed or discussions users have contributed to. Hence, implicit connections via artefacts are used to assume a relation in a social network. By clicking on the node in the visualisation, people can be contacted via email.

All in all, such people information should enhance the engagement in collaborative activities and the awareness of colleagues working in similar areas of interest. Communities of Practice could emerge from that and stronger collaborations or message exchange regarding topics. All these aspects support and foster sociofact maturing.

Enhanced Search The Search Widget was enhanced in order to provide more detailed information and (with respect to the last paragraph) to make users searchable. Figure 6.7 shows a search result for a user. A search result

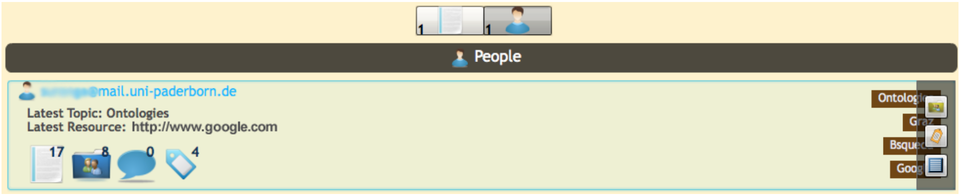


Figure 6.7: *A search result for user.*

entry shows different information. It shows the number of recent documents, the person had viewed or contributed to, it shows the number of shared collections, the user is subscribed to or the user has created. Furthermore, it shows the number of discussion entries the user has written and the number of tags which are assigned to the user. For each result entry, persons can be tagged and the summary shown above is available Additionally it was decided to provide the opportunity to add people to collections. When clicking from within a collection on a person, it is possible to establish the contact via e-mail.

Additionally, the artefact search result overview was adapted. Apart from minor changes for the search result view, especially a summary view was introduced for artefacts. Similar to the summary of user details, a summary of information about artefacts was developed (cf. figure 6.8). This view has 6 areas, which are numbered in the graphic. The first is showing all discussions about the resource and all collections, this resource is associated to in case it is not a collection itself. Area 2 shows a visualisation of all persons related to the document. This is exactly computed as described for the implicit social network above, each touch to the resource is recorded and displayed. Although possible, it was decided not to show the type of the connection (e.g *has viewed* or *has created*) for the sake of a better overview. The third area is showing which specific Knowledge Maturing Indicators are related to the artefact. For example, if it is used by many people, the indicator *used widely* is assigned or if it is often part of a search result, this

Figure 6.8: *The summary view for an artefact search result is divided into 6 areas.*

is also reflected in a certain indicator. The main idea behind it, was to increase the users' awareness of particular characteristics of artefacts and their relations. If the indicator *used widely* for example is assigned to the resource, it might be important and may stimulate the user to read it. It would be very interesting to know whether these pieces of information may initiate any user activities. However, the fourth area is displaying all recent activities the document was involved in, such as if it was tagged, added to a collection, rated or any similar. Area 5 shows the tag cloud for this document, and number 6 the document's overall rating and user rating.

Moreover, it is still planned to start a new search by clicking on tags or indicators in order to enable users to rather explore the knowledge base.

All in all, it is expected that all these awareness measure might help users to get a clearer picture of which resources are relevant or which persons are valuable contact persons for specific problems. By providing the specific indicators or the rating, it is intended to stimulate additional knowledge maturing activities. But it remains open if this actually improves knowledge maturing processes.

Chapter 7

Related Work

As this thesis develops a software concept for supporting knowledge maturing on different dimensions and incorporates very different activities, there is not much room to investigate different aspects really in-depth. Such a holistic approach to work-integrated learning could not be found in literature. However, there is some work related to different aspects of it, which is presented in this chapter.

7.1 General Widget-based PL(M)E Approaches

Several approaches to PLEs exist. However, some are rather technical widget based concepts. These can hardly offer convincing concepts for the support of learning processes (Fiedler & Väljataga, 2010). Others have a particular focus on the support of some of those activities, identified in 3.3.3.1 as Knowledge Maturing Activities. Both classes are shortly described in this section by means of different examples.

At the very beginning of active PLE research, often almost everything was claimed to be a PLE. Without thinking about pedagogical values added, the technical possibility to aggregate web applications into the user space was perceived to be a PLE. Thus, many web based approaches from commercial third-party suppliers were proposed as positive example, e.g. iGoogle[1], Netvibes[2] or MyYahoo[3]. All products have in common that they provide an interface, which is able to display and arrange small web widgets on a

[1]http://www.igoogle.com, last access 16.03.2012
[2]http://www.netvibes.com, last access 16.03.2012
[3]http://my.yahoo.com/, last access 16.03.2012

dashboard. They can typically display information about the weather, a calendar, and include RSS or Atom feeds [4]. Netvibes for example, additionally allows to share widgets with others or the dashboard configuration or (tagged) contents. These environments allow users to aggregate information and they possibly allow them to create notes and ideas. It is only the possible self-arrangement of the environment with free, interconnected tools that let researchers call them a PLE (Castañeda & Soto, 2010; Severance, 2008; Godwin-Jones, 2009). However, it is not obvious how it supports especially workplace integrated learning. Such systems are obviously disconnected from the organisational knowledge base. They rather address private interests. The problem is rather the software ownership and hosting than the idea behind it. Google Docs[5] for example provides an approach to collaborative synchronous artefact creation, which can be referred to the KMA *Create and co-develop digital resources*. Thus, such a technique might support knowledge maturing in an LME instance. However, the database can not be integrated into the organisational knowledge base, Google does not allow the technical access on an integration layer. Furthermore, in most organisations (data) privacy policies would not allow untransparent data access to a third-party. Hence, with respect to knowledge maturing in an organisational context, most of the Knowledge Maturing Activities can not be fully supported. Possibly relevant information can be bundled on a dashboard by means of widgets but a maturing process stops there, as the information can not be transferred into another context. Furthermore, it can hardly be transferred into another maturing phase, e.g. successfully sharing relevant artefacts with colleagues. It does not matter, which kind of software we consider, let it be a social bookmarking tool, microblogging, text editing or others. Generally, most of them may contribute to support Knowledge Maturing Activities. However, as long as they can not be integrated into the users' workplace, the value added compared to the PLME approach is very limited.

Apart from these third-party tools, an open source networking engine called ELGG[6] is available, which is technically similar to the systems described above but which is only the engine that provides the dashboard,

[4] RFC4287: http://tools.ietf.org/html/rfc4287,
RFC 5023: http://tools.ietf.org/html/rfc4287, 16.04.2012

[5] https://docs.google.com/, 17.04.2012

[6] http://www.elgg.org, last access 16.03.2012

embedded in a social network system. Hence, it comes up with well known functionalities for connecting with other users and for sharing contents. It has the advantage that it can be implemented in an organisational intranet but has the disadvantage that sophisticated widgets for knowledge maturing support still have to be implemented. However, the system might be helpful to create a PLME but in itself does not support knowledge maturing as it is only a basic engine.

Quite similar to the ELGG system is the approach of the EC co-funded project ROLE (Responsive Open Learning Environments), which started a year after MATURE and is also a TEL project.

> "Responsive Open Learning Environments (ROLE) offer adaptivity and personalization in terms of content and navigation and the entire learning environment and its functionalities. This approach permits individualization of the components, tools, and functionalities of a learning environment, and their adjustment or replacement by existing web-based software tools." (http://www.role-project.eu, last access 16.03.2012)

It seems to be comparable with the ELGG approach, allowing to add and arrange widgets loaded from a repository and to customise the whole environment. Similar to the IWC technology presented in section 4.2.2, for Responsive Open Learning Environments (ROLE) a new XMPP (Saint-Andre, 2004a, 2004b; Saint-Andre et al., 2009) based solution was developed (Friedrich et al., 2011). It is the objective of the project to provide a framework that might enhance individual and collaborative learning processes. By developing this framework, the project wants to

> "
>
> - to support the individual assembly of accessible learning services, tools and resources in Responsive Open Learning Environments (ROLE)
> - to research and develop a psycho-pedagogically sound framework for supporting the individual composition of learning services in ROLE
> - to create new engineering methodologies to enable significant contributions to ROLE from learner and developer communities from outside the project consortium

- to develop and sustain an evaluation methodology to systematically demonstrate the effectiveness of different ROLE in test-beds focused on the transition of learners
- to exploit and disseminate the ROLE results to wider communities and markets

" (http://www.role-project.eu, last access 16.03.2012)

The project is providing different bundles and each of them seems to represent a PLE on its own (ROLE Consortium, 2011). Most of them were evaluated in test scenarios, e.g. (Friedrich et al., 2011; Soylu et al., 2011) but it can not be said, to which degree they actually support knowledge maturing. However, the project seems to develop a promising technology to be built on, when the SIMPLE approach should be transferred to a web-based environment, as indicated in section 6.3.4.2.

7.2 Solutions for Particular Learning Support

Many solutions exist that focus on particular aspects of how learning processes can be initiated or how concrete learning activities can be addressed. Some of the very recent innovations will be briefly presented in this section.

7.2.1 Reflection

The EC co-funded MIRROR project started in mid 2010 as TEL project. It is working on a conceptual framework and on tools for supporting learning by reflection. Reflection is also an important knowledge maturing activity (*Reflect on and refine work processes*). Therefore, such tool approaches might have also been helpful for mature application partners, provided that the tools are adapted to the particular context. Here, an incomplete list of tools follows, that was taken from the project homepage[7]:

- **CroMAR** is a mobile augmented-reality application developed for the IPAD. It is aggregating different information inputs related to a certain event like a concert, including social media, or radio communication. It is supposed to enable workers operating e.g. as Disaster Managers

[7] http://www.mirror-project.eu/showroom-a-publications/mirror-apps-status, last access 16.03.2012

to reflect about the processes that happened during an event in order to create recommendations for actions or improve the own procedures (Boron, Mora, & Divitini, 2011).

- **CLinIC** is a serious game dealing with dialogues between nursing staff and patients. It shall help users to reflect on their decisions within the dialogue by getting feedback and to assess their answers in order to support learning. Furthermore, the software gives a concluding feedback about different parameters like "patient satisfaction" or "time management" (Mirror Consortium, 2012a).

- **Task Detection App** is a timeline that allows users to record daily work tasks and which gives a graphical overview afterwards. By means of becoming aware of the duration, interruptions and relations to other working tasks, it is assumed that users learn about their work efficiency and how to improve it. (Mirror Consortium, 2012b)

Generally, such reflection approaches (either about artificial scenarios or about user recorded input) would be very helpful to support knowledge maturing more in-depth. Due to the frequent contact of P.A. to clients, especially young persons, it can be easily imagined for example that it would be helpful to transfer the **CLinIC** idea into the career services context.

7.2.2 Resource and Expert Recommendation

APOSDLE is another EC co-funded TEL project, which was already finished in 2009. Its objective was also the support of self-directed learning. The Advanced Process-Oriented Self-Directed Learning Environment (APOSDLE) prototype is quite a complex software with many facets, including two, which are especially interesting for this work: resource recommendation and expert recommendation.

The main approach of this software was the determination of the user context, i.e. what is the user's current task and which topic is currently relevant, in order to make expert and resource recommendations on this basis. The contextual information was gained by means of analysing usage events (e.g. what was the last user input, which program was opened, which button was clicked) (S. N. Lindstaedt, Ley, Scheir, & Ulbrich, 2008). In order to match this information to resources and to make recommendations, all resources in a particularly classified user space were analysed regarding the content by means of the KnowMiner analysis framework (Granitzer, 2006). Based on enhanced full-text search mechanisms, recommendations for currently relevant documents could be made. Additionally to this automatic procedure, tasks and users were modeled in an ontology. This information was used to relate persons and documents to particular tasks and to recommend experts according to the current work context (Kump, Seifert, Beham, Lindstaedt, & Ley, 2010). Instead of trying to automatically infer user expertise, this method provided much more reliability in this context.

The MATURE project profited from these results as different techniques were transferred into the *SocialServer*, the backend that has been used for SIMPLE. Especially the identification of user-related knowledge maturing events, which is realised with an associative network (cf. (Granitzer, 2006)), is based on the concept of KIE (S. Lindstaedt et al., 2009; Kump et al., 2010; Stern, Kaiser, Hofmair, Kraker, & Lindstaedt, 2010). It served as a means to identifying user expertise areas (Schoefegger, Seitlinger, & Ley, 2010).

7.2.3 Learning Management System

Learning Management Systems are typically implemented in one of the following two main contexts: (1) in a learning institution like an university or (2) in an organisation for advanced training. Especially with respect to the organisational focus of the knowledge maturing concept and the rather limited success of the university case study described in section 6.3, it can be said that the case mentioned first is out of scope for the work presented in this thesis.

Larger organisations typically use some kind of Learning Management System (LMS) in order to foster on-the-job training. Especially in customer care and sale but of course also in other fields formal training is necessary to keep employees up-to-date. According to Baumgartner and Kalz (2004), these systems are typically providing the following functionalities:

- Presentation of content
- Tools to create exercises and tests
- Support for evaluation and assessment
- Tools for user and content administration

- Synchronous and asynchronous communication tools

Baumgartner and Kalz distinguishes between LMS and CMS here. They state that it is not the task of an LMS to provide content authoring tools as this should be the focus of Content Management System. For CMS he describes the following important functionalities:

- Acquisition and creation of contents
- Presentation and dissemination of contents
- Adaptation of contents
- Management and organisation of contents
- Integration of contents
- Processing of contents in workflows
- Re-using contents

He also recognises an increasing tendency that more and more authoring functionalities are also provided for LMS. Although this list of functionalities also reflects the Knowledge Maturing Activities *Share and release digital resources*, *Re-organise information at individual or organisational level* and *Embed information at individual and organisational level*, it does not reflect in my opinion the creation and usage of contents in real organisational environments.

The misleading and negative aspect is the fact that contents, which are created for the presentation in an LMS are probably very different to contents that are created to accomplish an organisational task. Those which were created for an LMS, are used to teach something. They have to be created pedagogically valuable, for example according to the principles of the Cognitive Load Theory (CLT) (Chandler & Sweller, 1991). Moreover, LMS resources are seldom shared or adapted by others as there is typically only one person who is formally an author and who is responsible for a certain topic area in advanced training. In contrast, organisational contents are often rather pragmatic and not necessarily well understandable without knowing the particular context. The resources might be shared and adapted by different team members, the role of authors and consumers of contents is not clearly separated (cf. Knowledge Maturing Phase Model in section 2.2.2). Thus, due to the different goals and probably the different workflows, there will always be a barrier between the creation of materials for the LMS-based usage and the daily work. Consequently, it is not of significance if the CMS is part of the LMS or not. For the authoring process it is probably not even necessary that the CMS part is strongly connected to an organisational database due to the different workflows, compared to creating contents that serve a direct business goal.

The positive aspect and the goal to be achieved in order to further support knowledge maturing should be the embedding of the created contents into the organisational knowledge base. In that way it is also available in the different work contexts. A further step, which is not reflected by Baumgartner and Kalz's LMS conception, is the access to the tasks, exercises and learning courses from outside the system. That would make it searchable and recommendable similar to normal resources. LMS courses could be integrated into an expert search. If for example no expert or MKO (cf. 2.4.3) could be found but a formal learning course instead, this could be recommended then as well. The idea behind all this is to provide formal and pedagogically valuable material for context-related problems. Apart from regularly scheduled vocational training, this should be a sustainable goal for any LME.

7.3 Conclusion

Many technical implementations follow a widget-based approach in order to improve learners' flexibility and the ability of self-arranging the work- and learning environment. Some, like the one of the ROLE project, are technically very similar to SIMPLE but are browser based. However, this seems to be a good choice to transfer the SIMPLE widgets into a better integrating environment in order to tackle the evaluation feedback.

Moreover, there are particular solutions that address specific problems of knowledge maturing, which should be considered for further work and research on LMEs. And although it is hardly possible to combine an LMS with the daily work environment, its contents including courses and exercises should be accessible from outside in order to make use of it by means of Maturing Services.

Chapter 8

Conclusion

This chapter recapitulates the findings and contributions of this thesis and reflects about anchor points for future research.

8.1 Contributions

The following paragraphs reflect the results of this thesis against the background of the objective formulated in section 1.2. Additionally, insights into Knowledge Maturing beyond them are discussed.

Shaping the Knowledge Maturing Model Starting from the basic idea of Knowledge Maturing, depicted in the Knowledge Maturing Phase Model, knowledge was differentiated into the three dimensions artefact, sociofact and cognifact. The underlying theory, the relation to knowledge maturing and the relation between the three knowledge dimensions were described and presented more detailed than this has been done before. Moreover, the relation to other concepts of the knowledge maturing landscape was emphasised. The three knowledge dimensions provided us with a lever to better understand learning and maturing processes. Along the different phases of the phase model, several theories of individual and social learning were examined and it was discussed how they relate to our knowledge maturing model.

The theoretical examinations were helpful to shape our understanding of knowledge maturing. The detailed investigation of related theories provided us with insights into individual and social learning in informal and organisational settings. It could be described how learning processes occur in the different phases of the Knowledge Maturing Phase Model and how the transition between the phases may be initiated. Based on this examination, a set of abstract software requirements could be identified, which might support particular aspects of knowledge maturing and phase transition. These requirements are helpful as part of a guideline during the context-related design process of a Learning and Maturing Environment.

Findings from Empirical Studies In order to derive concrete requirements for an LME, the results of the MATURE project's empirical studies were examined. The ethnographically informed study resulted in a set of Personas, which were analysed in this thesis. This resulted in a set of 73 services, which are supposed to support knowledge maturing.

The results of the Representative Study were especially useful as the justified Knowledge Maturing Activities helped in two ways. Firstly, KMA are a manageable set of activities, which are deemed to drive knowledge maturing and thus should be supported when designing an LME. Secondly, the set of services found (including those found in the project's use case analysis) can be mapped to these activities to a high degree. Only four activities had to be discarded. Thus, an indication could be found that these services actually might support knowledge maturing and they may provide a guideline for the design of an LME.

The results of the in-depth study confirmed these results, again the KMA were found to be very important and a kind of priorisation between them could be identified. Moreover, the study reinforced the understanding of the relevance of sociofact support, both by means of software but also by means of the management activities. It became very clear that it needs a holistic approach to support knowledge maturing in organisations efficiently.

Framework for a Learning and Maturing Environment The considerations and findings of the theoretic and empirical examinations were transferred into an architecture concept for a PLME. Suggesting a lightweight concept, which allows an easy and high level integration approach makes the concept flexible for many contexts with needs for fast enhancements, a short time-to-market, and flexible integration. Knowledge maturing support was found not be supported by the architecture as such, however it needs to be considered that Maturing Services have to be integrated.

It could be shown that an instance of the design architecture may support knowledge maturing when considering the guidelines for contextualising an implementation. This includes the Knowledge Maturing Activities, the derived services and the Knowledge Maturing Indicators. However, it was confirmed that especially the theoretical findings could not serve for developing the software design directly. They were needed to better understand aspects of Knowledge Maturing in order to create hypotheses about the design of the software (hypothesis-guided design). These were partly tested during the participatory design process. Results of these explorative activities were used to refine the hypotheses. The general backend architecture for example was initially supposed to base on a SOAP-based SOA architecture, which uses an enterprise service bus for the service registration, orchestration, enactment, etc. (cf. 4.2.1). This was supposed to be helpful to realise a flexible software architecture, which allows to create a user interface that can be arranged and adapted according to the knowledge worker's needs. However, during the participatory design process, it became clear that the complexity of the backend infrastructure needs to be reduced with respect to the particular environmental constraints we found at the application partner (cf. 3.5). Hence, the system design had to be refined. This shows that it is not possible to derive a system design directly from theory. The assumptions, which are formulated based on the theory have to be tested against particular contexts and might be validated then.

The thesis has shown that it is hard to distinguish between a Personal Learning and Maturing Environment and Organisational Learning and Maturing Environment (cf. 4.4.2). Therefore, both perspectives were mostly aggregated under the term Learning and Maturing Environment. However, yet it makes sense that this separation exists. As already discussed, there is probably not a technical distinction between them but definitively one which can be observed in different contexts and usage scenarios.

Evaluating an LME Instantiation A prototype is presented, which mainly implements the reference architecture (with few exceptions) and some of the Knowledge Maturing Activities. The feedback of three different case studies allows us to assume that the software concept actually might be able to support knowledge maturing activities successfully. Nevertheless, when introducing the software it firstly needs much more guidance activity than it was possible to provide for the evaluation and secondly the software itself needs an interface design that integrates much better into the users' familiar workflows.

Due to the experiences made in the case studies, improvements of the social aspects of the software could be suggested, which is mainly expertise awareness, activity awareness and people search. Possible improvements of the architectural concept could not be found.

However, already the early steps in the participatory design process showed that the implementation of new software always has to be guided by measures that support the process integration, user acceptance and daily usage. Barriers have to be lowered and motivations raised. The processes that should be supported by software need a pendant in reality. That is to say, if organisations for example want to support the creation and work in Communities of Practice by means of software, they also have to provide the room for face-2-face meetings and work processes have to be adapted to it. Isolated approaches to the introduction of knowledge maturing tools will fail.

The participatory design process but especially the evaluation activities clearly showed the relevance of the particular application context for the actual design and implementation of the software. In order to provide a software that really supports work-integrated learning and knowledge maturing it needs to be aligned with individual tasks and work processes. Software exists, which might support each single Knowledge Maturing Activities (cf. chapter 7). However, when trying to provide a holistic approach to Knowledge Maturing, a hole environment has to be created. This has to fit to tasks and work processes in terms of the technical integration, cultural integration (precognitions, user habits), management strategies (security policies, software policy) and of course suitability for the task. That could be observed in the two case studies in the career guidance context (cf. 6.1) and in the university context (cf. 6.3). SIMPLE was developed in the career guidance context. An implementation in the seminar context requires adaptation of the seminar concept as well as of the software in order to align both appropriately. Thus, a decontextualised software might support aspects of knowledge maturing but can hardly provide a holistic approach to Knowledge Maturing.

8.2 Further Research

A model of knowledge maturing was presented but it is actually not clarified nor justified in which way the modeled phases are passed. Thus, it should be considered to put more effort into the research on Knowledge Maturing Indicators in order to get meaningful and reliable reference points which allow to make statements about the status of knowledge maturing in a specific context. A deviation of the Balanced Scorecard principle (Kaplan & Norton, 1992, 1993), the Knowledge Maturing Scorecards (Mature Consortium, 2011d) can be one approach to it.

The tool SIMPLE was presented and according to all feedback, it provides a promising approach to support knowledge maturing. However, knowledge maturing is a process that can hardly be observed in a short period of time. Hence, in order to gain more insights into the possible knowledge maturing support of SIMPLE or similar approaches to an LME, which are based on this concept, a long term evaluation has to be implemented. An additional aim should be to gain more knowledge about the respective roles of the software and of operational guidance activities beyond the software deployment, in order to create a framework for the implementation of new knowledge maturing processes in different contexts.

The research community is appreciating concepts like tagging and bookmarking, tag clouds or ratings to support learning (Glahn, Specht, & Koper, 2008; Yew, Gibson, & Teasley, 2006). However, the case studies have shown that it seems to be the case that such quite new techniques are not used by many people and that they do not see an immediate value added. Moreover, collaborative activities (like collaboratively creating a resource) generally seem not to be as important as it has been expected. Hence, it would be interesting to know to which degree social and collaborative concepts are helpful for knowledge maturing in organisational contexts. Furthermore, basic research is necessary how these social concept can be introduced so that knowledge workers see a clear value added and engage in collaborative activities sustainably.

Knowledge work and workplace learning is an increasingly mobile activity (Attwell, Cook, & Ravenscroft, 2009; Sharples, Taylor, & Vavoula, 2005) and thus knowledge maturing does not stop at the office's door. An important field of research are mobile scenarios and the integration of mobile devices into the daily knowledge work. Furthermore, technical barriers have to be reduced in order to switch between desktop or mobile devices during Knowledge Maturing Activities. It is a technical, social, cultural and management-oriented challenge to achieve moving seamlessly between both worlds.

In conclusion, this thesis has developed the concept of an Learning and Maturing Environment, based on extensive theoretical and empirical research, enhanced with formative evaluation results. In particular a roadmap along which software can be developed that holistically supports knowledge maturing is provided. This has been missing so far and it makes this work outstanding. An extensive overview of the knowledge maturing theory and fundamental knowledge maturing concepts are presented. Together with results from empirical analyses it was shown how these were transferred into cutting edge technologies that might support knowledge maturing in practice.

Appendix

Appendix A

Personas & Identified Services

A.1 Overview of Persona Characteristics

Table A.1: *Persona dimensions according to (Pruitt & Adlin, 2006) and characteristics found in the ethnographically informed study. Taken from (Mature Consortium, 2009a).*

Dimension	Characteristics	Description
identifying details	name	name of Persona
	motto	an abstract statement that helps to quickly convey a central point that the Persona is about and thus can be used for explaining, referring to and visualizing the Persona
roles & tasks	roles / degree of standardisation	job description and some information about the degree of standardisation of tasks the Persona has to handle or likes to handle, respectively
	workplace / colleagues	a description of the Persona's workplaces and information about relationships to colleagues the Persona is surrounded by
	task management	description of how the Persona organizes own activities and of how activities are triggered
skills & knowledge	education and professional background	information about school education or possible degrees the Persona holds and about coining experience it gained on the job
	learning	self-motivated learning of the Persona and (frequency of) occasions the Persona is confronted with the need for learning new things and description of how the Persona approaches it
	knowledge	description of knowledge that is relevant for the Persona, that is needed to perform tasks or knowledge the Persona puts a high value on
	formal training	description of subjects of formal training the Persona is interested in and of motivation behind participation in formal trainings
context & environment	reaction to requests from colleagues	description of Personaś reaction when asked for help by a colleague
	communication strategy / approach to knowledge sharing	explanation of how the Persona interacts with colleagues or other people within its environment, description of aims the Persona hopes to achieve when acting this way
	content types	types of meaningfully arranged (electronic) data the Persona uses as input for its tasks
	structures	description of how the Persona organizes own workspace and how it connects contents to one another
	important tools	a list of IT-tools that have a big effect on Personaś daily work or leisure time, respectively
goals & motivation	problem solving and other knowledge routines	description of how Persona deals with problems or other knowledge-oriented activities that can be partly routinized
	motivation / drives / interests	description of Persona's reasons for wanting to do something or achieve something as well as explanation of things the Persona pays attention to
	attitude towards technology	explanation of opinions and feelings the Persona has about information technology

A.2 Example Persona Description

Table A.2: *A complete example of a persona description.*

provided by	UIBK
name	Sally
motto	If I have not seen it working, I do not believe it anyways.
education and professional background	She has a Bachelor degree in Computer Science and has been employed for four years.
role / degree of standardisation	She likes precise task descriptions and written documentations and therefore she documents her working solutions precisely and completely.
workplace / colleagues	She shares her office with five co-workers, engaged in similar tasks and problems. She feels comfortable inside her familiar environment.
learning	Sally has to continuously acquire new knowledge to fulfill her tasks. Sally's demand for learning occurs during execution of work tasks. Usually, she learns during problem solving.
knowledge	She needs knowledge about, e.g., configuration parameters and their consequences, systems interfaces and underlying procedures or client decisions. Her tasks require a wide variety of knowledge and this volatile knowledge highly depends on involved systems and clients.
content types	She always collects training materials, e.g., presentations, and stores them on her local disk. Besides that, she maintains a rather large collection of product documentation, personal notes, relevant emails, business/system proposals and configuration summaries.
structures	She organizes her workspace according to her own hierarchical structure, based on topics.
problem solving and other knowledge routines	If Sally has a problem and she needs knowledge to solve it, her first approach is to try something. In case of system functionalities, she changes several parameters and looks at the consequences. After some unsuccessful trials, she opens the system help or manuals. She has local copies of manuals and training presentations and she searches in her local data. By browsing through documents, she usually has some new ideas and starts some new trials in the system. Should these tests be unsuccessful as well, she starts searching in the Internet. She uses well-known developer pages or search engines to find relevant information. Again, she experiments with new solution ideas directly in the system and applies her search and test approach for a longer period of time. Typically, she is successful after a longer period of time and returns to her works tasks. In the case of no success, she writes a request in a developer forum or tries to delegate the task to a colleague (typically sitting in the same room) via e-mail. After getting a response in the developer forum, she occasionally writes a short thanks note to the anonymous or pseudonymous provider of the information the identity of whom she does not care about.

reaction to requests from colleagues	If one of her colleagues asks her for something directly, she answers if she has a proper solution. In the best case from her perspective, she can show solutions directly on the affected systems. Therefore, she moves to the colleague's computer and performs the solution. In this way, she avoids long explanations and discussions with asking colleagues. In the case she has only an assumption or a vague idea, Sally refuses the answer.
communication strategy / approach to knowledge sharing	Sally principally dislikes discussions or other verbal interactions with her colleagues. If a discussion occurs in her office, she ignores it and concentrates on her current tasks. She likes clear task descriptions and therefore, writes tight e-mails that make the receiver understand if her/his request was imprecise.
formal training	Between two and four times a year, Sally has to participate in formal trainings. Welcome are trainings closely related to her current or upcoming tasks with concrete solution procedures. She avoids general trainings or trainings without relation to her tasks whenever possible.
important tools	Office Software, PIM, software development environment.
motivation / drives / interests	Sally likes her work, especially finding solutions to given problems. Furthermore she has no career ambitions.
task management	Sally likes the time early in the morning and during lunch, because she can work unhurriedly. Routinely, tasks are distributed in the company per email or task assignments in the collaboration system. Sally's project or line manager or sometimes consultants delegate tasks to her. If some parts of her tasks remain unclear, she thinks about it and investigates the problem by browsing through related documents. Every morning, she plans her day by creating a paper- based to-do-list for herself. She hates to deviate from her plan, hence she dislikes ad-hoc tasks.
attitude towards technology	As a developer, Sally is interested in the functioning and further development of technology and has profound knowledge of this area.

A.3 Derived Services from Persona characteristics

Name	Igor	Services
Role / Degree of standardization	no standardized procedures, informal spontaneous work	
Workplace colleagues	distributed work in different teams and offices	Shared organizational and personal resources access service
		Context specific topic filter and access views
task management	milestone definitions	Individual (formal and informal) task management
Learning	Context specific search, client routines	Resource Search Service
		Client related information databases, information and resources gathering service
		Context specific topic filter and access views
Knowledge	Collect experiences & best practices, Knowledge about other people	Private and Shared FAQ Service
		Collaborative experience management tool
		Experience Reflection Service
		User Directory Service
		People and Expertise Search Service
		People Tagging Service
Formal Training	people overview and contact details	Social Network Activities Awareness Service
Content Types	linkage between used tools to improve efficiency, presentations, documents, visualizations	Graphic service
		Shared organizational and personal resources access service
		Inter-tool communication service
Structures	Hierarchy-based on topics and projects, no flat-tag; pattern based structures; someone else gardener; tagging only for pictures	Structure creation and management service
		Resource Tagging and Annotation Service
Reaction to requests from colleagues	knowing network nodes; being contact person	Personal information social network service
		Communication Service
Communication Strategy/ Approach to Knowledge Sharing	maintaining relationships, exchange contact information; needs to know about ongoing activities; being constantly well informed	Topic related people activity awareness service
		Dissemination Service
Important Tools	office, PIM, IM, SN, mind mapping	
Problem Solving and other knowledge routines	ask people, discussions on demand, internet search	Question and Answer Service
		Communication Service
		Resource Search Service
Motivation / drives/ interests	mobile services	
Attitude towards technology	technique affine	

Name	Sally	Services
Role / Degree of standardization	precise task descriptions and documentations	Task Management Service
Workplace colleagues	always same place, same colleagues	Organizational resources access service
task management	best, if not disturbed; task assignment per email or collaboration system; unclear stuff and remaining questions investigated in documents, paper based to-do list; dislikes ad-hoc tasks	Task Management Service Resource Search Service Individual (formal and informal) task management
Learning	learning during execution of work tasks	
Knowledge	knowledge about systems, definitions and client decisions	Visual decisions graph service Topic related people activity awareness service
Formal Training	likes task related trainings	Training Recommendation Service
Content Types	training materials on local disk; maintains collections of documentation, personal notes, emails, business proposals	Resource Search Service
Structures	topic based hierarchical structure	Structure creation and management service
Reaction to requests from colleagues	shows solutions directly, avoids discussions	Remote (active) training and presentation service
Communication Strategy/ Approach to Knowledge Sharing	does not like discussions; likes clear task descriptions and requests that	Pattern Management Service
Important Tools	Office, PIM, IDE	
Problem Solving and other knowledge routines	try out, locally stored system help/ manual, internet search/developer forums; task delegation via mail to colleague or asking in forums	Topic or context dependent information and resources gathering and aggregation service
Motivation / drives/ interests	-	Motivation Service
Attitude towards technology	technique affine	

Name	Aisha	Services
Role / Degree of standardization	leads several people maintaining software according to SLA; heavily involved in software management; network centre for specific software aspects; formal agreements important; formal approval for each change important	Service Level Agreement Management Project-status awareness service Process Management Service
Workplace colleagues	four team members in her office	
task management	needs to manage many appointments and deadlines, creates formal documents or messages for each content or message she receives	Task Management Service Pattern Management Service Process Management Service
Learning	formal trainings; informal learning by reading articles about upcoming products; reads company's process documentation; exchanges experiences with fellow team leaders	Training Recommendation Service Resource Recommendation Service Process Management Service Process and Task Management Recommendation Service Communication Service
Knowledge	reads product documentation; reads meeting minutes of team members to know about their projects; needs knowledge about management, leadership & processes	Resource Recommendation Service Process and Task Management Recommendation Service
Formal Training	internal management program, training courses by vendor of ES	
Content Types	nothing special	Organizational resources access service
Structures	organizationally prescribed resource structure, available to all	
Reaction to requests from colleagues	tries to provide a pointer to formal content, updates formal documents in employee portal, spec. quality management space,	Resource Recommendation Service
Communication Strategy/ Approach to Knowledge Sharing	short mails and phone calls, network is topic-oriented incl. consultants, developers, managers, customers	Social network visualization
Important Tools	PIM, DMS, CMS, Office, IDE	
Problem Solving and other knowledge routines	searches organizational database, searches developer fora, contacts a known expert,	Resource Search Service People and Expertise Search Service
Motivation / drives/ interests	experiments with new products, applied for international management program	Topic related keeping-up-to-date service Social Network Activities Awareness Service
Attitude towards technology	-	

Name	Carolina	Services
Role / Degree of standardization	content provider, no standardized tasks within job, only administrative	Resource Recommendation Service
Workplace colleagues	typically with 2 or 3 in a small office	
task management	with outlook and calendar; task priorities might change depending on context and current needs	Individual (formal and informal) task management
Learning	continuously acquires new knowledge depending on the clients, has internal procedure to learn new topics	Resource Recommendation Service Client related information databases, information and resources gathering service
Knowledge	depends on information (system) available at client side; based on experience; knowledge about market and business environment highly relevant	Client related information databases, information and resources gathering service Specific information database services
Formal Training	-	
Content Types	academic articles, news, client‘s knowledge, PIM, email, presentations	
Structures	hierarchies based on sources, topics, and projects; team uses project-based folder with standardized format	Structure and hierarchy recommendation service
Reaction to requests from colleagues	likes to ask colleagues when she needs help	Communication Service Question and Answer Service
Communication Strategy/ Approach to Knowledge Sharing	barriers exist sharing client information through IT restrictions	Topic related resource awareness service
Important Tools	Office, email, instant messaging	
Problem Solving and other knowledge routines	multiple steps of refining an approach; initially based on content the refined in discussions	Resource Tagging and Annotation Service
Motivation / drives/ interests	motivation highly job-oriented	Training Recommendation Service
Attitude towards technology	-	

Name	Raquel	Services
Role / Degree of standardization	gets un-structured content from colleague	
Workplace colleagues	works together with colleagues in different teams	
task management	online calendar she shares with other colleagues; adapts continuously task priorities depending on results of previous tasks or perceived importance	Individual (formal and informal) task management
Learning	new knowledge related to technology and pedagogy applied to online and new technologies; tests new tools	Topic related keeping-up-to-date service
Knowledge	technology-oriented knowledge; methodologies for online courses	Pedagogy recommendation service
Formal Training	short courses on different technologies like flash	Training Recommendation Service Entity assessment service
Content Types	-	
Structures	hierarchies based on sources, topics, and projects; team uses project-based folder with standardized format	Structure and hierarchy recommendation service
Reaction to requests from colleagues	likes to ask colleagues when she needs help	Communication Service Question and Answer Service
Communication Strategy/ Approach to Knowledge Sharing	barriers exist sharing client information through IT restrictions	Topic related resource awareness service
Important Tools	office, email, instant messaging, media editors	
Problem Solving and other knowledge routines	creates story boards	Process Management Service Story Board Management Service
Motivation / drives/ interests	searches for tools and different approaches to produce content faster	Collaborative experience management tool
Attitude towards technology	technology affine	

Name	Thomas	Services
Role / Degree of standardization	responsible for 15 project leader and their projects; generates new project ideas; administrative processes	Idea management service
Workplace colleagues	often meetings in meeting room; discusses projects with project leaders ; new projects ideas with project managers	Project-status awareness service Topic related resource awareness service Protocol management service
task management	calendars, emails, paper based	
Learning	informal discussions, internal documents about projects and organizations, internal portal, newsletters, books, magazines, blogs, forums	Topic related resource awareness service
Knowledge	existing products, technological developments and visions and market trends; knowledge about organization helps to find appropriate people for new projects	Resource Recommendation Service Idea management service People and Expertise Search Service Social network visualization
Formal Training	internal education programs	Training Recommendation Service
Content Types	PIM, paper based notes, visualizations, mobile support	Graphic service
Structures	excel spreadsheets for overview over projects and projects-leaders; emails indicate tasks and are archived after completion, public file system with defined structure	Project Management Service Project-status awareness service Structure creation and management service
Reaction to requests from colleagues	helps other people, knows people who can help	People and Expertise Search Service Private and Shared FAQ Service Communication Service
Communication Strategy/ Approach to Knowledge Sharing	knowledge about colleagues and other people is highly relevant, maintains relationships in social networks	People Tagging Service People and Expertise Search Service Social network visualization
Important Tools	office, excel, PIM, SN software, blogs	Knowledge reflection and externalization service
Problem Solving and other knowledge routines	contact project leader, discussion; external experts	Expert Recommendation Service
Motivation / drives/ interests	-	
Attitude towards technology	positively, tries out often new technologies	Topic related keeping-up-to-date service

Name	Kurt	Services
Role / Degree of standardization	team leader of 7 persons, only administrative tasks standardized	
Workplace colleagues	often meetings, discuses projects, except from that he works alone	Project-status awareness service
task management	using oneNote and Outlook	Individual (formal and informal) task management
Learning	workshops, conferences, informally, magazines, internet	Topic related keeping-up-to-date service Event recommendation service Topic or context dependent information and resources gathering and aggregation service
Knowledge	existing products, technological developments, client and market trends	Topic related keeping-up-to-date service
Formal Training	-	
Content Types	PIM, slides	
Structures	hierarchies based on topics and projects; standardized per project	Structure and hierarchy recommendation service Pattern Management Service
Reaction to requests from colleagues	proposes persons to contact	People and Expertise Search Service
Communication Strategy/ Approach to Knowledge Sharing	maintains relations to other people intensively, tries create new nodes	Social Network Activities Awareness Service
Important Tools	office, PIM, IM, mind mapping	
Problem Solving and other knowledge routines	meetings, email, external partners	Private and Shared FAQ Service People and Expertise Search Service
Motivation / drives/ interests	cultivating a creative space	Idea management service
Attitude towards technology	very critical	

Name	Silke	Services
Role / Degree of standardization	responsible for vocational training program	Process and Task Management Recommendation Service
		Pedagogy recommendation service
Workplace colleagues	-	
task management	plans tasks in detail; prepares meetings wi	Individual (formal and informal) task management
		Protocol management service
		Topic related resource awareness service
Learning	continuously improving work practice, reflects about tasks, updates templates and processes, discusses about experiences	Task Management Service
		Personal notes service
		Experience Reflection Service
		Communication Service
Knowledge	needs to be up-to-date re practices in her field;	Pedagogy recommendation service
		Topic related keeping-up-to-date service
Formal Training	typically quite new stuff is chosen	Learning Path Reflection Service
		Training Recommendation Service
Content Types	much paper based, email office, web, videos	
Structures	subject and chronologically based; needs shared structures to avoid work already done; needs a common structure	Structure and hierarchy recommendation service
		Shared organizational and personal resources access service
Reaction to requests from colleagues	reflects who is best person for request	People and Expertise Search Service
Communication Strategy/ Approach to Knowledge Sharing	likes to know what others do; wants to learn from them	People activity awareness service
		People and Expertise Search Service
Important Tools	paper, office, PIM, browser, handheld	
Problem Solving and other knowledge routines	tries to solve problems on their own	People and Expertise Search Service
Motivation / drives/ interests	self-reflects, tries to make sense of new trends	Topic or context dependent information and resources gathering and aggregation service
Attitude towards technology	not very technique; not very interested	

Name	Otto	Services
Role / Degree of standardization	specialization in certain domains	Topic related keeping-up-to-date service
Workplace colleagues	-	
task management	outlook, paper based, spontaneous, responsible for training planning	Individual (formal and informal) task management
		Training Recommendation Service
Learning	informal, try & error	Collaborative experience management tool
Knowledge	needs up-to-date knowledge from social network (internal & external); needs to stay up-to-date about his field he trains in	Social Network Activities Awareness Service
		Topic related keeping-up-to-date service
Formal Training	sometime he attends some	Training Recommendation Service
Content Types	email, paper, web-resources; journals, magazines	Topic or context dependent information and resources gathering and aggregation service
Structures	no clear structure/strategy	Structure and hierarchy recommendation service
		Resource Search Service
		Resource Tagging and Annotation Service
Reaction to requests from colleagues	expects pro-active behavior; does not like repeating the same questions	Private and Shared FAQ Service
Communication Strategy/ Approach to Knowledge Sharing	informal, F2F, communicative	Communication Service
		Topic related keeping-up-to-date service
Important Tools	paper, internet, PIM, office	
Problem Solving and other knowledge routines	personal contact, talks arbitrarily to persons about	People and Expertise Search Service
Motivation / drives/ interests	-	
Attitude towards technology	not very familiar	Specific information database services

Name	Axel	Services
Role / Degree of standardization	not standardized, not linear working	Individual (formal and informal) task management
Workplace colleagues	one colleague in a small office	
task management	project plan, not externalized	Project Management Service Task Management Service
Learning	invests much time for information seeking; informal; needs knowledge about PC techniques	Topic or context dependent information and resources gathering and aggregation service Resource Recommendation Service
Knowledge	about how to use social software, internal software	Collaborative experience management tool
Formal Training	continuously participates on formal trainings	Training Recommendation Service
Content Types	email, blogs, social networking, wikis	
Structures	no specific	
Reaction to requests from colleagues	refers to company wiki, searches himself or delegates to someone else	People and Expertise Search Service
Communication Strategy/ Approach to Knowledge Sharing	discusses a lot, policy for avoiding disturbance	Protocol management service
Important Tools	PIM, IM, SN	
Problem Solving and other knowledge routines	personal contact, web search, develops wiki entries as result of problem solving	Communication Service People and Expertise Search Service Collaborative experience management tool
Motivation / drives/ interests	wants to establish himself in web community	Social Network Activities Awareness Service
Attitude towards technology	very IT-affine	

Name	Heather	Services
Role / Degree of standardization	no given standards, she creates those for others	Task Management Service
		Process and Task Management Recommendation Service
Workplace colleagues	alone, but sometimes needs help for her tasks	People Tagging Service
		People and Expertise Search Service
task management	paper based, simple list based, but annotates finished tasks	Task Management Service
		Task annotation service
Learning	logistical stuff, customer‘s interests, needs, and desires	Collaborative experience management tool
		Client related information databases, information and resources gathering service
Knowledge	logistical knowledge	Collaborative experience management tool
Formal Training	-	
Content Types	emails, questionnaires, wiki, calendar	Event Planning Process Management Service
		Project-status awareness service
Structures	folder structure after events, wiki pages structured according to her tasks	Structure and hierarchy recommendation service
Reaction to requests from colleagues	cooperative, discusses, delegates to resources or people	People and Expertise Search Service
Communication Strategy/ Approach to Knowledge Sharing	maintains big social network, tags people, likes to refer to former topics when starting talks with people	People and Expertise Search Service
		People Tagging Service
		Social Network Activities Awareness Service
Important Tools	office, PIM, IM, SN, wiki,	
Problem Solving and other knowledge routines	personal contact and discussion, internal knowledge base, changes documentation after solving a problem	Communication Service
		Resource Search Service
		Topic related resource awareness service
Motivation / drives/ interests	also organizes events in her free-time	Collaborative experience management tool
		Process Management Service
Attitude towards technology	affine to software usage	Topic related keeping-up-to-date service

Name	Kevin	Services
Role / Degree of standardization	is working on a SIX Sigma project, which is standardized	Project Management Service
Workplace colleagues	office with 2 other people with completely different parts	
task management	tasks structured by the SIX Sigma process	
Learning	learning project relevant stuff	Resource Search Service Topic related resource awareness service
Knowledge	project related knowledge from formal training	
Formal Training	takes part in trainings about project proceedings and documentation	Context specific topic filter and access views Personal notes service
Content Types	wiki, email, IM	
Structures	no specific	
Reaction to requests from colleagues	-	
Communication Strategy/ Approach to Knowledge Sharing	participates in discussions that concern problems with certain tools	Specific information database services
Important Tools	office, PIM, IM, wiki	
Problem Solving and other knowledge routines	does not necessarily remember certain problem solving and asks again; needs good and formal task description; no improvements of processes	Specific information database services People and Expertise Search Service
Motivation / drives/ interests	project oriented	
Attitude towards technology	not very affine	

Name	Stella	Services
Role / Degree of standardization	standardized tasks, hardly own decisions to be taken	Task Management Service
Workplace colleagues	office with three colleagues	
task management	monthly recurring tasks; SIX Sigma	Topic or context dependent information and resources gathering and aggregation service
Learning	informal, depending on tasks	
Knowledge	un-experienced, needs new knowledge for each new task	Collaborative experience management tool
Formal Training	for SIX Sigma	
Content Types	email, IM, wiki, calendar, presentations	Resource Search Service
Structures	folders sorted by tasks and persons	
Reaction to requests from colleagues	delegates questions to other people	People and Expertise Search Service
Communication Strategy/ Approach to Knowledge Sharing	direct requests, needs to know skills of people	People Tagging Service
Important Tools	office, IM, SN, wiki, PIM	
Problem Solving and other knowledge routines	direct contact, IM	People and Expertise Search Service Communication Service
Motivation / drives/ interests	-	
Attitude towards technology	not affine	

Name	Deborah	Services
Role / Degree of standardization	informal	Collaborative experience management tool Topic related experience awareness service
Workplace colleagues	main office, frequent travels	
task management	has a lot of different tasks	Individual (formal and informal) task management
Learning	informal	Topic or context dependent information and resources gathering and aggregation service
Knowledge	new IT developments	Topic or context dependent information and resources gathering and aggregation service Private and Shared FAQ Service Collaborative experience management tool
Formal Training	-	
Content Types	office, internet, email, PIM	
Structures	-	
Reaction to requests from colleagues	-	
Communication Strategy/ Approach to Knowledge Sharing	-	
Important Tools	office, email, resource, MIS, SN	
Problem Solving and other knowledge routines	good overview	Collaborative experience management tool Artefact-Actor services
Motivation / drives/ interests	IT	
Attitude towards technology	IT affine	Topic or context dependent information and resources gathering and aggregation service

Name	Harry	Services
Role / Degree of standardization	manager, has to report to organization and government	Pattern Management Service
Workplace colleagues	leads a team	People Tagging Service
task management	calendar	Individual (formal and informal) task management
Learning	how to find tender	Topic or context dependent information and resources gathering and aggregation service
Knowledge	specific targets, possible applications and their concrete aims	Collaborative experience management tool
Formal Training	-	
Content Types	office, presentations, email, web resources	
Structures	specific implemented structures	Process and Task Management Recommendation Service Project-status awareness service
Reaction to requests from colleagues	-	
Communication Strategy/ Approach to Knowledge Sharing	does not share his knowledge	Collaborative experience management tool
Important Tools	office, email, MIS, browser, SN	
Problem Solving and other knowledge routines	alone	Private and Shared FAQ Service
Motivation / drives/ interests	seeking out further opportunities for funding	Topic related keeping-up-to-date service
Attitude towards technology	normal user	

Name	Becky	Services
Role / Degree of standardization	informal	
Workplace colleagues	in school, local office, administrative central	Shared organizational and personal resources access service Virtual Desktop Service
task management	paper-based, mainly appointments	Schedule Optimization Service
Learning	LMI continuously, contacts organizations	LMI provision service User Directory Service People and Expertise Search Service People Tagging Service Topic related keeping-up-to-date service
Knowledge	LMI	
Formal Training	yes	
Content Types	office, browser, email, PIM, MIS	
Structures	paper-based	
Reaction to requests from colleagues	unspecific	Shared organizational and personal resources access service LMI development, sharing and presentation service
Communication Strategy/ Approach to Knowledge Sharing	email, social network at work	Private and Shared FAQ Service Collaborative experience management tool
Important Tools	office, browser, email, PIM, MIS	
Problem Solving and other knowledge routines	disseminates collected information	Shared organizational and personal resources access service Dissemination Service
Motivation / drives/ interests	keen on expanding her knowledge of local employers and opportunities	Topic or context dependent information and resources gathering and aggregation service Topic related keeping-up-to-date service
Attitude towards technology	normal user, especially important for communication	Communication Service

Name	Gina	Services
Role / Degree of standardization	informal	
Workplace colleagues	works in schools and office	
task management	paper-based, mainly appointments	Schedule Optimization Service
Learning	informal processes, volunteering to pilot initiatives	
Knowledge	LMI, coach	Topic or context dependent information and resources gathering and aggregation service Feedback service
Formal Training	-	
Content Types	office, email, web-resources, organizational database, paper based	Entity assessment service
Structures	mixture of given, informal and hard copy	
Reaction to requests from colleagues	-	
Communication Strategy/ Approach to Knowledge Sharing	meetings for keeping up-to-date, kept within specific teams but not organization-wide	Topic related keeping-up-to-date service Dissemination Service
Important Tools	office, email, browser, MIS, paper based, SN	
Problem Solving and other knowledge routines	information is not shared	Shared organizational and personal resources access service Topic related keeping-up-to-date service
Motivation / drives/ interests	-	
Attitude towards technology	PC affine, gets too many emails	Shared organizational and personal resources access service

Name	Colin	Services
Role / Degree of standardization	specialist in LMI	
Workplace colleagues	works in a small team	
task management	regular tasks and developmental tasks	Individual (formal and informal) task management
Learning	informally	
Knowledge	national, regional and local LMI	Data visualization service
		Statistical Data Processor Service
		Entity assessment service
Formal Training	-	
Content Types	statistical data	Statistical Data Processor Service
		Data visualization service
Structures	-	
Reaction to requests from colleagues	likes applying knowledge in practice	Private and Shared FAQ Service
Communication Strategy/ Approach to Knowledge Sharing	sees potential in sharing his knowledge and combining it with softer knowledge of PAs	Dissemination Service
		Knowledge reflection and externalization service
		Resource Ontology Service
Important Tools	office, email, browser, statistic software, MIS, surveys	
Problem Solving and other knowledge routines	linking information to available and old vacancies, IT systems not used	Client related information databases, information and resources gathering service
		Information source recommendation service
Motivation / drives/ interests	keen on developing resources for colleagues; sees potential for linking different kind of information	Topic related resource awareness service
		Resource Ontology Service
Attitude towards technology	user	

Name	Fiona	Services
Role / Degree of standardization	share and disseminate information on website, likes routines	Individual (formal and informal) task management
Workplace colleagues	has one colleague, working in office	
task management	paper-based	Individual (formal and informal) task management
Learning	researches what materials similar organizations are producing	Client related information databases, information and resources gathering service
		Topic related keeping-up-to-date service
Knowledge	organizational services offered, same for projects, initiatives; about output/ outcome statistics and requirements; must be up-to-date	Topic related keeping-up-to-date service
		Topic related resource awareness service
		General keeping-up-to-date service
Formal Training	on IT systems	
Content Types	office, email, PIM, paper-based	
Structures	-	
Reaction to requests from colleagues	-	Topic related keeping-up-to-date service
		Dissemination Service
Communication Strategy/ Approach to Knowledge Sharing	web page development for young people and PAs, need for shared information	Dissemination Service
		Shared organizational and personal resources access service
Important Tools	office, email, DTP	
Problem Solving and other knowledge routines	paper-based and web publishing	Resource Tagging and Annotation Service
		Dissemination Service
Motivation / drives/ interests	-	
Attitude towards technology	not affine, does not rely on email communication	

Name	Andrew	Services
Role / Degree of standardization	informal	
Workplace colleagues	works in school, open office	Shared organizational and personal resources access service
task management	electronic diary	Individual (formal and informal) task management
Learning	internet search about LMI	Resource Search Service
Knowledge	LMI, asked colleagues for relevant information	Experience Reflection Service
		Topic related keeping-up-to-date service
		Topic or context dependent information and resources gathering and aggregation service
Formal Training	-	
Content Types	office, email, web-resources, MIS	
Structures	clients information stored centrally in national MIS; local intranet available	Structure extraction service
		Resource Recommendation Service
Reaction to requests from colleagues	email	Private and Shared FAQ Service
Communication Strategy/ Approach to Knowledge Sharing	shared as part of development process for product or training	Process Management Service
		Pattern Management Service
Important Tools	office, browser, email, MIS	
Problem Solving and other knowledge routines	informal via web, email reading,	Topic or context dependent information and resources gathering and aggregation service
		Collaborative experience management tool
		organizations‘ employments opportunities collection service
		automatic LMI data analysis service
		Data visualization service
Motivation / drives/ interests	-	
Attitude towards technology	IT affine, email central to networking	Collaborative social networking service
		People Tagging Service
		Skill Matching Service

Name	Edward	Services
Role / Degree of standardization	implements a new IT system, informal	Process Reflection Service
Workplace colleagues	8 people, one office	
task management	email, laptop for minutes and actions, reactive	Protocol management service Individual (formal and informal) task management
Learning	informal	
Knowledge	about web-site systems and IT implementation in general	
Formal Training	company internal IT systems	
Content Types	office, email, web-resources, SN	
Structures	personally organized; works on a laptop	Shared organizational and personal resources access service
Reaction to requests from colleagues	answers to requests were not formally recorded; team meetings	Private and Shared FAQ Service Protocol management service Protocol reflection service
Communication Strategy/ Approach to Knowledge Sharing	asks for emails, not phone calls; SN becomes interesting	Social Network Activities Awareness Service Communication Service
Important Tools	office, browser, email, SN	
Problem Solving and other knowledge routines	involved in design, implementation, piloting and roll-out of IT system	Process Management Service Process Reflection Service
Motivation / drives/ interests	IT systems and their implementation for gaining value added	Topic related keeping-up-to-date service
Attitude towards technology	IT affine	Communication Service

A.4 Mature Service Mapped to Set of Persona-derived Services

Table A.3: *Mapping of services derived in the project to those of the Persona analysis. This provides an overview over services which are already identified and new services. Service names and descriptions were taken from (Mature Consortium, 2010a) and (Mature Consortium, 2011a)*

Mature-Service	Description	Persona-derived service mapping
Search Service	Connects to other MATURE services via a collection of service interfaces and therefore searches for information of various databases.	Resource Search Service
		Information source recommendation service
Metadata Storage Service	Acts as a storage repository for general metadata information associated with knowledge objects stored in other services.	[new service]
Knowledge Base Service	Artefact / document management, versioning and storage of pure files, documents and artefacts, most of the metadata capabilities outsourced to the Metadata Storage Service.	Shared organisational and personal resources access service.
Pervasive Permissions Database	Ubiquitously accessible database with graduated access permissions for the entire system to ensure privacy and confidentiality.	[new service]
Access Moderator	Watchdog / guard service that acts as an intermediary between a user and other users' data, relying on the Permissions Database or (optionally/possibly) smart heuristics.	[new service]
Knowledge Aggregation Service	Dispatches a search query to several subordinate search services and databases, aggregating the results into an easily comprehensible document.	Resource Search Service
		Topic or context dependent information and resources gathering and aggregation service
Search Persistence Service	Provides saved searches / smart folder functionality.	[new service]

Personal Collection and Bookmarking Service	Keeps track of a user's personal stash of documents and links, forming a part of this user's PLME.	Shared organisational and personal resources access service
Introduction Service	Introduces two users previously unknown to each other but connected through their organisational or social network, using a safe and moderated approach.	[new service]
Community Directory	Maintains and aggregates data about a user's social environment, i.e. voluntarily formed friendships and connections in the system (compare to organisationally mandated associations).	Social Network Activities Awareness Service
Contact Data Service	Information service dealing exclusively with users' real-world contact data, providing graduated and privacy-conscious sharing of contact information.	User Directory Service
Expert Finder	Uses information gathered from various other services to find an available expert on a specified field or topic.	People and Expertise Search Service
Social Network Analysis Service	Processing and analysis of network structures and graphs to support the management and understanding of social networks by the system.	Social Network Activities Awareness Service
		Social network visualization
		[new service for analyzing SN data]
People Annotation Service	Metadata- and ontology-based annotation service specifically engineered for individual users (internal and external contacts).	People Tagging Service
Maturing Dialogue Service	Aids maturing of artefacts via tracking and structuring discussions about them comprehensively.	[new service]
MATURE-enabled Communication Services	Mature-enabled versions of common place web communication platforms (forums, blogs, messengers, ...)	Communication Service
		[new specific communication services]
Context Awareness Service	Userspace analysis to determine individual working contexts and problem sets for users in the system.	[missing work-context analysis service]
Change Awareness Service	Keeps track of changes happening in the system, integrating with the metatracking service, and notifies interested users via the Notification Service.	Topic related resource awareness service

Diff Service	Automatically determines what has changed between two versions of an artefact and tries to evaluate this change in the context of knowledge maturation.	[new service for determining differences in resources and whether they have matured]
Notification Service	Uses one or more of the communication methods available to the system to inform a user about events.	General keeping-up-to-date service
		[new service for notifying about arbitrary events[
Annotation Service	Metadata- and ontology-based service geared specifically towards annotation of knowledge artefacts.	Resource Tagging and Annotation Service
User Directory / Organisation Topology Service	Directory of 'full' users of the system, also providing support for the organisational structure MATURE is running in, optionally integrating with external services (LDAP, etc.).	User Directory Service
Organisational Entity and Workflow Directory	Directory of entities that are neither wholly personal or artefact-related, such as company activities or project groups.	Project-status awareness service
Ontology Service	Provides assistance with extending, grooming and navigating an ontology.	Structure creation and management service
Collaboration Mapper	Maps user interaction with a knowledge artefact over time and generates a collaboration profile.	Artefact-Actor services
Context-Independent Artefact Assistant Service	Aids knowledge workers with forming relations from an artefact to its context or making an artefact independent of its context, enabling transplantation of artefacts from one context to another.	[new service]
Media File Analysis and Extraction Service	Generates usable metadata from audio or video files so they can be better processed by other services.	[new service]
Automatic Metadata Translator	Translates on-the-fly between various standards of metadata description.	[new service]
Rating Service	Lets users rate and appraise artefacts, storing and aggregating these opinions in the metadata and making them available to everybody.	Entity assessment service
Competence Management and Assessment Service	Passively tracks user's interaction with the system and the valuation of their generated knowledge artefacts, creating a competence profile, distributed by topic, over time.	[new service]

Structure Gardening Service	Ties in with the Ontology Service to prune and extend topical structures.	Structure creation and management service
Profile Maintenance Service	Lets users manage a personal profile of themselves and helps with making it available to the public, graduated by access level.	Collaborative social networking service
MATURE-enabled Documentation Service	Repository for text-based documentation of knowledge work, itself Mature-enabled to enable reflection on processes.	Process Reflection Service Learning Path Reflection Service Experience Reflection Service
Network visualisation	This service provides a visualisation for the content of a Wiki. Each node in the graph represents either an article in the Wiki or a registered user. Edges represent the relation between two nodes. For example an article might have an assigned category, author, tag, or linked article. A user might have written one or more articles. A category might contain one or more sections, articles, tags, etc. Depending on the choice of the maximum shown path-length, users can define how many levels (and nodes) of the network are shown in the visualisation, as well as the type of the representing graph (e.g. hierarchically, cyclic). By clicking on a node in the graph, the visualisation is updated and nodes connected to the clicked one are shown, which enables users to browse easily through the content of the wiki within the graph. Additionally, new nodes (users or articles) can be created; articles corresponding to a certain node in the graph can be opened and edited in a new browser window; and users corresponding to nodes can be contacted by using the Collaboration Initiation Service.	Social network visualization
Documentation overview	Relating to a specific release of a product, the service gives an overview of all relevant documents that have been produced during the development process of the current release and displays them together with all links/relations that exist between individual items. This includes support for analysing the relative importance of different inputs, especially customer feedback.	Topic or context dependent information and resources gathering and aggregation service

Ontology overview	The service displays ontology elements, together with user details and descriptions and how they are related to others. It shows a list with web resources, other users have associated with an ontology element. Additionally, users can explore related discussions. If a user needs more information and wishes to start a new knowledge maturing dialogue, the service proposes potential dialogue partners.	[new service]
Information subscription service	The service provides a means for individuals to define their own profile of interests and thus subscribe to any new relevant information that may appear in the organisational knowledge base, including trainings.	Topic or context dependent information and resources gathering and aggregation service
Recent changes subscription service	retrieves an atom feed of recent changes about entities of the system (e.g. related to any annotated document/person, a specific concept, and a specific person)	Topic related keeping-up-to-date service
Assembly service	Provides relevant artefacts needed to fulfill a certain task. This can be supported by the rating of knowledge artefacts (see negotiation services).	Topic or context dependent information and resources gathering and aggregation service
Adaptive execution service	Flexibly adds or removes tasks depending on user behaviour. Tasks can be assigned not only to organisational members, but also to clients.	[new service]
Combination of modeled and ad hoc processes service	Users are enabled to add resources or subtasks to a workflow-generated task. These resources or subtasks may be generated by users themselves or retrieved from a repository that stores data on historical tasks executed previously by other users (see task-related process support below).	[new service(s)]
User behaviour evaluation service	Proposes adequate education, experience sharing, etc.	Recommendation services
Task-related process support	during the execution of a task, being it within a given workflow or in any other situation, provides information on previous related/similar tasks that other users have executed based on the work context of a user. This can happen on demand by the user or proactively.	[new service]
Community search service	For a user working on a certain case (or in a certain context), provides communities discussing similar cases or other employees with experience in similar cases/contexts.	Topic related experience awareness service Expert Recommendation Service

Metadataservice	Supports annotation of artefacts with metadata during process execution.	[new service]
Document annotation service	Provides an interface to collect and annotate documents with concepts from the community Wiki (categories and articles). For new terms, it automatically creates a new category or article within the Wiki.	Resource Tagging and Annotation Service
Wiki structure	The service visualises the structure of categories and relations in a semantic Wiki. The user can reorganise categories and relations via drag'n'drop. She/he can also rename them and delete and create new ones.	[new service]
Ontology structure	The service supports users with identifying candidates for cleansing of unused ontology elements or marking very similar elements.	Structure and hierarchy recommendation service [new service for recommending gardening activities]
Semi-Automatic process refinement service	At a later stage, the service also supports the transition between task patterns and process models. For instance, the combination of ad hoc tasks and modelled processes (see process support services above) can be exploited by observing which types of subtasks or resources users frequently add to a workflow-generated task. By providing aggregated information on user behaviour during workflow execution, the service supports the refinement of process models, frequently by adding subtasks pointing at amendments that need to be made to the process model.	[new service]
Competence management	supports the annotation of people with their skills.	People Tagging Service
Content delivery and feedback service	Helps users to push the artefacts that they have created towards those who need it.	Dissemination Service
Rating service	Supports users in rating the quality of artefacts in the context of a given case. Additionally a comment can be added which later on can also be discussed. The information source might be improved after having discussed it (see refinement service).	Entity assessment service

Collaboration Initiation	Offers the facility to initiate easy collaboration with authors of articles or interested persons via Skype without having to switch to another tool since it is embedded into a wiki and enables easier use. Users can send messages or web-links to wiki articles in order to support negotiation of and consolidation of artefacts. Additionally, within the visualisation of the wiki network, every user who is also an author in the wiki can be contacted by clicking on the node.	[new service]
Maturing dialogue service	Supports the negotiation of ontology changes (e.g. splitting a concept in two) via dialogue games. In order to structure their discussion, users choose from specific Moves and Openers with which they start their contributions. At the end, the involved users can make a voting about the proposed solutions. After reaching a decision, the service supports users in implementing the decision with change suggestions. The dialogue is saved and linked to the relevant ontology elements.	[new service]

A.5 Clustering Services According to Knowledge Maturing Activities

Table A.4: *Table shows the number of LME services mapped to each activity.*

Find relevant digital resources	Topic or context dependent information and resources gathering and aggregation service
	Context specific topic filter and access views
	Client related information databases, information and resources gathering service
	Specific information database services
	Information source recommendation service
	Resource Search Service
	Organisations‘ employments opportunities collection service
Embed information at individual or organisational level	Structure and hierarchy recommendation service
	Media File Analysis and Extraction Service
	Context-Independent Artefact Assistant Service

Keep up-to-date with organisation-related knowledge	Project-status awareness service
	People activity awareness service
	Topic related people activity awareness service
	Topic related keeping-up-to-date service
	General keeping-up-to-date service
	Topic related resource awareness service
	Social Network Activities Awareness Service
	Topic related experience awareness service
	Training Recommendation Service
	Resource Recommendation Service
	Event recommendation service
	Context Awareness Service
	Notification Service
Familiarise oneself with new information	Private and Shared FAQ Service
	Question and Answer Service
	Data visualization service
	Structure creation and management service
Reorganise information at individual or organisational level	Resource Ontology Service
	Structure extraction service
	Metadata Storage Service
	Metadataservice
	Automatic Metadata Translator
	Wiki structure service
	Ontology structure service
	Ontology overview service

Reflect on and refine work practices or processes	Service Level Agreement Management
	Process Management Service
	Event Planning Process Management Service
	Task Management Service
	Project Management Service
	Individual (formal and informal) task management
	Collaborative experience management tool
	Schedule Optimization Service
	Process and Task Management Recommendation Service
	Learning Path Reflection Service
	Experience Reflection Service
	Process Reflection Service
	Protocol reflection service
	Knowledge reflection and externalization service
	Semi-Automatic process refinement service
	Adaptive execution service
	Combination of modeled and ad hoc processes
	Task-related process support
Create and co-develop digital resources	Pattern Management Service
	Graphic service
	Collaborative social networking service
	Idea management service
	Protocol management service
	Personal notes service
	Story Board Management Service
	Pedagogy recommendation service
	Task annotation service
	Visual decisions graph service
Share and release digital resources	Shared organisational and personal resources access service
	Dissemination Service
	Organisational resources access service
	Resource Tagging and Annotation Service
	LMI provision service
	LMI development, sharing and presentation service
	Search Persistence Service

Restrict access and protect digital resources	Pervasive Permissions Database
	Access Moderator Service
Find people with particular knowledge or expertise	User Directory Service
	People Tagging Service
	Personal information social network service
	Expert Recommendation Service
	People and Expertise Search Service
	Skill Matching Service
	Artefact-Actor services
	Social network visualization
	Social Network Analysis Service
	Competence Management and Assessment Service
Communicate with people	Communication Service
	Remote (active) training and presentation service
	Maturing dialogue service
	MATURE-enabled Communication Services
	Collaboration Initiation
Assess, verify and rate information	Entity assessment service
	Feedback service
	Statistical Data Processor Service
	automatic LMI data analysis service
not mapped	Motivation Service
	Virtual Desktop Service
	Inter-tool communication service
	Introduction Service

Appendix B

Case Study I: Career Guidance

B.1 Discussion Questions & Interview Guideline

The 18 questions guiding the final feedback discussions were:

1. Give one example of how you have used the demonstrator.
2. How was this different from the way you would have completed this task without the support of the demonstrator?
3. Do you think that the demonstrator has helped you to think more creatively about:
   (a) How LMI could be used?
   (b) How LMI could be integrated more into IAG sessions?
4. Thinking about the 'search' tool in the demonstrator, has this tool been useful or not?
5. Has using the 'search' tool in the demonstrator made it easier or harder to:
   (a) Locate LMI?
   (b) Identify new sources?
6. Thinking about creating and using 'collections' in the demonstrator, has this tool been useful or not? (Users were also asked to say more about their answer, for example did this relate to tagging/labelling of sources, organisation of sources, accessibility of sources, commitment to creating a collection).

7. Has the ‘collections’ tool made it harder or easier to:
   (a) Collect LMI?
   (b) Collate LMI?
   (c) Identify new LMI?
8. Have you created a collection with a colleague/s? (Users’ were asked to explain, for example, how was this discussed and agreed, what was it created for a joint project, interest etc.).
9. Have you shared your collections and/or subscribed to collections created by other colleagues? (Users were asked to explain whether this was with colleagues in the same office or different offices within the organisation).
10. Have you used or shared the collections with, for example, other colleagues, careers co-ordinators in schools or pupils/students? (Users were asked to give an example).
11. As a result of using the demonstrator, do you think that you have more awareness of what LMI your colleagues are interested in and/or researching?
12. Thinking about how you have used information from the ‘search’ and ‘collection’ tools to create information/pages in the wiki, how has the demonstrator helped you to develop LMI for different purposes, such as presentations, sessions with students, information/leaflets, or other purposes (please specify)?
13. Again thinking about the creation of information/pages in the wiki, have you been able to combine information from a range of sources from the ‘search’ and/or ‘collection’ tool and presented in different formats (i.e. created more information sheets, hand-outs, presentations etc.)?
14. Do you feel more confident in your ability to:
   (a) Identify new knowledge on the labour market?
   (b) Assess the quality or reliability of labour market information and sources?

15. Do you think that by using the demonstrator you have increased you knowledge of, for example, a particular topic, local labour market, educational courses and qualifications?

16. Do you feel more motivated to develop your understanding of LMI for IAG by engaging in information searching, collecting, collating and tagging?

17. Overall, do you think that the demonstrator has been successful in:

    (a) Supporting the collection and development of LMI for practice?

    (b) Increasing efficiency of researching the labour market?

    (c) Reducing individual effort in researching the labour market?

    (d) Retaining and developing organisational knowledge?

18. Are there are any further comments or remarks you would like to make about the MATURE demonstrator?

B.2 Questionnaire Knowledge Work Activities

Table B.1: *Questionnaire regarding usual knowledge work activities. Those marked red where not considered in the text as they were not deemed to be helpful for the purpose of this thesis.*

Please indicate for each of the following activities to which extent these are typical for your own work	Untypical	Rather untypical	Typical	Very typical
I search for colleagues to ask for help	☐	☐	☐	☐
I search on the internet for relevant information	☐	☐	☐	☐
I search on my own desktop for relevant information	☐	☐	☐	☐
I search in other resources for relevant information (paper based copies…)	☐	☐	☐	☐
I take individual notes that I revisit at later points in time	☐	☐	☐	☐
I store relevant results in collections on my desktop or laptop	☐	☐	☐	☐
I add keywords or tags to my digital resources in order to find them at a later date	☐	☐	☐	☐
I add keywords or tags to my paper-based resources in order to find them again at a later date	☐	☐	☐	☐
I make relevance judgements for digital documents in order to highlight the most interesting resources and find them at a later date	☐	☐	☐	☐
I make relevance judgements for paper-based resources in order to highlight the most interesting resources and find them at a later date	☐	☐	☐	☐
I maintain my private collections and continuously add materials	☐	☐	☐	☐
I discuss relevant resources with my colleagues	☐	☐	☐	☐
I share my private digital collections with colleagues	☐	☐	☐	☐
I share my private paper-based collections with colleagues	☐	☐	☐	☐
I share my private notes with colleagues	☐	☐	☐	☐
My colleagues and I have a common taxonomy/ classification for tagging (or labelling) resources	☐	☐	☐	☐
My colleagues and I maintain common digital collections of information materials	☐	☐	☐	☐

Table B.2: *Overview over current practices of knowledge work. Those marked red where not considered in the text as they were not deemed to be helpful for the purpose of this thesis.*

Item	N	Un-typical	Rather un-typical	Typical	Very typical	M	Median	s
I search for colleagues to ask for help	7	0	2	3	2	3.00	3.0	0.816
I search on the internet for relevant information	7	0	0	0	7	4.00	4.0	0.000
I search on my own desktop for relevant information	6	0	1	2	3	3.33	3.5	0.816
I search in other resources for relevant information (paper based copies. . .)	7	0	0	4	3	3.43	3.0	0.535
I take individual notes that I revisit at later points in time	7	0	1	2	4	3.43	4.0	0.787
I store relevant results in collections on my desktop or laptop	7	1	0	3	3	3.14	3.0	1.069
I add keywords or tags to my digital resources in order to find them at a later date	7	0	4	3	0	2.43	2.0	0.535
I add keywords or tags to my paper-based resources in order to find them again at a later date	7	2	2	3	0	2.14	2.0	0.900
I make relevance judgements for digital documents in order to highlight the most interesting resources and find them at a later date	7	1	2	3	1	2.57	3.0	.976
I make relevance judgements for paper-based resources in order to highlight the most interesting resources and find them at a later date	7	0	3	3	1	2.71	3.0	0.756

I maintain my private collections and continuously add materials	7	1	1	4	1	2.71	3.0	0.951
I discuss relevant resources with my colleagues	7	0	1	3	3	3.29	3.0	0.756
I share my private digital collections with colleagues	7	2	0	5	0	2.43	3.00	0.976
I share my private paper-based collections with colleagues	7	1	2	3	1	2.57	3.0	0.976
I share my private notes with colleagues	7	2	3	2	0	2.00	2.0	0.816
My colleagues and I have a common taxonomy/classification for tagging (or labelling) resources	7	2	4	1	0	1.86	2.0	0.690
My colleagues and I maintain common digital collections of information materials	7	1	3	2	1	2.43	2.0	0.976

B.3 Needed Improvement of Knowledge Work

Table B.3: *Questionnaire regarding the perceived need for improvement of usual knowledge work activities.*

Please indicate for each of these activities whether they work well at the moment or whether the facilities (such as IT, paper-based materials etc.) that support these activities need changing or improving.

	Not crucial for my work	Works well	Needs some improvement	Needs a lot of improvement
Searching for colleagues to ask for help	☐	☐	☐	☐
Searching on the internet for relevant information	☐	☐	☐	☐
Searching on my own desktop for relevant information	☐	☐	☐	☐
Taking individual notes that I revisit at later points in time	☐	☐	☐	☐
Storing relevant results in collections on my desktop or laptop	☐	☐	☐	☐
Adding keywords or tags to my digital resources in order to find them at a later date	☐	☐	☐	☐
Making relevance judgements for digital documents in order to highlight the most interesting resources and find them at a later date	☐	☐	☐	☐
Maintaining private collections and continuously adding materials	☐	☐	☐	☐
Discussing with my colleagues about relevant resources	☐	☐	☐	☐
Sharing private digital collections with colleagues	☐	☐	☐	☐
Sharing my private notes with colleagues	☐	☐	☐	☐
Creating a common taxonomy/ classification for tagging (or labelling) resources	☐	☐	☐	☐
Maintaining common digital collections of information and materials with colleagues	☐	☐	☐	☐

B.4 Questionnaire Perceived Support of Knowledge Work Activities

Table B.4: *Questionnaire regarding the perceived support of knowledge work activities by SIMPLE.*

In the following, a couple of activities are described that are intended to be supported with the MATURE demonstrator tool.

Please indicate for each of these activities whether you think the demonstrator supports them well or whether improvements are needed.

	I don´t know	Supports the activity well	Needs some improvement	Needs a lot of improvement
Searching for colleagues to ask for help	☐	☐	☐	☐
Searching on the internet for relevant information	☐	☐	☐	☐
Searching on my own desktop for relevant information	☐	☐	☐	☐
Taking individual notes that I revisit later	☐	☐	☐	☐
Storing relevant results in the ‘collections’	☐	☐	☐	☐
Adding keywords or tags to my resources in order to find later	☐	☐	☐	☐
Maintaining private collections and continuously adding materials/resources	☐	☐	☐	☐
Discussing relevant resources with my colleagues	☐	☐	☐	☐
Sharing private digital collections with colleagues	☐	☐	☐	☐
Sharing my private notes with colleagues	☐	☐	☐	☐
Creating a common taxonomy/classification for tagging (or labelling) resources	☐	☐	☐	☐
Maintaining common digital collections of information and materials with colleagues	☐	☐	☐	☐

B.5 Usefulness and Ease of Use

Table B.5: *Questionnaire regarding the perceived usefulness of SIMPLE*

	Not useful at all	Somewhat useful	Very useful
Such Widget	☐	☐	☐
Collection Widget	☐	☐	☐
Tagging Widget	☐	☐	☐
Tag Cloud Widget	☐	☐	☐
Diskussions Widget	☐	☐	☐
Mature Fox (Browser Plug-in)	☐	☐	☐
Mature software as a whole	☐	☐	☐

Table B.6: *Questionnaire regarding the perceived ease of use of SIMPLE*

	No answer	Easy to use	Rather easy to use	Not easy to use at all
Such Widget	☐	☐	☐	☐
Collection Widget	☐	☐	☐	☐
Tagging Widget	☐	☐	☐	☐
Tag Cloud Widget	☐	☐	☐	☐
Diskussions Widget	☐	☐	☐	☐
Mature Fox (Browser Plug-in)	☐	☐	☐	☐
Mature software as a whole	☐	☐	☐	☐

Appendix C

Case Study II: E-Learning Provider

C.1 Demographic Data

Table C.1: *Demographic data of questionnaire participants.*

		Frequency	Percentage
Sex	Male	30	75
	Female	10	25
Age	<30	13	32,5
	30-39	23	57,5
	40-49	3	7,5
	50-59	1	2,5
		40	100 %

C.2 Questionnaire Knowledge Work Activities

Table C.2: *Questionnaire regarding usual knowledge work activities.*

Please indicate for each of the following activities to which extent these are typical for your own work

	Do not reply	Untypical	Rather untypical	Typical	Very typical
Searching on the internet for relevant information	☐	☐	☐	☐	☐
Storing relevant results in collections on my desktop or laptop	☐	☐	☐	☐	☐
Making relevance judgements for digital documents in order to highlight the most interesting resources and find them at a later date	☐	☐	☐	☐	☐
Maintaining private collections and continuously adding materials	☐	☐	☐	☐	☐
Discussing with my colleagues about relevant resources	☐	☐	☐	☐	☐
Sharing private digital collections with colleagues	☐	☐	☐	☐	☐
Sharing my private notes with colleagues	☐	☐	☐	☐	☐
Creating a common taxonomy/ classification for tagging (or labelling) resources	☐	☐	☐	☐	☐
Maintaining common digital collections of information and materials with colleagues	☐	☐	☐	☐	☐
Adding keywords or tags to my digital resources in order to find them at a later date	☐	☐	☐	☐	☐

C.3 Questionnaire Improvement of Knowledge Work Activities

Table C.3: *Questionnaire regarding the perceived need for improvement of usual knowledge work activities.*

In the following, a couple of activities are described that are intended to be supported with the MATURE demonstrator tool.
Please indicate for each of these activities whether you think the demonstrator supports them well or whether improvements are needed.

	Do not reply	Works well	Needs some improvement	Needs a lot of improvement	Not crucial for my work
Searching on the internet for relevant information	☐	☐	☐	☐	☐
Storing relevant results in collections on my desktop or laptop	☐	☐	☐	☐	☐
Making relevance judgements for digital documents in order to highlight the most interesting resources and find them at a later date	☐	☐	☐	☐	☐
Maintaining private collections and continuously adding materials	☐	☐	☐	☐	☐
Discussing with my colleagues about relevant resources	☐	☐	☐	☐	☐
Sharing private digital collections with colleagues	☐	☐	☐	☐	☐
Sharing my private notes with colleagues	☐	☐	☐	☐	☐
Creating a common taxonomy/ classification for tagging (or labelling) resources	☐	☐	☐	☐	☐
Maintaining common digital collections of information and materials with colleagues	☐	☐	☐	☐	☐
Adding keywords or tags to my digital resources in order to find them at a later date	☐	☐	☐	☐	☐

C.4 System Usability Scale

Table C.4: *The System Usability Scale questionnaire. Developed by (Brooke, 1996)*

		Strongly disagree				Strongly agree
1	I think that I would like to use this system frequently	1	2	3	4	5
2	I found the system unnecessarily complex	1	2	3	4	5
3	I thought the system was easy to use	1	2	3	4	5
4	I think that I would need the support of a technical person to be able to use this system	1	2	3	4	5
5	I found the various functions in this system were well integrated	1	2	3	4	5
6	I thought there was too much inconsistency in this system	1	2	3	4	5
7	I would imagine that most people would learn to use this system very quickly	1	2	3	4	5
8	I found the system very cumbersome to use	1	2	3	4	5
9	I felt very confident using the system	1	2	3	4	5
10	I needed to learn a lot of things before I could get going with this	1	2	3	4	5

Appendix D

Case Study III: University Seminar

D.1 Questionnaire Knowledge Work Activities

Table D.1: *English version of the questionnaire regarding usual knowledge work activities.*

	No reply	Very typical	Typical	Rather untypical	Untypical
Searching on the internet for relevant information	☐	☐	☐	☐	☐
Storing relevant results in collections on my desktop or laptop	☐	☐	☐	☐	☐
Adding keywords or tags to my digital resources in order to find them at a later date	☐	☐	☐	☐	☐
Making relevance judgements for digital documents in order to highlight the most interesting resources and find them at a later date	☐	☐	☐	☐	☐
Maintaining private collections and continuously adding materials	☐	☐	☐	☐	☐
Discussing with my fellow students about relevant resources	☐	☐	☐	☐	☐
Sharing private digital collections with fellow students	☐	☐	☐	☐	☐
Sharing my private notes with fellow students	☐	☐	☐	☐	☐
Creating a common taxonomy/ classification for tagging (or labelling) resources	☐	☐	☐	☐	☐
Maintaining common digital collections of information and materials with fellow students	☐	☐	☐	☐	☐

Table D.2: *German version of the questionnaire regarding usual knowledge work activities.*

	Keine Antwort	Sehr typisch	Typisch	Eher untypisch	Untypisch
Ich suche im Internet nach relevanten Informationen	☐	☐	☐	☐	☐
Ich speichere relevante Ergebnisse in Ordnern oder Sammlungen auf meinem Computer	☐	☐	☐	☐	☐
Ich füge Annotationen oder Tags zu meinen digitalen Ressourcen hinzu, um sie später wieder zu finden	☐	☐	☐	☐	☐
Ich bewerte digitale Dokumente ihrer Relevanz nach, um die Interessantesten hervorzuheben und zu einem späteren Zeitpunkt wieder zu finden	☐	☐	☐	☐	☐
Ich verwalte private Ressourcensammlungen und füge kontinuierlich Material hinzu.	☐	☐	☐	☐	☐
Ich diskutiere relevante Ressourcen mit meinen Kommilitonen	☐	☐	☐	☐	☐
Ich teile meine privaten digitalen Ressourcensammlungen mit Kommilitonen	☐	☐	☐	☐	☐
Ich teile private Notizen mit meinen Kommilitonen	☐	☐	☐	☐	☐
Meine Kommilitonen und ich führen eine gemeinsame Taxonomie bzw. Klassifikation zum Taggen oder Annotieren von Ressourcen	☐	☐	☐	☐	☐
Meine Kommilitonen und ich verwalten eine gemeinsame digitale Sammlung von Ressourcen	☐	☐	☐	☐	☐

D.2 Questionnaire Improvement of Knowledge Work Activities

Table D.3: *English version of the questionnaire regarding the perceived need for improvement of usual knowledge work activities.*

	No reply	Works well	Needs some improvement	Needs a lot of improvement
Searching on the internet for relevant information	☐	☐	☐	☐
Storing relevant results in collections on my desktop or laptop	☐	☐	☐	☐
Adding keywords or tags to my digital resources in order to find them at a later date	☐	☐	☐	☐
Making relevance judgements for digital documents in order to highlight the most interesting resources and find them at a later date	☐	☐	☐	☐
Maintaining private collections and continuously adding materials	☐	☐	☐	☐
Discussing with my colleagues about relevant resources	☐	☐	☐	☐
Sharing private digital collections with colleagues	☐	☐	☐	☐
Sharing my private notes with colleagues	☐	☐	☐	☐
Creating a common taxonomy/ classification for tagging (or labeling) resources	☐	☐	☐	☐
Maintaining common digital collections of information and materials with colleagues	☐	☐	☐	☐

Table D.4: *German version of the questionnaire regarding the perceived need for improvement of usual knowledge work activities.*

	Keine Antwort	Gute Unterstützung	Braucht etwas Verbesserung	Braucht sehr viel Verbesserung
Ich suche im Internet nach relevanten Informationen	☐	☐	☐	☐
Ich speichere relevante Ergebnisse in Ordnern oder Sammlungen auf meinem Computer	☐	☐	☐	☐
Ich füge Annotationen oder Tags zu meinen digitalen Ressourcen hinzu, um sie später wieder zu finden	☐	☐	☐	☐
Ich bewerte digitale Dokumente ihrer Relevanz nach, um die Interessantesten hervorzuheben und zu einem späteren Zeitpunkt wieder zu finden	☐	☐	☐	☐
Ich verwalte private Ressourcensammlungen und füge kontinuierlich Material hinzu.	☐	☐	☐	☐
Ich diskutiere relevante Ressourcen mit meinen Kommilitonen	☐	☐	☐	☐
Ich teile meine privaten digitalen Ressourcensammlungen mit Kommilitonen	☐	☐	☐	☐
Ich teile private Notizen mit meinen Kommilitonen	☐	☐	☐	☐
Meine Kommilitonen und ich führen eine gemeinsame Taxonomie bzw. Klassifikation zum Taggen oder Annotieren von Ressourcen	☐	☐	☐	☐
Meine Kommilitonen und ich verwalten eine gemeinsame digitale Sammlung von Ressourcen	☐	☐	☐	☐

D.3 Questionnaire Seminar Support

Table D.5: *English version of the questionnaire regarding the perceived support of typical seminar work activities by using SIMPLE*

	Not an application case	Applies	Rather applies	Does not apply
Tagging of the resources has helped to summarise and reflect the seminar discussions	☐	☐	☐	☐
The collaborative collection of resources has helped to gain a better impression of the respective topic	☐	☐	☐	☐
The discussion widget has helped to prepare the seminar discussion session	☐	☐	☐	☐
A collaborative text editor had helped for the preparation and the follow-up of the seminar session	☐	☐	☐	☐

Table D.6: *German version of the questionnaire regarding the perceived support of typical seminar work activities by using SIMPLE*

	Kein Anwendungsfall	Trifft zu	Trifft im Großen und Ganzen zu	Trifft nicht zu
Das Tagung der Materialien hat geholfen, die Seminardiskussionen leichter zusammenzufassen	☐	☐	☐	☐
Das kollaborative Sammeln von Materialien hat geholfen, einen besseren Überblick über das jeweilige Thema zu bekommen	☐	☐	☐	☐
Das Diskussionswidget war hilfreich, um sich in der Vor- und Nachbereitung der Stunden über die Materialien auszutauschen	☐	☐	☐	☐
Ein kollaboratives Schreibwerkzeug (bspw. Wiki) hätte mir zur Seminarvorbereitung und -nachbereitung weitergeholfen	☐	☐	☐	☐

D.4 Questionnaire Ease of Use

Table D.7: *English version of the questionnaire regarding the perceived ease of use of SIMPLE*

	No answer	Easy to use	Rather easy to use	Not easy to use at all
Such Widget				
Collection Widget				
Tagging Widget				
Tag Cloud Widget				
Diskussions Widget				
Mature Fox (Browser Plug-in)				
Mature software as a whole				

Table D.8: *German version of the questionnaire regarding the perceived ease of use of SIMPLE*

	Keine Antwort	Einfach zu benutzen	Im Großen und Ganzen Leicht zu benutzen	Nicht leicht zu benutzen
Such Widget				
Collection Widget				
Tagging Widget				
Tag Cloud Widget				
Diskussions Widget				
Mature Fox (Browser Plug-in)				
Mature Software im Ganzen betrachtet				

D.5 Interview Guideline

Support of Knowledge Maturing Activities For all questions applies: If yes, how specifically? If not, why not? What are your suggestions for improvement?

1. Does the software support you in finding relevant documents?
2. Does the software help you to collect resources and to provide them to your class/seminar group?
3. Do you think, the software has the potential that you keep up-to-date about relevant topics?
4. Does the software help you to get familiar with new information?
5. To which degree does the software support you in creating documents/artefacts in co-operation with fellow students/colleagues?
6. Is the software appropriate to release and share resource with others?
7. Does the software help you to find experts for a particular topic?
8. Does the software enable you to communicate with fellow students in order to discuss about certain topics?
9. Does the software support the assessment of resources to a sufficient extent?

Questions regarding the software concept, especially with respect to usability

1. Do you assess the Adobe AIR/desktop concept appropriate?
2. How do you assess the widget concept?
3. Do you judge the concept of self-composed work environments helpful/applicable against the background of your learn and working context?
4. The software allows to do some activities in different ways (e.g. tagging): Is that a blocker or rather a driver?
5. Which component is rather well or badly usable? For which components do you appreciate the usability, for which do you assess them as negative?
6. How do you assess the complexity of the overall tool? Do you have any comments regarding single widgets?

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