14

Schriften aus der Fakultät Wirtschaftsinformatik und Angewandte Informatik der Otto-Friedrich-Universität Bamberg

Information Management for Digital Learners

Introduction, Challenges, and Concepts of Personal Information Management for Individual Learners

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Band 14

University
of Bamberg
Press
2014

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von Stefanie Gooren-Sieber

University of Bamberg Press
2014

Bibliographische Information der Deutschen Nationalbibliothek
Die Deutsche Nationalbibliothek verzeichnet diese Publikation in der Deutschen Nationalbibliographie; detaillierte bibliographische Informationen sind im Internet über http://dnb.ddb.de/ abrufbar

Diese Arbeit hat der Fakultät Wirtschaftsinformatik und Angewandte Informatik der Otto-Friedrich-Universität als Dissertation vorgelegen.
1. Gutachter: Prof. Dr. Andreas Henrich
2. Gutachter: Prof. Dr. Ute Schmid
Tag der mündlichen Prüfung: 27.09.2013

Herstellung und Druck: docupoint, Magdeburg
Umschlaggestaltung: University of Bamberg Press, Andra Brandhofer

ISSN: 1867-7401
ISBN: 978-3-86309-206-1 (Druckausgabe)
eISBN: 978-3-86309-207-8 (Online-Ausgabe)
URN: urn:nbn:de:bvb:473-opus4-64705

Acknowledgements

“The journey is the reward!”

Chinese Proverb

My passion for teaching and learning led me on a journey that is about to come to an end. Altogether, this thesis presents the results of an interesting and informative journey that has helped me to grow on many different levels. However, I would never have been able to complete this work without the help of many hands. This is an attempt to express my gratitude to all those who supported me during this journey.

First and foremost, I would like to thank my doctoral advisor Prof. Dr. Andreas Henrich for providing me with the opportunity to take this journey and for his enduring guidance during the course of it. His openness and understanding were one of the most important supplies on my way. I also express my appreciation to Prof. Dr. Ute Schmid for furnishing a second opinion about my thesis and to Prof. Dr. Otto K. Ferstl who kindly agreed to join my thesis committee.

Being a member of the Media Informatics Group at the University of Bamberg provided me with a working environment characterised by fruitful collaborations. Accordingly I would like to thank all of my colleagues who have accompanied me on my way over the years; each of them has contributed to my journey and this thesis in his or her own unique way. Namely I would like to thank my companions Daniel Blank, Dr. Raiko Eckstein, Tobias Fries, Tobias Gradl, Adrian Hub, Dr. Volker Lüdecke, and Dr. Nadine Weber as well as the team members Silvia Förtsch, Siegfried Hofmann, and Daniela Pielenhofer.

This still leaves a number of valuable contributors unnamed. For that reason, I would additionally like to thank all those colleagues I was able to meet and talk to at international conferences and all those who helped take my mind off work at times during the most intense working periods.

Ultimately I would like to thank my family, especially my parents Thea and Michael, for encouraging me to take this journey, for never losing faith in me, and for their reliable support whenever I needed it. At the very end I want to express my sincere gratitude to my husband Achim who supported me in more ways than I can actually count, got never tired of gently but firmly pushing me towards the finish line, and always stood by my side through a very special first year of marriage.

Stefanie Gooren-Sieber

May 2013
Bamberg, Germany

Zusammenfassung

Der gegenwärtige Wandel unserer Gesellschaft zu einer digitalen Gesellschaft hat weitreichenden Einfluss auf alle Aspekte des menschlichen Lebens. Neue Technologien wie das Internet und mobile Geräte zur Nutzung dieser Technologien ermöglichen einen nahezu ungehinderten Zugriff auf Wissen in weltweiten Netzwerken. Dieser Fortschritt bringt einerseits einen großen Freiheitsgrad für Entscheidungen und Handlungen des Einzelnen, andererseits aber auch eine immer lauter werdende Forderung nach Strategien für einen adäquaten Umgang mit dieser Freiheit und der verfügbaren Menge an Informationen. Naturgemäß verändern dieser Fortschritt und die zugehörigen Technologien nicht nur unser Arbeitsleben und den privaten Alltag, sondern auch die Art und Weise zu lernen.

Diese Arbeit beschäftigt sich mit der Frage, wie Lernende diesen neuen Anforderungen gerecht werden und mithilfe von modernen Technologien in einem adäquaten Informationsmanagement unterstützt werden können. Die Besonderheit liegt dabei in einem ausschließlichen Fokus individuell Lernender, genauer gesagt jenen, die sich eigenständig auf individuellen Lernpfaden bewegen. Zusammengefasst untersucht diese Arbeit daher Möglichkeiten des *personalisierten Informationsmanagements für Lernende.*

Die Untersuchung dieser Fragestellung erfolgt auf zwei Ebenen. Die erste Ebene dieser Arbeit umfasst eine theoretische Untersuchung der Thematik. Zu diesem Zweck wird ein *übergreifendes Rahmenwerk für das persönliche Informationsmanagement von Lernenden* entwickelt, das eine ganzheitliche Betrachtung dieser Fragestellung ermöglicht. Das entwickelte Rahmenwerk zeichnet sich insbesondere durch eine Verschmelzung der Domänen E-Learning und Wissensmanagement aus. Dazu werden im Rahmen dieser theoretischen Untersuchung prägende Facetten des Lernens beschrieben und Theorien des organisatorischen Wissensmanagements zur Bewältigung des persönlichen Informationsmanagements untersucht. Dies führt schließlich

zu einer Charakterisierung von individuell Lernenden, der Identifikation grundlegender Herausforderungen für diese Lernenden sowie einem Modell zur Beschreibung des individuellen Informations- und Wissensmanagements.

Die zweite Ebene dieser Arbeit umfasst die Umsetzung des entwickelten Rahmenwerks in ein *praktisches Konzept zur effizienten Verwaltung von persönlichen Lerninhalten und -informationen einzelner Lernender*. Das realisierte System ist dabei durch die Berücksichtigung von Informationsbedürfnissen individuell Lernender sowie besonders durch den gezielten Einsatz von Information Retrieval Techniken zur Unterstützung dieser Lernenden gekennzeichnet. Das konstituierende Merkmal dieses Systems ist daher eine flexible Architektur, die die Erfassung von Lernobjekten unter besonderer Berücksichtigung des Lernkontexts erlaubt. Detaillierter betrachtet ermöglicht die Erfassung von Basisinformation in Form von Lernobjekten in Kombination mit hierarchischen und nicht-hierarchischen Zusatzinformationen eine individuelle und umfassende Verwaltung von Lerninhalten und –informationen, die auch eine verbesserte Wiederauffindbarkeit dieser Informationen zu einem späteren Zeitpunkt unterstützt.

Die wichtigsten Ergebnisse dieser Arbeit werden aktuellen Entwicklungen und Projekten in verwandten Bereichen gegenübergestellt und im Rahmen einer Nutzerstudie grundlegend validiert.

Contents

Introduction

> *"Technology is an agent of change, and major technological innovations can result in entire paradigm shifts.*
> *The computer network known as the internet is one such innovation."*
>
> David A. Wiley [Wil02, p.3]

We are currently witnessing a cultural transition—the transition of our society from a literary society into a digital society [Riv08, p.vi]:

> *"Digital technology is transforming every aspect of people's lives. [...] Modern life brings greater chances and choices for individuals, but also greater risks and uncertainties."* [Com10, p.7]

Above all, this transition enables an *"unobstructed access to knowledge in worldwide networks as well as individual channels of information, communication, and education"* [RRM00, p.9]. In a nutshell, this unobstructed access to knowledge and the required circulation of knowledge are, in turn, facilitated by technologies like the internet and modern devices like smartphones that allow the utilisation of these technologies at any time and any place [Riv08, p.vi].

This observable rise and progress of new technologies—gently but emphatically becoming part of people's everyday lives—not only changes the way people work, communicate, and shape their leisure but also the way people learn. To reflect this change of learning and the influence that technology has on learning, this "new" kind of learning is also referred to as *technology enhanced learning.*

Naturally these advancements bring with them a great freedom in decisions and actions—in general as well as for learning in particular. However at the same time this enhancement is also a source of disorientation that has to be taken control of [RRM00, p.9]. As a consequence, an appropriate mastering of this freedom of choice is also required for learners:

> *"It is [...] indispensable for today's learners to be able to find their way through the explosion of information, to develop standards for assessing and selecting information and, most importantly, to be capable of independently evolving their individual knowledge."* [RRM00, pp.9ff]

In brief, technology can be identified as the cause of these changes and, therefore, also the cause of the resulting need to master this freedom of choice and the amount of knowledge that has become available today. However most importantly, technology can also be a carrier of solutions to these changes and for novel requirements [RRM00, p.9], which implies that technology can assist learners in achieving the required mastery.

Generally speaking, this thesis is motivated by these changes and dedicated to an examination of the support that technology is able to provide to learners.

Objectives

A number of efforts are already dealing with this change of education, the rise of technology in and for education, and the support that technology can provide learners with. This thesis, thus, addresses these changes and places a particular emphasis that is absent from previous work in the field and thus makes it distinctive: the explicit focus on *individual learners.*

As a result, the main concern of this thesis can be described as the *examination*, *development*, and *implementation* of

Personal Information Management in Learning.

Consequently, the general *research question* of this thesis can be phrased as follows:

> *"How can learners moving on individual learning paths be supported by the utilisation of modern technology for learning?"*

Refining this generic question, the main research problem can be further divided into three main issues that will be addressed within the scope of this work:

- The identification of characteristics, needs, and challenges that distinguish individual learners from within the larger crowd of uniform learners.

  Learning and individual learners are the focus and, in turn, foundation of these examinations. For that reason, learning and personalised learning as accomplished today have to be studied and characterised to facilitate a clearer understanding of individual learners. This characterisation has to include an identification of challenges faced by individual learners and the particular needs that these learners have.

- The unified acquisition, representation, and organisation of information related to an individual's learning—that is an improvement of support for the *management* of personal information in learning.

  Today's learners—in particular those moving along individual learning paths—have to rise to the challenge of dealing with a number of sources of information. These different sources of information have to be identified and are to be unified by the provision of a common facility for collecting, storing, and managing all information assets from these sources. Acknowledging the learning process and a learner's environment, this management is supposed in particular to incorporate the context of information.

- An improved find-ability of personal information across all relevant sources of information—that is an improvement of support for the *retrieval* of personal information in learning.

  The overall goal of information management is to enable the provision of collected information when required. To be able to ensure the availability of information, the find-ability of personal information is substantial. Within the scope of this work, an improved find-ability is supposed to be based on the provided unification of different information sources and an appropriate representation.

In summary, the objective of this thesis is the *derivation and proposal of an architecture* to efficiently manage—that is to collect, store, organise, and (re-)find—the personal information of individual learners.

In a Nutshell

Altogether two different steps towards a solution and the answering of the research question and its refinements have been chosen: the development of a *theoretical framework* and its *practical implementation* into a comprehensive concept. These two steps are reflected in the structure of this thesis which has been designed in three parts.

Part I: Establishing a Theoretical Framework for Personal Information Management in Learning

To establish a theoretical framework for personal information management in learning, the spheres of *learning*, *e-learning*, and *personalised learning* have been combined with theories of *organisational* and *personal knowledge management* to form a so far unique holistic view of personal information management in learning.

Chapter 1. The first chapter starts to define the scope of this work with an examination of *learning in a digital world.* This consideration includes the selection and description of the most important facets of learning addressed within this thesis as well as an introduction to the current common stage of learning—that is technology enhanced learning. Ultimately, these deliberations result in a definition of *modern learning.*

Chapter 2. Continuing to build the theoretical framework, a deeper understanding of learning is facilitated by exploring *what learners learn.* This analysis provides a profound definition of knowledge from different perspectives and introduces working with knowledge as a wider perspective for learning.

Chapter 3. This chapter focuses for the first time on the core topic: *management in learning.* Since *management* is typically considered to be an entrepreneurial concern, the different schools of traditional knowledge management are introduced. Having set *learning* as the primary field of application, a dual perspective on these two disciplines is required. As a result a merging of learning and knowledge management is tested and proposed as a consequence of this chapter.

Chapter 4. Completing the description of the theoretical framework, the scope is narrowed by homing in on *personalised learning*: individual learners are the primary concern and main focus. This chapter achieves the necessary change of perspectives by moving from organisational to personal knowledge management. In addition, concepts of tools for personalised learning are introduced and *challenges in personalised learning* further specify the objective of this work.

Chapter 5. This chapter bridges the gap between *theory and practice* and, hence, between parts I and II.

Part II: Designing and Building a Personal Learning Information Management System

The theoretical framework defined within the first part is now transferred to a comprehensive technical concept for personal information management in learning. The realisation and design of this concept as well as its practical implementation are strongly characterised by the utilisation of *information retrieval* techniques to support *individual learners*.

Chapter 6. To provide a basis for the practical design and implementation of a corresponding system, begins with an analysis of *what learners need*. Starting off with a general definition of information needs, this chapter approaches the needs of learners to be considered for the design of a personal learning information management system. More precisely, this foundation is constructed from an examination of information demands, the information seeking process, a determination of information sources and resources.

Chapter 7. This chapter is comprised of the proposal of *PLIMS*—the personal learning information management systems designed and built within the scope of this work. To support and illustrate its profound design, the theory of personal information management is introduced based on personal management activities, the personal information collections built by these activities, and the anticipated needs that these collections cater for. Finally, PLIMS is derived from and depicted by a basic functional description.

Chapter 8. Ultimately, the *architecture to store personal information* as implemented within PLIMS is specified. To be able to develop the architecture, learning objects are introduced and depicted as the integral part of this architecture. Subsequently, the comprehensive area of metadata standards is examined. The introduction of the PLIMS architecture constitutes one of the main contributions: a two-tier architecture with three index levels to store personal information.

Chapter 9. Having defined the architecture establishing PLIMS, this architecture needs to be actually supplied with personal information to *build the learning repository.* For that reason, the scope of learning objects covered by PLIMS as well as strategies to construct the personal collection of learning object within PLIMS are described.

Chapter 10. Completing the proposal of PLIMS, a description of possibilities for *advancing and accessing the learning repository* is provided. Three different options are analysed: an integration of the social context of learners by facilitating *collaboration*, an improved utilisation of the information collected within a learning repository—that are *recommendations* to learners—and the advanced *exploration* of information within a repository by learners.

Part III: Evaluating Personal Information Management in Learning

This third part is comprised of the evaluation of PLIMS and completes this thesis by providing a conclusion that gives an overview of what has been accomplished:

Chapter 11. To allow an assessment of the previous proposal, PLIMS is eventually evaluated. In conjunction with a selection of existing related systems, PLIMS is classified as a system for personalised learning and compared to the related systems. Furthermore, a small user study has been conducted to gain feedback from the people that PLIMS has been designed for—the learners. The presentation of the design and results of this study complete the evaluation of PLIMS.

Chapter 12. This last chapter completes this work by presenting a conclusion regarding the overall results.

Part I

Establishing a Theoretical Framework for Personal Information Management in Learning

1 Learning in a Digital World

*"Real learning gets to the heart of what it means to be human. Through learning we re-create ourselves. Through learning we become able to do something we never were able to do. Through learning we re-perceive the world and our relationship to it. Through learning we extend our capacity to create, to be part of the generative process of life.
There is within each of us a deep hunger for this type of learning."*

Peter Senge [Sen06, pp.13f]

Learning is of vital importance. In a world where learning is a prerequisite to survive for every living being and particularly for humans, learning is requirement and opportunity all in one [GWZ07, p.7]:

> *"Learning is that which enables you to participate successfully in life, at work, and in groups that matter to you."* [Cro07, p.XIX]

Learning is a complex process or, to be more precise, a collective term for *processes* leading to the acquisition or transformation of knowledge or skills and, in this way, resulting in an increased competence level [MG06, p.344]. However, learning is also a process eluding direct observation that can only be deduced [Mie07, p.33]. Due to this characteristic, learning can only be identified retrospectively by a change of behaviour. Such change is, of course, also likely to imply a modification of future learning. So, interestingly, what we learn affects the way we will learn. As a consequence, it is only natural that learning changes and evolves over time—individually as well as collectively.

To this day—more than ever—learning is an essential part of our society. Summarising its evolution in the past, Europe has previously moved towards an *information society* [Org96, p.3] and has or is subsequently moving to what is called a *knowledge-based society and economy*[1] [Com10, p.5]. By implication, these changes have reinforced the importance of learning, leading to an even clearer presence of learning in research, business, education, and everyday life.

Describing learning itself, traditional behaviourists and psychologists agree in defining learning as a behaviour modification—as the obvious sign for a change of knowledge. However, in order to be able to refer to this change as learning, firstly, the occurred change has to be comparatively permanent [RDH09, p.67]. This prerequisite explicitly excludes short term temporary changes; nevertheless it is assumed that not every learning process leads to an utterly permanent change—sooner or later loss, at least in parts, has to be anticipated. Secondly, learning is required to be the result of exercises and experiences—an activity element within the learning process is an indispensable prerequisite for successful learning. Hence, there has to be either a cognitive or physical action in order to learn. [Mie07, pp.33f]

> *"Learning is an interactive process: Meanings are constructed by exchanging information with the environment, particularly with other people. Learning asleep is therefore impossible."* [Mie07, p.34]

Moving on to the level of *explanation* the question of *how* this observable behaviour modification came about has to be answered. In other words, in order to reasonably support learners we have to ask ourselves how people learn.

Therefore, the first two sections of this chapter take a closer look at learning: Important *facets of learning* deliver detailed insights into the nature of learning while *technology enhanced learning* observes the current stage of learning supported by modern technology—both to determine the understanding of learning and to delimit the scope of this work. Finally, the third section proposes a comprehensive *definition*

[1] In contrast to an information society, a knowledge-based society puts humans, their abilities, attitudes, and values in the centre and values knowledge as a central factor of production [RRM00, p.10]. An in-depth consideration of this structural change can be found in [Nor11, pp.9ff]

for modern learning whereas the fourth and last section of this chapter reports on *tools* for what has been previously defined as modern learning.

1.1 Facets of Learning

Learning—as undoubtedly one of the most important human abilities—has many facets, each of them influencing the way learning is perceived, recognised, and accomplished—again individually as well as collectively. This variety and the fact that the study of learning is not a discipline itself [Dri05, p.6] explain why a precise definition of learning is so hard to shape.

Marcy P. Driscoll [Dri05, pp.11ff] explores some of the possibilities and complexities for defining learning—that is the *epistemology of learning*. One way to define learning is to identify *valid sources of knowledge*, which is the concern of *empiricism*, *nativism*, and *rationalism*. Another approach followed by *scepticism*, *realism*, *idealism*, and *pragmatism* is to examine the presumed *content of knowledge*. And finally, consulting *knowledge traditions* results in three major epistemological orientations: *pragmatism*, *objectivism*, and *interpretivism*[2]. Still debated about today, these three orientations are evident within many learning theories. The three most common and prevalent learning theories—*behaviourism*, *cognitivism*, and *constructivism*—will now be described in more detail to introduce different ideas about how the human brain actually works and, hence, how learners actually learn.

Traditionally, learning was only perceived as a change of behaviour based on experiences. This stringent restriction to the behaviour of an organism and the abandonment of interpreting the observable by utilising inner processes became the programme of *behaviourists*. According to behaviouristic arguments, learning can change the form or quality of a behaviour as well as the incidence—where behaviour is defined by a stimulus, the reaction triggered by this stimulus, and their connection [Mie07, pp.35f]. In other words, learning is considered to be a conditioned reflex acquired by adoption. Moreover, behaviouristic teaching strategies assume that tutors know what learners have to learn. This indicates that for successful learning all that needs to be

[2] For a detailed explanation of the beliefs, the historical development, and coherencies of all the concepts named above, see [Dri05, pp.11ff].

done is to present the corresponding stimulus [BP94, p.101]. Learners are for that reason described as being reactive or passive. Simply stated, this leads to the predication that learners are under the control of their environment [Mie07, pp.35f].

This radical way of thinking was, however, not approved by all behaviourists. In the 1950s and 1960s a group of behaviourists studying cognitive processes within human beings emerged. Yet they were still regarded as (cognitive) behaviourists due to the fact that they were assuming reactive learners whose information processing is subject to foreign control. [Mie07, pp.201f]

Putting information processing at the centre of attention and understanding the learner as an individual being—who independently processes stimuli and is therefore not easily controllable through stimuli [Tul96, p.43]—transforms (cognitive) behaviourism into *cognitivism*. It is assumed that learners selectively percept, interpret, and process impressions based on their individual stages of experiences and development [RDH09, p.71]. According to cognitive psychology—which is traced back to Jean Piaget's developmental theory and Jerome S. Bruner's studies on developmental psychology—learning is based on cognitive structures [Sch97, p.71] formed by those individual stages of experiences and developments.

Trying to find a theoretical model for the mental processes taking place between input (stimuli) and output (reaction), the cognitivistic base model defines learning or, more generally, human thinking as information processing [BP94, pp.103ff]. Therefore, cognitive learning theories often utilise the paradigm of problem solving and constitute *discovery-based learning* [Sch97, p.71].

These cognitivistic theories also provided the psychological-philosophical basis for *constructivism* which started to gain more attention in the 1980s. Only from the time when it is acknowledged that a learner does something that eludes external control, the crucial step towards constructivism has been made [Mie07, p.202].

Constructivism considers learning to be an active process where individuals construct knowledge in relation to previous experiences or in complex real life situations [BP94, p.107]. In contrast to cognitivism, constructivism denies the existence of a concept of reality that could be scientifically discovered and is existing independently from thinking human beings [RDH09, p.72]. Moreover, focussing on the independent creation of problems replaces the focus on solving presented problems [BP94, p.107]. To be more precise, creating a constructivist learning environment requires capabilities for knowledge construction, cooperative learning, self-regulation to a certain degree, and an authentic learning situation [Rey09, pp.34f] [LG08, pp.351ff].

In summary, constructivism accentuates the active and constructive role of learners and passes the responsibility for learners' success to the learners themselves. However, there are those who forward the argument that limiting capabilities of learning in complex environments to such discovery-based learning may overburden learners. Instead a mix of discovery-based and guided learning are seen to be more effective [Rey09, p.34].

Although behaviourism remains a valuable choice for learning in particular situations—such as the training of physical skills [BP94, p.102]—from a current perspective constructivism can be seen to be the learning paradigm of choice for actively supporting learners. Numerous technological progresses have resulted in a vast amount of information moving around the globe with lightning speed at every moment, and potential users or learners are faced with the task of making a deliberate selection. They have to be capable of putting together information from different sources to construct complex meanings. It is no longer sufficient to turn learners into passive recipients of information that have been put together by others. Rather it has to be ensured that learners gain the ability to independently evaluate and select information. [Mie07, p.41]

However, very recently, an alternative approach to defining learning has been proposed by George Siemens: the theory of *connectivism*[3]. Connectivism integrates principles of chaos, network, complexity, as well as self-organisation theories and is driven by the understanding that learning (decisions) are based on rapidly altering foundations. Learning is, therefore—even tough starting at the individual—

[3] The concepts of connectivism and connective knowledge have been explored in a Massive Open Online Course (MOOC) in 2008; the course reran in 2009 and 2011. While the course website is no longer available, the course support wiki—offering insight into the course structure and content—can be found at `http://ltc.umanitoba.ca/wiki/Connectivism_2008`. For current findings and explanations see George Siemens's blog on connectivism—`http://www.connectivism.ca/`.

presented as *"as a connection/network-forming process"* [Sie05b]. The implication is nothing less than the fact that learning is no longer a completely internal, individual activity or process. [Sie05a]

For that very reason, connectivism incorporates significant trends in learning in the 21st century and in particular includes *"technology and connection making as learning activities"* [Sie05a] to present learning *"conceptualised through the lens of today's world"* [Sie02]. To be more precise, eight principles are associated with connectivism:

1) Learning and knowledge rests in diversity of opinion.
2) Learning is a process of connecting specialized nodes or information sources.
3) Learning may reside in non-human appliances.
4) Capacity to know more is more critical than what is currently known.
5) Nurturing and maintaining connections is needed to facilitate continual learning.
6) Ability to see connections between fields, ideas, and concepts is a core skill.
7) Currency is the intent of all connectivist learning activities.
8) Decision-making is itself a learning process; choosing what to learn and the meaning of incoming information is seen through the lens of a shifting reality.

Connectivism thus considers, in particular, facets of learning such as informal (cf. section 1.1.1) and self-directed learning (cf. section 1.1.2), the change of learning in the course of a learner's lifetime (cf. section 1.1.3), and technology in learning (cf. section 1.2)—which is why this theory is especially valuable for the approach presented within this work.

Hence, different learning situations—referred to as *formal, informal, and non-formal learning*—are examined in the following section, in order to offer a more comprehensive view of learning. Thereafter, the shift of control from other-directed to *self-determined learning* is outlined, whereas the last part of this section deals with *lifelong learning* in contrast to episodic learning.

1.1.1 Formal, Informal, or Non-Formal Learning

In order to truly understand how people learn, it is useful to consider learning situations. A common distinction is the differentiation of three groups of learning situations: *formal*, *informal*, and *non-formal learning*.

> *"Workers learn more in the coffee room than in the classroom. They discover how to do their jobs through informal learning: talking, observing others, trail and error, and simply working with people in the know. Formal learning—classes and workshops—is the source of only 10 to 20 percent of what people learn at work."* [Cro07, p.III]

Although this distinction of learning situations is established, there are completely different understandings and definitions of formal, informal, and non-formal learning. Boundaries are elusive and, ironically, trends that formalise the informal and—the other way round—that informalise formal learning can be traced [HCM03, p.313]. Some—like Christopher Kay Knapper and Arthur J. Cropley—even claim that this distinction is to some extent artificial [KC00b, p.12].

However, the Commission of the European Communities (European Commission)[4] has proposed a clear distinction between and definition of the three basic categories of purposeful learning [Com10, p.8] which is adopted for the scope of this work:

Formal Learning takes place in education and training institutions, leading to recognised diplomas and qualifications.

Non-Formal Learning occurs alongside the mainstream systems of education and training and does not typically lead to formalised certificates. Non-formal learning may be provided in the workplace and through the activities of civil society organisations and groups (such as in youth organisations, trades unions, and political parties). It can also be provided through organisations or services that have been set up to complement formal systems (such as arts, music, and sports classes or private tutoring to prepare for examinations).

[4] Commission of the European Communities (European Commission)—`http://ec.europa.eu/index_en.htm`

Informal Learning is a natural accompaniment to everyday life. Unlike formal and non-formal learning, informal learning is not necessarily intentional learning, and may thus not be recognised—even by individuals themselves as contributing to their knowledge and skills. Informal learning is also referred to as natural learning and the major source of knowledge transfer and innovation [Cro07, p.XIX].

Despite this clear distinction, it is not so simple in practice to differentiate those three manifestations of learning. Typically, formal learning is the most recognised form of learning, whereas non-formal learning is usually not seen as "real" learning. Even worse, informal learning is most likely to be forgotten, despite being the oldest form of learning [Cro07, pp.16f] and building on the most powerful instructional technology, namely human conversation [Cro16].

> *"Informal learning is effective because it is personal, just-in-time, customised, and the learner is motivated and open to receiving it. It also has greater credibility and relevance."* [Cro07, p.17]

An extensive investigation conducted by Helen Colley et al. [CHM02] revealed that differences in the usage of terms "informal learning" and "non-formal learning" are hard to find. Instead, both terms are used interchangeable to formulate an opposite to formal learning [HCM03, p.2].

However, even if informal and non-formal learning are merged, the problem of a clear distinction between formal and informal learning remains. It is not possible to define separate ideal types of formal and informal learning which then bear any relation to real learning situations [HCM03, p.2]. N.J. Colletta, for instance, identified formal, non-formal, or informal learning as a result of employing four dimensions to classify learning situations—namely *deliberateness*, *structuredness*, type of *content*, and the role of *certification* [Col96a, p.22][KC00b, p.12]. A more comprehensive approach to solving this problem—proposed by Phil Hodkinson et al. [HCM03, p.3]—suggests four different aspects of formality or informality to analyse learning situations [HCM03, p.3]:

Process. Learning situations can be classified as more formal or informal depending on *facets of the learning process* such as 1) the occurrence of learning—incidental or in structured tasks—, 2) the examination of learning—teacher-controlled or student-led (cf. section 1.1.2)—, 3) the "pedagogue" involved—a formal trainer, friend, or colleague—, and 4) the assessment of learning—formative, summative, or no assessment at all.

Location and Setting. Building on facets of the learning process, location and setting also determine a certain degree of formality or informality. Where the component *location* can be equated to the physical location of learning, attributes like time, curriculum, learning objectives, and certification—being specifically set (formal) or consciously left blank (informal)—construct a particular learning *setting*.

Purposes. The main purpose of learning contributes to a similar classification. If learning is the primary and deliberate focus of activities, a more formal setting can be assumed, whereas other prime purposes would lead to an informal situation. Politically, it also needs to be asked what purposes actually lie behind the learning—learning can be learner-initiated or externally determined.

Content. Last but not least, the content of learning assists in identifying formality or informality. Where the acquisition of established knowledge suggests a more formal situation, the development of something new assumes an informal learning situation.

Trying to classify learning situations, these four attributes of formality or informality can be of assistance. However it has to be noted that those four attributes are by no means independent from each other but closely interrelated. Additionally, (almost) all learning situations contain attributes of formality as well as informality [HCM03, p.5] or, to put in other words, blend formal and informal aspects of learning [Cro07, p.17]. Jay Cross succinctly states that *"formal and informal learning are ranges along a continuum of learning"* and both—formal and informal learning—*"have important roles to play"*. A learning situation is, for that reason, always both-and, not either-or [Cro07, pp.16f]. Manifestations of this continuum of learning as proposed by Jay Cross are shown in table 1.1 [Cro07, p.127].

	Most Formal	Most Informal
Intentionality	On purpose	Incidental
Timing	Scheduled	Whenever
Location	Fixed	Anywhere
Contract	Written	None
Structure	Highly structured	Unstructured
Control	Strict	Laissez-faire
Outcomes	Specific	Unstated
Content	Certain	Fuzzy

Table 1.1: Dimensions of Formal and Informal Learning [Cro07, p.127]

To conclude, it is essential to signify the importance of all kinds of learning situations—formal, informal, and non-formal learning. Whereas formal education is, by now, the most prevalent and recognised kind of learning, attention also needs to be paid to informal and non-formal learning. Yet, these learning situations entail learning in less defined, structured, or guided situations—and thus bring with them a request that learners accept the responsibility for their own learning. In other words, accentuating non-formal and informal learning also asks for *self-directed learners*.

1.1.2 Other- or Self-Directed Learning

In the moment when an individual recognises the need or comes to the—externally driven or internally derived—decision to learn something, there are two general ways of doing so: a learner can either turn to a professional teacher (lecturer, instructor, etc.) or, instead, decide to act on his own [Tou67, p.3]. This is what is called *self-determined* or *self-directed learning*[5].

> *"All learning is self-directed."* [Cro07, p.16]

[5] Self-determined or self-directed learning is also referred to as self-teaching, self-instruction, self-education, independent study, individual study, self-directed study, or self-planned learning [Tou67, p.3], [Kil08, p.1f].

Definitions for Self-Directed Learning

Trying to define self-directed learning, a basic commitment defines learning as self-determined if there is no, or at least no significant, exercise of influence by other individuals. It is, therefore, simply a contrast to *other-directed learning* that is defined by the absence of an external control of learning [Wei82, p.99]. A more tangible definition is, for instance, proposed by Malcolm S. Knowles:

> *"Self-directed learning describes a process in which individuals take the initiative, with or without the help of others, in diagnosing their learning needs, formulating learning goals, identifying human and material resources for learning, choosing and implementing appropriate learning strategies, and evaluating learning outcomes."* [Kno75, p.18]

Barry J. Zimmerman defines self-direction as being an *"open-ended process that requires cyclical activity"* [Zim98, p.2] in three phases: 1) *forethought*—including influential processes setting the stage for learning—, 2) performance or *volitional control*—comprising of processes during learning, also affecting concentration and performance—, and 3) *self-reflection*—involving processes after the learning itself influencing a learner's reaction to a learning experience. Completing the phase of self-reflection is, in turn, supposed to initiate additional forethoughts. [Zim98, p.2]

There are varying definitions as how to differentiate between phases or stages of self-directed learning. According to Tobias Büser there are four stages of self-directed learning to be distinguished [Büs03, pp.30f]:

1) *self-learning*—requiring the independent initiation of learning itself

2) *self-regulated learning*—implying the control and regulation of learning with regard to learning goals

3) *self-paced learning* or *self-determined learning*—allowing an own definition of learning goals—

4) *self-organised learning*—including the arrangement and administration of all required learning resources

In contrast, *self-organised learning* is also likely to be defined as a subset of self-directed learning. According to Sandra Schaffert and Wolf Hilzensauer or Detlef Kuhlenkamp, self-organised learning implies controlling one's own learning for predefined content and goals [SH08, p.4], whereas self-determined learning explicitly emphasises the decision of a learner with regards to goals and content, forms and ways, results and times as wells as venues of learning [Kuh10, p.141].

What all these definitions share is the conviction that self-directed learning requires a learner to control the *"preparation, execution, regulation, control, feedback, and maintenance of learning activities"* [vHWSV00, p.22]; a process of self-directed learning always requires a certain degree of self-awareness [Edu09, p.2].

It is, however, important to realise that "acting on one's own" does not imply a private or individualistic matter because learning is—even though individual—always embedded in a social context [MG06, p.344]. Self-directed learning itself, usually, builds upon *"various kinds of helpers, such as teachers, tutors, mentors, resource people, and peers"* [Kno75]. In fact, self-directed learning is often more social than any classroom learning [Don03, p.3].

On the Way towards Self-Determined Learning

Franz E. Weinert depicts self-directed learning as prerequisite, method, and objective of learning for any instruction and constitutes that *"there is no single class of learning processes that can be characterised as self-directed.* Instead this labelling only signifies that a learner *"has serious and consequential influence on the essential decisions if and what will be learned—when, how, and for which purpose".* [Wei82, p.102]

For this very reason, self-directed learning is also a prerequisite for improving one's education beyond institutions of learning—which is simply an enabling and fostering of *informal learning* [RRV03, p.13]. It is an essential aspect of maturing to take increasing responsibility for our own life [Kno75, p.15]. It should therefore be even more essential to take responsibility for our own learning—helping us to mature in life.

There are, however, two crucial aspects or indications for self-directed learning. Firstly, freedom of action is not sufficient for self-directed learning [Kil08, p.3]. Instead, motivation and, in particular, learning competencies need to be simultaneously fostered [Wei82, p.99]. Developing the ability for self-determined learning is, therefore, heavily reliant on *learning strategies* [Kil08, pp.4ff][NDH+08, pp.72ff][Fri99, pp.9f][vHWSV00, pp.25f][LL03, pp.48ff]:

- *Cognitive* learning strategies—simply structured or more complex primary learning strategies for information processing and task execution such as strategies for memorisation, organisation, elaboration, and using knowledge
- *Meta-cognitive* learning strategies—constituting a superior level of learning strategies and, therefore, including skills to plan, monitor, and regulate the learning process
- *Motivational* learning strategies—abilities that influence learning motivation also including connected emotions
- *Resource-based* learning strategies—embracing strategies to optimise available learning resources such as time management or designing the learning environment
- Strategies for *social interaction*—the ability to learn in conjunction with others through selecting appropriate learning partners or strategies for cooperation

Secondly, not every learner is inherently self-directed. Many learners are still waiting for directions where it should be *"in their self-interest to become proactive learning opportunists"* [Cro07, p.175]—among others, due to an explosion of knowledge, new information and communication technologies, a change of perspective from teaching to learning in sciences, interest in extracurricular learning, and a growing importance of self-monitoring [Fri99, p.2f].

In summary, the implementation and application of self-determined learning fosters the development towards a mature, responsible, and self-reliant learner equipped with the required learning and social skills [HPLK08, p.15]. Self-directed learning, in that way, also meets the demand to place individuals and their needs at the centre of attention for teaching and learning [Com10, p.6]—which is also a crucial aspect of *lifelong learning*. Self-directed learning can, therefore, also be depicted as an important prerequisite for lifelong learning [Dub06, p.438].

1.1.3 Lifelong Learning

Education in former times was a mater of strictly separated concerns. Education started with pre-school, primary and secondary school, was potentially continued with a graduation of higher education, and was supposed—even if not naturally—to be completed by vocational education and training. Very often acquired knowledge was likely to be sufficient up to retirement. Opportunities to refresh or update existing qualifications potentially arose years later with programmes of further education which slowly started to gain attention in the 1960s. Symptomatically, no connection existed between those different chapters of education. Thus it was common for wide gaps to appear.

The concept of lifelong education or lifelong learning aims to reconnect those time-limited and separated phases of learning. Even though the term *lifelong education* appeared almost 85 years ago [KC00b, p.1], the first change of thinking started to spread gently in the early 1970s: The previously strict separation of concerns for different fields of education was revisited, and although the distribution, implementation, and acceptance would take a little longer—and is not finished yet—first studies conducted by the Council of Europe[6], the United Nations Educational, Scientific and Cultural Organisation (UNESCO)[7], or the Centre for Educational Research and Innovation (OECD/CERI)[8] were early signs that the concept of *lifelong learning*

[6] "Permanent Education. Fundamentals for an Integrated Educational Policy", published in 1971 by the Council of Europe, summarises 15 previous public studies. It is comprised of a long-term perspective as well as an abstract concept on permanent education. The presented concept envisions a flexible sequence of learning units, allowing individual timing and the highest possible freedom of choice. However, it is still primarily focussing on adults. [Kuh10, p.14f]

[7] "Learning to be. The world of education today and tomorrow", published in 1972 by UNESCO, is the report of a committee of experts commissioned to draw up a critical assessment of the worldwide educational situation, and also delivering a guideline for future structural reforms [FHK+72].

[8] "Recurrent Education - A strategy for lifelong learning", published in 1973 by OCED/CERI, describes the concept, main features, and objectives of recurrent education. Recurrent education embraces the idea to spread *"education opportunities [...] out over the individual's lifetime, as an alternative to the ever-lengthening period of continuing education for youth."* [Org73, p.5]. However, to realise this concept a serious transformation of labour market and social policies would have been required, which is why the presented concept was not followed up thereafter. [Kuh10, p.19]

was on its way. Different studies in the 1990s[9] were, finally, concluded by a report by the European Commission that has been influential—"A Memorandum on Lifelong Learning" in 2000 [Com10].

Lifelong Education or Lifelong Learning?

Lifelong education is a set of organisational, financial, and didactic principles established with the aim of fostering lifelong learning. Hence, lifelong education is the system and lifelong learning is the content, the goal, and the result of this system [KC00b, p.6]. Lifelong learning—being the result of lifelong education—is systemic, purposeful, and organised; lifelong learning itself also embraces spontaneous, unplanned, incidental, and even unconscious learning as a normal and natural part of everyday life [KC00b, p.12].

Lifelong learning neither ends on the threshold to adulthood like vocational training nor merely begins at this stage of life as being true for further education. Instead emphasis is placed on lifelong learning as combination of all the different chapters of education that, as a consequence, comprises of learning throughout a whole life:

> *"Lifelong learning is the common umbrella under which all kinds of teaching and learning should be united. [...] [It] sees all learning as a seamless continuum from 'cradle to grave'. "* [Com10, p.4,7]

In other words, lifelong learning defines a continuum of learning throughout life [Com10, p.7]. It is, thus, a comprehensive and complex process taking place in a wide variety of settings: It embraces *formal*, *non-formal*, and *informal learning* (cf. section 1.1.1)—respecting the unique contribution of each setting and bringing together their respective merits [Com10, p.9]. Moreover, the implementation of lifelong learning also actively initiates a shift of responsibilities. The responsibility for learning and further education devolves from lecturers to learners and from institutions of learning to the subject of learning [Kuh10, p.7]. Learning is no longer other-directed but one's own responsibility and, hence, *self-directed learning* (cf. section 1.1.2).

Being more precise, according to Margaret Kiley and Robert Cannon [KC00a, p.3], lifelong learners learn in both *formal and informal* settings, *plan and assess* their own learning and are therefore *active rather*

[9] For more details on conducted studies see [Kuh10].

than passive learners which are able to learn from their *peers, teachers, and mentors.* Lifelong learners also integrate *knowledge from different subject areas* when required and use *different learning strategies* for different situations.

Key Messages for Lifelong Learning

The *necessity* for this kind of learning is—according to Gerd Mietzel [Mie07, p.11]—the result of four independent developments: 1) globalisation of the world economy, 2) technical developments, 3) a higher standard in education, and 4) an increased life span in good health—each of them contributing to personal, social, and economical needs for lifelong learning. Moreover, lifelong learning is an essential companion for a successful transition to a *knowledge-based society and economy* because it promotes active citizenship and employability [Com10, p.3,5].

To be able to put lifelong learning into practice, the "Memorandum on Lifelong Learning" offers a structured framework for an open debate by delivering *six key messages for lifelong learning* [Com10, p.4,10ff]:

New Basic Skills for All are the essential foundation for active citizenship and employability. The implementation of this first key message, therefore, has the objective of guaranteeing universal and continuing access to learning for gaining and renewing the skills needed for sustained participation in society. More precisely, the new basic skills include IT skills, foreign languages, technological culture, entrepreneurship, and social skills.

More Investment in Human Resources clearly states not only that the previous investment levels were regarded as too low but also that the definition of investments needs to be reconsidered. Hence, this message intends a visible raising of levels of investment in human resources in order to prioritise Europe's most important asset—its people.

Innovation in Teaching and Learning refers to a changing understanding of learning due to our existence in an age of knowledge. For that reason, the implication is a major shift towards user-oriented learning systems with permeable boundaries or, in other words, to develop effective teaching and learning methods and contexts for the continuum of lifelong and lifewide learning.

Valuing Learning meets the rising demand for qualified labour. It is, therefore, extremely important to significantly improve the ways in which learning participation and outcomes are understood and appreciated—in particular for non-formal and informal learning.

Rethinking Guidance and Counselling is implicated by a more open—and hence more complex—society. Lifelong learning brings with it more frequent changes between the different stages of living, learning, and working. For these reasons, it is important to ensure that everyone can easily access good quality information and advice about learning opportunities.

Bringing Learning Closer to Home is lastly defined as the sixth key message in order to emphasise that the provision of education and training as policy area is an indispensable part of lifelong learning. This implies the provision of lifelong learning opportunities as close to learners as possible—in their own communities and supported through ICT-based facilities wherever appropriate.

By now, there is no doubt that lifelong learning is essential for individuals as well as society. It is however important to recognise that the gap between rhetoric and reality is substantial [Kuh10, p.87].

In summary, all of these definitions and findings regarding lifelong learning can be embodied in the three following general—however particularly meaningful for the purpose of this work—*imperatives for lifelong learning*: Valuable lifelong learning is intended to *foster individual development*, *foster social development*, and to help *mastering the computerized world* [KC00b, p.20].

What has been described within this section are *facets of learning* considered to be of importance to understand learning. Different approaches to support learning may foster and emphasise differing facets or focus on a special selection from facets of learning as depicted above. Within the scope of this work, *self-directed* learners shifting between *formal*, *non-formal*, and *informal* learning situations on their *lifelong* learning path are addressed. Technology has become an important pillar to support this kind of learners—which is why *technology enhanced learning* is explored next.

1.2 Technology Enhanced Learning

About 20 years ago, it seemed like there were two contrary—often even prejudiced—points of views opposing each other: the socio-scientific-pedagogic discipline—which was sceptical about the usage of computers for teaching and learning—and a basically pragmatic-technical view—said to be naive-euphoric and excessively optimistic about learning with computers [BP94, p.11].

However in fact, the development to support learning with computers had already begun in the 1950s [Sch97, p.91] and has grown stronger over the last decades[10]. Various political programmes for hard- and software procurement in the second half of the 1980s—aiming to foster the use of computers in schools and universities [Sch97, pp.14f]—and the rise of the internet in the 1990s, paved the way for a new way of learning.

1.2.1 Supporting Learning with Computers: E-Learning

Early but prevalent methods to support learning with technology are computer-based training—for an individual workplace—and later on web-based training—focussing on communication [AKTZ11, p.18]. However, by now, supporting learning with computers is what is commonly referred to as *e-learning*[11]—where the "e" in e-learning stands for "electronic", indicating that is the learning process is in some way electronically guided, managed, or supported.

The term e-learning is commonly applied if computers in networks are employed to build the technological foundation for teaching and learning [ESN11, p.3]. E-learning can, therefore, basically be defined as *"the use of internet technologies to deliver a broad array of solutions that enhance knowledge and performance"* [Ros01, p.28]. Indeed, this

[10] For an in-depth consideration of the historical evolution in learning with computers—namely authoring systems, courseware, instructional design, intelligent tutoring systems, hypertext, and hypermedia—see the historical abstract by Helmut M. Niegemann et al. [NHD+04] or Rolf Schulmeister's extensive review [Sch97].

[11] Terms that can and have been used synonymously are computer-based training, web-based training, computer-based learning, online learning, or multimedia-based learning [Rey09, p.15]. However, the term e-learning became prevalent in scientific and practical usage [AKTZ11, pp.17f].

basic definition already implies a strong understanding of e-learning—that is learning by computer *and* internet.

Employing new media results in three leading functions of new media for learning—where each of them presents differing challenges to learners as well as lecturers [RRV03, pp.32ff]:

E-learning by Distributing. E-learning is what happens when a learner purposefully searches the internet for sources of information. The character of technology in this scenario is the *distribution of information*. The learner is, therefore, self-directed in collecting, processing, and implementing *learning from information*. [RRV03, p.32f]

Concerning challenges and requirements, a learner-friendly design of information is required to allow the formation of learning processes. Requirements are, altogether, rather high—in particular concerning learners. Learners are challenged in motivation, prior knowledge, media literacy, and the ability to learn self-directedly. [RRV03, p.34]

E-learning by Interacting. E-learning also occurs when a learner works through a web-based training. Technology, in this case, helps to offer didactically edited information and allows the acquisition of new content—that is *learning by interaction*. Hence, the learner is technically guided and *learning for feedback*. [RRV03, p.32f]

E-learning by interacting adds a professional design of instructions, exercises, tasks, and feedback to the list of requirements for lecturers or media designers. In contrast, requirements for learners are rather low due to the guidance delivered by instructions—however it still includes such basics as motivation and self-direction. [RRV03, p.34]

E-learning by Collaborating. Learning together in virtual classrooms or small groups also belongs to the group of e-learning scenarios. This is where technology puts different learners in touch with each other and allows *learning by collaboration*—in particular including *learning from different perspectives*. [RRV03, p.32f]

E-learning by collaborating builds on profoundly designed environments but adds the provision of a suitable social context—also with regards to content—as crucial element. Herein, again,

> requirements for learners are quite high: cooperation always requires a high degree of experiences in media, social competences, and, again, self-direction. [RRV03, p.34]

These three stages can also be found in IBM's 4-tier model [IBM02]. This models adds the superior level of *e-learning by collocation* that is implemented as a face-to-face level, actually allowing learners (and also lecturers) to meet, facilitating *experience-based learning*, and—in contrast to the first three stages—in particular supporting *informal learning*.

Of course, there a different strategies to define and foster e-learning. A completely different approach to active and interactive online learning is, for instance, promoted by Gilly Salmon [Sal06]: the *e-tivities*. E-tivities are designed as an efficient way to use new technologies in teaching and learning. An e-tivity, therefore, takes place online and requires at least two people working or learning together [Sal06, pp.3f]. It is based upon the use of a small piece of *information* (the "spark") to start an online activity—including an interactive or participative element—that is concluded by a summary or feedback; as a prerequisite all instructions needed are provided in one online message [Sal06, p.1]. E-tivities are fostered by using a five-stage framework as a model for learning—1) access and motivation, 2) online socialisation, 3) information exchange, 4) knowledge construction, and 5) development—where stages build on each other [Sal06, p.11].

Technology Enhanced Learning = E-Learning?

In contrast to e-learning, *technology enhanced learning* is a more comprehensive concept comprised of the widest range of technologies [Ebn12]. Learning and teaching is said to be technology enhanced whenever technologies are employed for teaching and learning scenarios [ESN11, p.2]. Technology enhanced learning is thus defined as teaching and learning through various electronic media [Rey09, p.15]—whereas media can be either used to 1) (re)present knowledge—that is for description and organisation—, 2) transfer knowledge—in other words for management and control—, or as 3) knowledge tool—that means for communication and cooperation [Ker01, pp.94ff]. As a consequence, technology enhanced is *multimedia-based*. However, in addition it also needs to be identified as being *multi-coded* and *multi-modal*. Technology enhanced learning, thus, employs *different media*—books, e-books, e-lectures, audio and video players, as well as computers—featured in *different encodings*—(hyper)text, images, or animations—that can be perceived using *different human senses*—mainly sight and hearing [Rey09, pp.16ff]. In other words, technology enhanced learning is comprised of a diverse concrete and organisational arrangement of electronic or digital media that can be used for the purpose of learning—individually as well as collectively—developed on the basis of information and communication technology [AKTZ11, p.18]—where the list of technologies actually utilised for learning (cf. section 1.4) is long and evolves constantly [ESN11, p.2].

Unfortunately, the two terms e-learning and technology enhanced learning are frequently used interchangeably—also due to an often wider understanding of e-learning that actually refers to technology enhanced learning. However, within the scope of this work, a tighter understanding of e-learning as explained above is employed.

To show that this narrow definition is actually not as tight as it seems to be at a first glance, a more figurative definition of e-learning—drawn by Elliott Masie [Ros01, pp.35ff] and offering several alternatives for the meaning of "e" in *e*-learning—is cited:

1) E is for *experience*—due to the fact that e-learning distinctly changes the experience of learning and, in turn, evolves and increases the experience level.

2) E is for *extended*—because it extends the number of learning options.

3) E is for *expanded*—for the simple reason that learning is expanded beyond the classroom.

Reasons for and Implications of E-Learning

E-learning was boldly overhyped at the beginning of the 21st century. This led to a number of misconceptions that Marc J. Rosenberg [Ros07, pp.18ff] transferred into nine myths of e-learning: 1) Everyone understands what e-learning is. 2) E-learning is easy. 3) E-Learning technology equals e-learning strategy. 4) Success is getting e-learning to work. 5) E-Learning will eliminate the classroom. 6) Only certain content can be taught online. 7) E-Learning's value proposition is based on lowering the cost of training delivery. 8) If you build it, they will come. 9) The learners are the ones who really count. Moreover, it is also crucial to understand that successful e-learning cannot be achieved by a simple transfer of traditional learning concepts to an online environment because a change of environment brings with it changing interaction, communication, and work practices. [TMK10, pp.132,135ff].

Nevertheless, there are valuable and decisive arguments that militate in in favour of e-learning[12]: E-learning is about *"specific improvements of knowledge, performance, and compentences* [ESN11, p.4]. Also, e-learning obviously allows for learning content, activities, and feedback to be delivered independently from place and time—that is learning any time and anywhere. In particular, e-learning offers the following additional potentials to be tapped [AKTZ11, pp.45ff]: 1) openness and variety of learning resources, 2) differentiation and diversity of teaching and learning activities, 3) autonomy and self-direction in learning, 4) new social contexts and new types of cooperation, and 5) presentation and discussion of learning results.

Considering *facets of learning* that can be supported using technology, it can said that e-learning and (most) e-learning environments build on *constructivism* [Kre11, pp.15f] that has been identified as a learning paradigm that in particular accentuates the active and constructive role of a learner and is, therefore, most suitable for learning nowadays (cf. section 1.1). Moreover, providing education that is computer- or even web-based allows the advantage of an independent access for learners—that is the opportunity for *self-directed learning* (cf. section 1.1.2) and the support of *informal learning* (cf. section 1.1.1) [RRV03, p.13]. Finally, e-learning is said to be a pathfinder for *lifelong learning* (cf. section 1.1.3) due to the fact that it helps integrate learning into working life and leisure time as seamlessly as possible.

1.2.2 Blended Learning

In the middle of the e-learning hype, a new phenomena emerged. Educators, teachers, and lecturers realised that not everything needs to

[12]The arguments delivered focus entirely on reasons benefiting the individual learner. For an argument for introducing e-learning into companies or universities, see [Ros01], [Ros07], and [Kre11] for further reading.

be black or white and, as a result, no longer saw the need to completely substitute traditional learning with e-learning. Rather, traditional teaching and learning was complemented by new learning technologies. Thus it happened that *blended learning* appeared on the scene in 2002 [Cro07, p.170][13]. Blended learning is, therefore, simply *"part of the ongoing convergence of two archetypal learning environments"* [Gra06, p.5]: traditional face-to-face and distributed learning environments.

As a consequence, everyday education today is not only face-to-face without using technologies *or* pure online learning [ESN11, p.6]—it is a deliberately arranged mix of both, concerning media and methods but also learning theories and strategies [RRV03, p.30].

> *"Blended is a transitory term. In time it will join programmed instruction and transactional analysis in the dustbin of has-beens. In the meantime, blended is a stepping-stone on the way to the future. It reminds us to look at learning challenges from many directions"* [Cro07, p.172]

Different attempts have been made to try and define this mix of learning styles. A very pragmatic approach is adopted by the Centre of Excellence in Teaching & Learning[14] at the University of Glamorgan—represented by Norah Jones [Jon06]—where blended learning is defined as an activity within a *continuum of blended Learning*. Four stages define this continuum of blended learning: At stage one, basic blended learning within this continuum starts at the moment when teaching and learning includes basic usage of information and communication technologies. Stages two—e-enhanced—and three—e-focused—gradually increase the usage of online resources whereas within stage four—e-intensive—whole modules are finally delivered online. [Jon06, p.168]

Definitions like this are, however, not precise in terms of methods as well as learning theories and styles. From the perspective of learning theories, blended learning allows and delivers an integration on three different semantic levels [RRV03, pp.38ff]:

[13] Blended learning is also referred to as hybrid learning and teaching, distributed learning, integrated learning, and flexible learning [RRV03, p.29]. The term blended learning, however, seems most prevalent which is why it is used throughout this work.

[14] Center of Excellence in Teaching & Learning—`http://celt.glam.ac.uk/`

Blending Theories. Blended learning illustrates an integrative conception of teaching and learning by allowing *a blend of learning theories*. Learning is, hence, a balance of learning according to instructional and constructional theories—however, based on a moderate constructivist (cf. section 1.1) setting. Blending in this way signifies an integration on a *normative level*. [RRV03, p.39]

Blending Methods. Moving on to the next level, blended learning uses *a blend of learning styles and methods* for the purpose of learning. Blended learning combines self-directed and guided learning, receptive practising and active exploring, as well as individual and cooperative learning. Blended learning, therefore, allows for an integration on a *strategic level* [RRV03, p.41].

Blending Media. Finally, blended learning is *a blend of learning media* to deliver learning. To literally transmit learning, a mix of different media elements such as face-to-face, online, and offline elements is employed—including the consideration of various implications those different elements bring with them. This mix thus establishes integration on an *operative level*. [RRV03, p.39]

In other words, blended learning is *"an integrated learning concept to optimally utilise currently available methods of networking via internet or intranet in conjunction with traditional learning methods and media within a meaningful learning arrangement"*. It enables learning, communication, informing, and knowledge management free from time and venue in combination with an exchange of experiences, role play, and personal meetings in classic classroom trainings. [SSB04, p.68].

How to Actually Blend?

At this stage there remains the question of how to actually blend. Charles R. Graham identifies three different categories of blends [Gra06, p.13f]: 1) enabling blends—primarily focussing on a greater learner flexibility—, 2) enhancing blends—incrementally changing learning pedagogics for either face-to-face or distributed environments—, and 3) transforming blends—radically changing pedagogics by allowing activities not possible within one of the basic scenarios without including the other. From a technological and systemic perspective, Andrea Back et al. [BBSS01, pp.217ff] define blended learning as an interplay of poles

Fleeting know-how	Lasting knowledge
Individual	Community
Generic	Proprietary
Training	Knowledge Sharing
Text	Visual
Self-directed	Guided navigation
Content focus	Experience focus
Exploring	Participating
Push	Pull
Personalised	One-size-fits-all
Skills	Values
Information	Transformation
Formal	Informal

Table 1.2: Dimensions of the blended learning stew [Cro06, p.xx]

within three different dimensions: The first dimension polarises virtual and non-virtual learning, whereas the second dimension contrasts mobile and stationary learning. The third dimension is comprised of four opposed pairs—local and distributed learning, static and dynamic learning, synchronous and asynchronous learning, as well as individual and collaborative learning.

In contrast, according to Jay Cross, the ideal blend is a blend of blends [Cro06, p.xx] with dimensions of the blended learning stew as shown in table 1.2 and where the individual opportunities do not imply a rating but that choice is up to teachers and learners [ESN11, p.6]. Interestingly, this blended learning stew also implies that a blend may contain no face-to-face elements at all since interaction comes in many forms: learner-to-instructor, but also learner-to-content, learner-to-learner, and learner-to-infrastructure [Cro07, pp.171f].

Why Blend at All?

Critics often emphasise that *"the term 'blended learning' tells nothing that is not already known"* [AKTZ11, p.118] which is why, finally, Jay Cross states that learning should not be imagined unblended. Instead of asking "Why blend?" we should ask ourselves "Why not blend?" [Cro07, pp.170f].

Elliott Masie [Mas06a] identified seven important reasons for learners and their teachers to implement and foster blended learning:

Multiple Perspectives on Content. By enabling different ways through the material and, hence, different learning processes, blended learning allows for *multiple perspectives on content* and supports different learning styles. [Mas06a, p.23]

Cognitive Rehearsal. The reprocessing of content by, for instance, talking about it is what is called cognitive rehearsal—an experience that is often richer for the speaker than for the listener. Blended learning in particular fosters *cognitive rehearsal* by facilitating and encouraging an active participation of learners. [Mas06a, p.23]

Context is Often More Important Than Content. Context is of importance in learning. Due to their variety, face-to-face as well as other interactions enable the *addition of context* for learners. [Mas06a, p.24]

Value Sorting is Core to Blended Learning. Learners always face the challenge to sort learning content by value. Multiple processes, models, and applications increase a learner's *ability to sort*. [Mas06a, p.24]

Learning is Longitudinal. It is important to acknowledge that learning is sometimes accomplished over time. This kind of knowledge acquisition can be nicely supported by a flexible model like blended learning. [Mas06a, pp.24f]

Learning is Social. Social experience is crucial to human beings. Learning is one such *social experience*—even though often unrecognised in traditional settings. Blended learning *"aligns with the social dimensions of learning"*. [Mas06a, p.25]

Learning is Often Tacit and Unstructured. Due to its nature, blended learning enables the integration of personal experiences into learning—that is *informal* and *non-formal* learning.[Mas06a, p.25]

The imperative, according to Elliott Masie, is *"to accept and embrace blended learning"* [Mas06a, p.25]—just as great learning will always have an "e" in it, it will also always be blended.

> *"Blended learning is an imperative. It reflects the blended nature of our world, our workforce, and the natural process of how people really learn."* [Mas06a, p.26]

This conviction is, among others, also approved by the trend monitors "MMB Learning Delphi"[15]—which names blended learning as central to learning within organisations in the three years since 2009 (96% for 2009 [Ins09, p.2], 91% for 2010 [Ins10, p.1], and 92% for 2011 [Ins11, p.1]).

1.2.3 E-Learning 2.0—The Next Level?

In relation to current or future developments in e-learning, what has been described so far is commonly phrased as *e-learning 1.0*: Learners are provided with high quality learning material by a teacher or lecturer via a learning management system (cf. section 1.4). Hence, e-learning 1.0 is simply a means of accomplishing traditional learning with new media [Ebn07, p.1236]. *Blended learning* (cf. section 1.2.2) means not solely relying on new media, but explicitly blending these new technologies with traditional learning.

E-learning 2.0—a buzz word for a new way of learning—therefore sets out to foster what was already intended with e-learning 1.0 but has been missing so far: a more constructivistic setting (cf. section 1.1) for learning by employing Web 2.0 technologies. *Web 2.0*[16] is a collective term—not for new technologies but a socio-technically different usage of the internet [LSb]. Two attributes describe the heart of the changes that come with Web 2.0[17]: 1) the internet changes *"from*

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[15] The "MMB Learning Delphi" is a trend monitor published annually by the Institute for Media and Competence Research (MMB)—`http://www.mmb-institut.de/english/profile.html`—based on surveys conducted with learning experts from throughout the German-speaking world.

[16] The term "Web 2.0" itself arose in 2005 and was essentially coined by Tim O'Reilly with his famous article "What is Web 2.0? Design Patterns and Business Models for the Next Generation of Software" [O'R05].

[17] For a more detailed description of seven principles defining Web 2.0 see Tim O'Reilly's influential article [O'R05].

me to us" and 2) instead of a pure information supplier, the internet is now a platform for active users who also create content—that is simply a shift from consumers to prosumers of web content where *social software*[18] is a motivating factor [AKTZ11, p.66]. For these reasons, the appendix "'2.0" is associated with a positive enhancement, future trends, a change of paradigms, and often a more active involvement of users which is why this phrase is likely to be transferred to other branches such as e-learning. For that reason, e-learning 2.0 is also especially connected to the concept of *social learning*[19].

E-learning 2.0, therefore, describes what is likely to be depicted as desired current—or at least future—mode of learning. It is defined by the use of social software for learning and an active usage of the internet to collaborate, design, publish, and distribute own content [HPLK08, p.16]. Being more precise, e-learning 2.0 can also be discovered by depicting its characteristics. Describing the way of learning, a *facilitation of content authoring*—enabling a more active role for learners—*knowledge and information sharing*—inherent in many of the new tools and technologies—a *diversity of learning content and media*—also resulting from new tools and user-generated content—and a new *ease of collaborative learning* due to easy-to-use tools for interaction and collaboration embedded in learning environments is what e-learning 2.0 brings with it. Regarding the actual content of learning, e-learning 2.0 results in using micro content and other Web 2.0 features to create learning experiences, a greater leveraging of "collective intelligence", "wisdom of crowds", and growing social networks for learning, and the facilitation of "rapid e-learning"—by using blogs, wikis, podcasts etc. [Tro18, pp.3f]. In other words, this development accepts and meets of

[18] The fuzzy term "social software" evolved in the 1990s and is, typically, used as a label for software allowing users to communicate, to build social connections, and to work together [Brü07]. For an explanation of the historical evolution of social software see Christopher Allen's blog post [All04]. Today, social software is comprised of tools such as weblogs, wikis, podcasts, and web sharing applications [Ebn07, pp.1236f] and, in particular, social networking sites.

[19] The concept of *social learning* may be defined as *"a change in understanding that goes beyond the individual to become situated within wider social units or communities of practice through social interactions between actors within social networks"* [REC+10]. John Seely Brown suggests *"a shift between using technology to support the individual to using technology to support relationships between individuals"* to be the essence of social learning and a step toward *"a more general culture of learning"* [Bro02b]

one of the challenges of future learning (cf. section 1.3) as depicted by Marc J. Rosenberg: it breaks the bonds of the course [Ros01, p.307].

> *"This approach to learning means that learning content is created and distributed in a very different manner. Rather than being composed, organised and packaged, e-learning content is syndicated [...]. It is aggregated by students [...]. From there, it is remixed and repurposed with the student's own individual application in mind, the finished product is being fed forward to become fodder for some other student's reading and use."* [Dow05, p.8]

Most importantly, e-learning 2.0 is not just a bunch of applications but the idea of adopting new practises in learning [Kar07]. Such a substantial change in learning culture, of course, also brings along pedagogic implications for learning: Learners are no longer just learners, but learners *and* tutors—which in turn means that not every learning content has a profound didactic design [AKTZ11, p.67]. Moreover, e-learning 2.0 is, in particular, expected to support *self-directed learning* [HPLK08, p.16]—which is, however, also a key prerequisite for this kind of learning [AKTZ11, p.167]. Hence, learners have to take over responsibility for their learning.

Overall, e-learning 2.0 is *not* simply the application of Web 2.0 technologies to traditional teaching and learning but the demand for new concepts and approaches to learning [Ebn07, pp.1238f]. According to Stephen Downes it needs to be recognised that *"the learning comes not from the design of learning content but in how it is used"* [Dow05, p.8].

Within this section supporting learning with technology—that is *e-learning in general*, in its special form of *blended learning*, and its latest representative *e-learning 2.0*—has been explored. However, the question how this support might change learning remains. The next section, therefore, proposes a *definition for modern learning.*

1.3 Modern Learning—a Definition

Modern life brings greater chances and choices for individuals, but also greater risks and uncertainty [Com10, p.7]. So does *modern learning.*

The book "New Learning" [SvdLD00b], published in 2000, examined whether there is actually a new way of learning—bringing with it new learning outcomes, new kinds of learning processes, and new instructional methods. As a contribution to new learning as defined at the time, three major differences in learning were identified and proposed [SvdLD00b, p.vii]:

- ▷ Attention is given to *active*, *independent*, and *self-directed* learners (cf. section 1.1.2)—also due to a rising significance of the concept of *lifelong learning* (cf. section 1.1.3).
- ▷ As a result, there is a growing awareness of the need for learners to acquire knowledge on how to learn—including cognitive, metacognitive, motivational, and resource-based learning strategies [Kil08, pp.4ff] (cf. section 1.1.2)—and the ability to learn collaboratively.
- ▷ All these changes are a consequence of a shift regarding learning theories (cf. section 1.1). In contrast to previous developments in learning, this evolution results from a shift to *constructivism* and utilises empirical research as a foundation for learning.

Considering facets of learning as defined in the previous sections, these three aspects already provide important indications for modern learning. However, as one would expect, the past decade carried some additional significant changes. For that reason a comprehensive definition of modern learning—as it is today and may be in the future—is proposed by using three components of learning as defined by Shirine Voller et al. [VBC11]: *context*, *learning* itself, and *learners*.

1.3.1 Modern and Future Contexts of Learning

Context is, in general, extremely important to memory and, very often, can be a trigger to recall certain information. Hence, if context is of importance in memory, it certainly can be of help in learning.

Contexts for learning are the *"political, environmental, social, and technological changes that we face now and may face in the future"* [VBC11, p.3]. Whereas political and environmental changes are harder to grasp—and actually beyond the scope of this work—it should be clear from the previous sections that technological change affects learning: What is, by now, known as *traditional learning* changed to *technology enhanced learning* and is, maybe, on its way to *E-Learning 2.0*. Aside from a general technological progress, this change can—to a great extent—be attributed to the rise of the internet. In particular, the spreading and intensification of internet usage and, specifically, the penetration of everyday life by the internet resulted in a huge growth of abilities: abilities 1) to communicate—also through blogs and social networking sites—, 2) to access information and resources, and 3) to produce content [TMK10, p.130]. These abilities combined with the capability of doing all this in a mobile, personal, and global way [TMK10, p.130] result in a comprehensive change of the *technological context* for learning.

Of comparable importance is the *social context* for learning. In other words—quoting David A. Wiley [UB12]—if social interaction and other people were not an indispensable perquisite for obtaining answers to one's own questions, universities would never have developed from libraries. This is why the usage and integration of technology in learning induced a fundamental change of our *social context* for learning. Possibilities, opportunities, and occasions to interact with others throughout the world completely changed. In fact, some even argue that this change is so fundamental that learners today *"are no longer the people our educational system was designed to teach"*. [TMK10, p.129]

Overall, changing these contexts results in an alteration and widening of learning situations—that is the incorporation of not just formal education but also non-formal and informal learning (cf. section 1.1.1)—and, altogether, in a re-definition or a new conceptualisation of *worthwhile knowledge* [TMK10, p.140].

1.3.2 Modern and Future Learning

Considering learning itself—and even though technology seems to be the catalyst for modern and future learning—learning should not be driven by advances in technology. Among others, due to the fact that *"technology, quite simply, is not here to stay"* [Gru11, p.55]. Current technology will soon be superseded by more powerful tools—that we maybe cannot even imagine today [Gru11, p.55]. It is, therefore, quite the contrary: technology exists *"to serve the interests of education"* [TMK10, p.129]. Therefore, it is not technology itself that is most interesting to future learning but *"how it reflects, allows for, and stretches the ways in which we learn"* [VBC11, p.49]. In other words, technology in learning is assigned two major roles: 1) it simplifies existing learning processes and 2) it changes the way we are thinking [VBC11, p.49]. This is reflected in the fact that *"media is no longer what we do, it is something we became part of"* [Rob03]. As a result, there is no longer the need to differentiate "e" from "non-e" [Ros01, p.311]: e-learning is no longer a technical possibility but an ubiquitous and natural reality [Rob03].

To further define modern and future learning, it is possible to draw on the three elements of learning—learning outcomes, learning processes, and instructional methods for learning—as employed by Robert-Jan Simons et al. [SvdLD00a]:

Learning Outcomes in modern and future learning need to be defined on two different levels. In general, learning outcomes are intended to be durable, flexible, functional, meaningful, generalisable, and application-oriented [SvdLD00a, pp.1f].

There is, however, a superior level of learning outcomes that is of the utmost importance for modern learning[20]. This level is comprised of so-called *meta-learning*—that is the essential accomplishment of learning how to learn in order to improve learning performance [Cro07, p.77]. Among others, this ability includes self-empowerment, knowing and choosing the best way to learn—individual, group, debate, or triage—and the best sources of learning, personal knowledge management—that is capturing and reflecting one's tool kit (cf. chapter 4)—forming powerful relationships—with mentors, colleagues, and information sources—continuous reflection, and moving to a reinforcing learning environment.

Learning Processes are those courses of action needed to actually reach learning outcomes. According to Robert-Jan Simons et

[20]Even though Robert-Jan Simons et al. [SvdLD00a, p.2] claim this to be a new kind of learning outcome, "learning to learn" is considered to be learning outcome that has been around for a while. Peter Drucker, for instance, already claimed learning to learn to be an essential skill within a knowledge society in 1992 (his book was—though published in 1994—written in 1992) [Dru94, p.201]. The claim is, therefore, that *learning to learn* has previously not been emphasised as much as it is today.

al. there are three ways of learning: 1) guided learning—where a teacher, tutor, or lecturer takes all the decisions and sets the learning goals learners are supposed to follow—, 2) experiential learning—describing learning rather determined by various factors such as personal motivation or experiments than defined by explicit learning goals—, and 3) action learning—where learning directed by an active learner and self-determined learning goals are the key aspect [SvdLD00a, pp.3ff].

In modern and future learning an emphasis is on a shift towards *experiential learning*—comprising discovery-oriented, contextual, problem-oriented, case-based, social, and intrinsically motivated learning—and action learning—including active, cumulative, constructive, goal-directed, diagnostic, and reflective learning [SvdLD00a, pp.6ff].

Out of these, modern learning currently in particular accentuates *social learning* and the usage of *social software* for learning—that is *e-learning 2.0*.

Instructional Methods for Learning foster the attainment of learning outcomes through a facilitation of learning processes. Therefore—building on learning processes—instructional methods need to deliver process-oriented instruction on *what* and *how* to learn [SvdLD00a, pp.9ff]. For modern and future learning, instructional methods, in particular, need to be of assistance in achieving what has been described as superior level of learning outcomes—that is in acquiring the skills for meta-learning.

In addition, following Douglas Thomas and John Seely Brown [TB11], a new way of instruction—in particular addressing the shift towards more active and self-directed learners—is suggested: *bounded environments* yet providing a complete freedom of action within those boundaries. Thomas and Brown compare this "defined" scope of action to a contemporary notion of play and games—where play is defined as *"the tension between the rules of the game and the freedom to act within those rules"*. [TB11, p.18]

Instruction, by definition, is a direction, order, or detailed information about how something should be done [Oxfa]. Therefore,

> what has just been suggested might be conceived as being contradictory to instruction. However, considering the demands on modern learners, it seems to be a justified claim—offering the potential to find a new balance.

Learning, all in all, is considered to be *more flexible* for learners. This trend has, for instance, already been depicted by Curtis J. Bonk et al. [BKZ06, pp.560ff] when identifying *mobile* blended learning, *self-determined* blended learning, *greater individualisation*, and an *increased connectedness* as four (out of ten) future trends for blended learning.

To summarise, modern learning does not set out to eliminate traditional learning but lays emphasis on particular aspects such as more self-direction and choices in learning. But this does not just mean that we merely cram our old classrooms with new technology. In addition to traditional learning—where *experts* as teachers, tutors, or lecturers teach *one-to-many* largely within a *classroom* [Gru11, p.53]—learning is now complemented by what is likely to be called *new learning*. New learning means that, basically, *everybody* is able to impart knowledge to *everyone* using *one-to-one*, *one-to-many*, or *many-to-many* communication in a *custom-defined environment* that is not restricted by place or time constraints. Thus, learners can decide to learn from a "sage on the stage", a "guide on the side", or the "crowd in the cloud" [Gru11, p.67].

However—at least to this day—it is not imaginable to completely withdraw from traditional learning and education. Even though changed by technology and supplemented by new learning, only on rare or special occasions will traditional learning be completely substituted. Hence, the combination of traditional learning *and* new learning—defined by new learning outcomes, new learning processes, and new instructional methods for learning—is what is meant by *modern learning.*

1.3.3 Modern and Future Learners

Learning transforms who we are and what we are able to do—it is an experience of identity. Moreover, learning is *"not just an accumulation of skills and information, but a process of becoming"* [Wen02, p.215]. The question that needs to be answered is, therefore, actually quite simple: What does a modern learner need to be able to become who he or she intends to be? What specifics are entailed in modern learning that need to be mastered by modern learners?

What a modern and, especially, a future learner should be like, is, in particular, reflected in the key competences defined as requirements for *lifelong learning*—and therefore basic requirements for modern and future learners: Key competences defined within the reference framework of the European Union [Eur18] are 1) communication in the mother tongue, 2) communication in foreign languages, 3) mathematical competence and basic competences in science and technology, 4) digital competence, 5) learning to learn, 6) social and civic competences, 7) sense of initiative and entrepreneurship, and 8) cultural awareness and expression.

Considering the definitions given above, what needs to be additionally elaborated upon are the requirements on learning to learn: Modern and future learners are demanded to be *independent* and *active*, have a high level of *self-direction*, and be able to *reflect* their own learning. Moreover, it is assumed that learners are able to learn and work *collaboratively*. A learner, thus, needs to be equipped with the ability to *organise, manage, and master their own learning*—for the following simple reason:

> *"Instead of learning solutions to yesterday's problems, people need to learn how to deal with the unknown. In the real world, the issues we face are ones that no one knows the answers to."* [Cro07, p.175]

Comparing these descriptions to the findings of Robert-Jan Simons et al. [SvdLD00b]—described at the beginning of this section—it becomes evident that these findings could be validated and have in fact even been strengthened in the last decade.

Overall, these skills and abilities are what is considered to be indispensable to master future learning and its challenges that are already in place. These include, to name just a few as identified in the Horizon Report[21] Higher Education edition of 2012, *mobile apps* and *tablet*

[21] The Horizon Report is a yearly publication of emerging technologies *"likely to have a large impact over the coming five years in education around the globe"* [Rob16]. The 2012 report is the 10th edition of this series and—as every year—a collaborative effort of the New Media Consortium (NMC)—`http://www.nmc.`

computing as emerging trends with a time-to-adoption horizon of one year or less. *Game-based learning* and *learning analytics* are supposed to be trends for adoption in two to three years, whereas *gesture-based computing* and the *Internet of Things* is attested with a four to five year horizon [New12]. Other challenges might be demonstrated by future visions of a new way to read text—that is, for instance, text 2.0[22] presented by the German Research Center for Artificial Intelligence[23] [Deu09].

To summarise, *modern learning* is depicted using the six strings of *authentic learning* defined by Ben Wilkoff [Wil], but using a broader interpretation. These strings emphasise that learning is not a single assets—a single note in this picture—but a chord—that is a combination of different assets or notes. Thus, learning is constituted by six strings representing learning as *contextual*, *connected*, *collaborative*, *change-directed*, *conversational*, and *continuous* all in one.

To illustrate *future learning* a picture described by Stephen Downes is employed:

> *"Learning integrates into every aspect of our lives [...]. Learning and living, it could be said, will eventually merge."* [Dow05]

Finally, concluding this definition for modern learning it needs to be noted that this section was explicitly *not* dedicated to a new definition for learning that is generally and unlimitedly applicable for future learning. Instead what has been depicted above, represents a *definition of modern learning* in particular taking into account developments of the last decade. This definition provides the understanding of learning up to date—specifically comprising *facets of learning* as described in section 1.1—and is employed for the scope of this work.

To further elaborate the concept of modern learning, an overview of *tools* that have, can, and will be used for modern learning is presented in the next section.

`org/`—and the Educause Learning Initiative (ELI)—`http://www.educause.edu/eli`. It delivers three editions: a higher education edition—being the flagship of the Horizon Reports [Rob16]—a K-12 edition, and museum edition.

[22] Text 2.0 project web page—`http://text20.net/`

[23] German Research Center for Artificial Intelligence—`http://www.dfki.de/web/welcome/`

1.4 Tools for Modern Learning

What the definitions and developments depicted in the last section should have revealed is the variety of teaching and learning today. In turn, this results in a variety of tools that can be employed for modern learning, in particular, since not just tools designed specifically for learning are employed to learn[24]. This assumption is easily proven by consulting the study *Top 100 Tools for Learning*[25] [Cen11] which were listed as follows:

1) Twitter[26]—micro-sharing site
2) YouTube[27]—video-sharing tool
3) Google Docs[28]—collaboration suite
4) Skype[29]—instant messaging/voice-over-IP tool
5) WordPress[30]—blogging tool
6) Dropbox[31]—file syncing software
7) Prezi[32]—presentation software
8) Moodle[33]—course management system
9) Slideshare[34]—presentation sharing site

[24] A very extensive consideration of future online learning, in particular concerning technological support and tools has been written by Stephen Downes [Dow08] and can be consulted for an in-depth consideration of the whole range of technologies and tools.

[25] Top 100 Tools for Learning is a study that is annually conducted by the Centre for Learning and Performance Technologies (C4LPT)—`http://c4lpt.co.uk/`—since 2007. Learning professionals worldwide are requested to list their top 10 learning tools and these listings are compiled to the comprehensive top 100 list. The study and results of 2011 incorporated 531 learning professionals. [Cen11]

[26] Twitter—`https://twitter.com/`

[27] YouTube—`http://www.youtube.com/`

[28] Google Docs—`http://www.google.com/docs/`

[29] Skype—`http://www.skype.com/intl/en/home/`

[30] WordPress—`http://wordpress.org/`

[31] Dropbox—`https://www.dropbox.com/`

[32] Prezi—`http://prezi.com/`

[33] Moodle—`http://moodle.org/`

[34] Slideshare—`http://www.slideshare.net/`

10) (Edu)Glogster[35]—interactive poster tool

Thus, according to this study, Twitter is the number one learning tool—already for the third year in a row—directly followed by YouTube—which is also in the top three for the third year. It is not until rank eight that the first "real" learning tool makes this list. Clearly there are a wide variety of applications that are able to be employed for learning.

Therefore, to provide an overview of the tools, three levels of technical and system oriented design—as defined by Helmut M. Niegemann et al. [NHD+04, pp.248ff]—are merged into two categories and used to structure this section: *basis technologies* and *learning technologies & e-learning systems.*

1.4.1 Basis Technologies

Basis technologies supporting modern learning are basis applications and infrastructure components. This group of tools, therefore, includes all applications *not* initially designed to support technology enhanced learning.

Seven subcategories can be used to categorise basis technologies by purpose: 1) provision of information, 2) synchronous and 3) asynchronous communication, 4) production, 5) evaluation, 6) administration, and 7) hardware or systems software [NHD+04, pp.248f]. Since within the scope of this work the focus is on learners and not learning providers, the first four subcategories are now explored.

Provision and Production of Information

Providing digitally edited information to learners or searching this kind of information as a learner is, for sure, one of the fundamental applications within a digital environment. Basis technologies within this category are, therefore, techniques drawn from the area of *information*

[35] (Edu)Glogster—`http://edu.glogster.com/`

retrieval[36]—in particular their most famous representatives: search engines. [NHD+04, p.249]

> *"Google is the world's largest learning provider, answering thousands of inquiries every second."* [Cro07, p.177]

However, applications within this category are not necessarily as complex as a search engine crawling the internet. Consulting our top ten list, GoogleDocs, WordPress, Dropbox, Prezi, Slideshare, and (Edu)Glogster can be assigned to this category.

Synchronous and Asynchronous Communication

Obviously, communication can be identified as a core concept of learning. For modern learning two kinds of communications are distinguished: *synchronous* and *asynchronous communication*.

Synchronous communication comprises more elementary technologies such as chat or instant messaging but also more comprehensive applications for audio and video conferences or an application sharing [NHD+04, p.249]. Glancing over our top ten list again, Skype is the only tool allowing for a synchronous communication.

In contrast, possibilities for *asynchronous communication* seem to be more versatile. Basis technologies such as e-mail and newsletters or forums are widespread. Concerning tools from our top ten list, Twitter and Youtube can be added as asynchronous communication services.

In fact most of the web technologies and applications can be assigned to the category of basis technologies due to the fact that they have not initially been designed for the purpose of learning. Concerning the assignment to subcategories, it has to be noted that those assignments are, by no means, unique and exclusive. Depending on their actual usage, tools can be assigned to various categories.

[36] Information retrieval is a field of study generally concerned with searches. According to Ricardo Baeza-Yates and Berthier Ribeiro-Neto it is comprehensively defined as follows: *"Information retrieval deals with the representation, storage, organisation of, and access to information items such as documents, Web pages, online catalogs, structured and semi-structured records, multimedia objects. The representation and organisation of the information items should be such as to provide users with easy access to information of their interest."* [BYRN11, p.1]

1.4.2 Learning Technologies & E-Learning Systems

Moving along the categories, *learning technologies* follow and build on basis technologies. Learning technologies integrate a number of basis technologies. However in contrast to basis technologies, learning technologies comprise applications directly concerned with e-learning—that is a predetermined field of application—and are supposed to follow the learning process.

Hence, applications are likely to be either classified as basis *or* learning technology. Where technologies supporting meetings are only basis technologies within a particular scenario, a learning scenario such as Computer Supported Cooperative Work (CSCW)[37]—especially building on communication for learning—might consider applications supporting meetings as learning technologies. [NHD+04, p.250]

Frequently, learning technologies are building blocks for *e-learning systems*—that is single parts of e-learning systems. In contrast to learning technologies, e-learning systems are characterised by means of data and content—solidifying the field of application. [NHD+04, p.253]

E-learning systems are web-based systems building on a *"server-sided software installation allowing to mediate arbitrary learning content using the internet and supporting the organisation of necessary learning processes"* [BHMH02, p.24]. Required areas of operation are, for instance[38], described using six categories [AKTZ11, pp.59ff]—that is e-learning systems are required to support and/or provide 1) proposition and information, 2) planning and administration, 3) a media library and work results, 4) an interface to application software, 5) communication and cooperation, and 6) assessment and evaluation.

Finally talking tools, content management systems (CMS), learning management systems (LMS), and learning content management systems (LCMS)—a combination of content and learning management

[37] Computer Supported Cooperative Work or Computer Supported Collaborative Work (CSCW) refers to working in teams to collectively perform a task—where, in particular, communication, coordination, decisions, and working on task is supported by technology [LSa]. CSCW in particular aims to foster efficiency and simplicity in working together in distributed teams [Ger07, p.145]. For a detailed introduction to CSCW, collaborative systems, and applications see [Ger07].

[38] Required areas of operation are defined in differing ways. A good overview of different categorisations and the evolution of areas of operation can be found in [AKTZ11, pp.57ff].

systems—also have to be listed. However, to date, *learning management systems* are the dominant technology for the organisation and delivery of online courses [Dow05, p.x]. Revisiting our top ten learning tools introduced at the beginning of this section, Moodle is a learning management system implementation.

There is quite some debate about the future of learning technologies, tools, and systems, which very often focuses on the question weather learning management systems have a future or not [Gnä23][Bac23]. Most educators agree in confirming that learning management systems have a future, but perhaps define this future somewhat differently.

Possible directions for future learning systems—in particular meeting the challenges of social learning and social learning environments—are, for instance, described by Michael Kerres et al. [KHN11]. Three possible paths to be followed had been identified—that is abandonment of learning systems, utilising community tools, or social learning systems [KHN11, pp.7ff]—whereas the third one—*social learning systems*—is their declared choice to illustrate future learning. According to Kerres et al., a social learning system will not primarily differ from current learning management systems concerning available functionalities but regarding *presentation* and *focus* [KHN11, p.9]. In particular, four key aspects are suggested: 1) a focus on *activities*, 2) *permeability* to the internet, 3) the *mapping of social relationships*, and 4) options for *privacy* in perceiving, contributing, and performing [KHN11, pp.10ff].

A slightly different approach to *social learning environments* is presented in the "Social Learning Environment Manifesto" by Matt Crosslin [Cro10]. According to Crosslin, a social learning environment pursues two different goals: 1) to aggregate a student's personal learning networks and 2) to make a teacher's administrative tasks easier in the process.

So, clearly, the end of the line has not been reached regarding tools for learning, as there is more to come.

2 What Learners Learn

"To know is nowhere near knowing what you are talking about."

Gabi Reinmann, Martin J. Eppler
[RE08, p.18]

Being aware of *how* learners learn—to be able to talk about support for learners, we have to ask ourselves what it is that learners want to achieve and need to be supported in. Therefore, it needs to be settled *what* learners learn or aim to learn. In turn, this requires thinking about *educational objectives* or *learning targets* since these goals are supposed to deliver a guideline for what can and needs to be managed. Learning targets are commonly classified into three dimensions [Blo68, p.7]:

- ▷ Firstly, *cognitive learning targets* cover all objectives related to remembering and recalling knowledge, thinking, problem solving, and creating. This dimension, therefore, deals with recall or recognition of knowledge and the development of intellectual abilities and skills.
- ▷ Secondly, *affective learning targets* can be aimed at but are more hard to conceptualise. Objectives can be described as changes in interest, attitudes, or values, as well as the development of appreciation and adequate adjustment.
- ▷ Finally, *psychomotor learning targets* refer to motor skills or, in other words, actions requiring neuromuscular coordination.

However, it has to be noted that a learning target will somehow always incorporate all three of these dimensions. It is therefore more appropriate to talk about cognitive, affective, or psychomotor *accentuated* learning targets [Stab]. Nevertheless—using these dimensions to

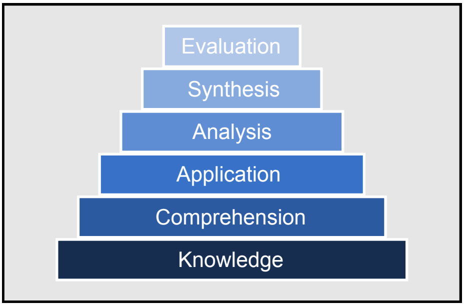

Figure 2.1: Bloom's taxonomy of learning [Blo68, p.18]

set the scope of this work—the primary scope can be found within the cognitive, or cognitive accentuated, dimension.

Different taxonomies of educational objectives can be found to analyse this dimension. One common taxonomy of educational objectives within the cognitive dimension is Benjamin S. *Bloom's Taxonomy* [Blo68, p.18] as shown in Figure 2.1 where concepts are ordered bottom-up from simpler to more complex behaviours. This educational-logical-psychological classification system was developed by a group of college and university examiners in the 1950s in order to represent the intended outcomes of the educational process—that is the intended behaviour of students—without classifying the particular subject matter or content[1].

Since this taxonomy can look back on more than 50 years of utilisation, several revisions of this original taxonomy have been developed: A comparatively new revision of this taxonomy has, for example, been provided by Lorin W. Anderson et al. in 2001 [And06]. This revision introduces two different dimensions: the *cognitive process dimension* and the *knowledge dimension*. Whereas the cognitive process dimension contains the six categories *remember*, *understand*, *apply*, *analyse*, *evaluate*, and *create*, the knowledge dimension comprises the four categories *factual*, *conceptual*, *procedural*, and *metacognitive*. An even more recent revision was provided by Robert J. Marzano and John

[1]The findings that emerged from the work of this group also include a taxonomy for the affective domain [KBM68] which is not considered here due to reasons of simplification and scope. However when delving into the subject of educational objectives this taxonomy should also be considered.

S. Kendall in 2007 [MK07]. Although their taxonomy maintains six levels, the levels themselves have been renamed and revised in the following way: *retrieval*, *comprehension*, *analysis*, *knowledge utilisation*—all so far within the cognitive domain—*metacognitive system*, and *self-system*. While those levels outline the *levels of processing*, a second dimension is comprised of the *domains of knowledge*—*psychomotor procedures*, *mental procedures*, and *information*.

Of course, there are other different taxonomies and further revisions of the original taxonomy defined by Bloom's group of experts[2]. However, all of those are—at least to some extent—based on or can be related to Bloom's Taxonomy, which is why this taxonomy is used for the purpose of this work.

To summarise and try to give a more precise definition of what it is that learners actually aim to learn, put simply, *knowledge* is defined as the (desired) basic outcome of any learning process and experience—neither by disregarding pedagogics and learning psychology nor by going into great detail. By outlining educational objectives, it should also become clear that learning and knowledge are closely interrelated. In a way, learning and knowledge are different perspectives on the same phenomenon [RE08, p.13]:

- ▷ As defined in the previous chapter, *learning* is a process eluding direct observation based on two fundamental conditions: 1) learning leads to comparably permanent changes in behaviour and 2) learning aims to be the result of exercises and experience.
- ▷ According to the perspective of developmental psychology, *knowledge* is the result of human acting and cognition—based on cognitive structures of individuals. These structures, in turn, are the result of an active examination of individuals with their surrounding environment—hence, the result of learning [RE08, p.13].

Therefore, definitions and differentiations of *knowledge* are examined in the first section of this chapter, whereas the second section deals with *knowledge work and knowledge workers* as a more general kind of

[2]For further reading see the comparison of Bloom's taxonomy and 11 unidimensional alternative frameworks [And06, pp.262ff] as well as a comparison of Anderson's revision and 8 multidimensional alternative frameworks [And06, pp.276ff] drawn up by Lorin W. Anderson.

learner—since almost every human action is in a way knowledge-based [RE08, p.12].

2.1 Knowledge

Knowledge is a term that is used frequently—in everyday language and in professional terminology. However, its meanings are quite divergent. Very often knowledge is used interchangeably with skills or abilities. Documented results—as for example in encyclopaedias—are also referred to as knowledge. In addition, people are also likely to talk about "knowing something" when actually stating that they understood the value of something or learnt something out of personal experiences throughout life. [RE08, p.18]

The origins of the term itself can be traced back to the area of philosophy and two of its perhaps most famous representatives—the ancient philosophers Plato and Aristotle. Interestingly enough—even though Aristotle was Plato's student—these two Greeks already disagreed with regards to defining knowledge: where Plato defines knowledge as "justified, true, and believed" achieved because of prenatal knowledge, Aristotle argues that knowledge is abstraction gained by experience and reflection. These roots were strengthened and continued by the two mainstreams of modern epistemology: Continental rationalism—represented by René Descartes—and British empiricism—shaped by John Locke. This dispute can be looked upon as symbolic for definitions of knowledge today as there are several well-founded but though controversial definitions of knowledge depending on the purpose of usage. [SH10a, p.427]

Therefore to offer an initial broad—but established—definition, the Oxford English Dictionary is consulted:

> *"knowledge, noun 1) facts, information, and skills acquired through experience or education; the theoretical or practical understanding of a subject: i) the sum of what is known, ii) information held on a computer system, iii) philosophy: true, justified belief; certain understanding, as opposed to opinion; 2) awareness or familiarity gained by experience of a fact or situation."* [Oxfb]

Knowledge is	Behaviourism	Cognitivism	Constructivism
created by being	deposited	processed	constructed
defined as	a correct input-output-relation	an adequate internal processing	the ability to cope with a situation

Table 2.1: Definitions of knowledge according to the three learning paradigms [BP94, p.110]

However, this broad definition is—though reasonable—not specific enough for the purpose of this work. Approaching a simple definition of knowledge within in the context of learning, Peter Baumgartner and Sabine Payr [BP94, p.110] define knowledge according to the three general learning paradigms—introduced in chapter 1.1—as shown in table 2.1.

Nevertheless, even though a definition for knowledge as learning outcome is sought, the basic scientific definitions and distinctions of knowledge first have to be outlined—especially since most knowledge management books would argue that the definitions and examples given above should be referred to as information rather than knowledge [RE08, p.18].

Therefore, the traditional *data-information-knowledge-wisdom-chain* will first be examined, followed by a brief consideration of *knowledge taxonomies* to satisfy the foundations of science. Yet—despite the fact that knowledge is perhaps one of the most personal "things" a human being can own—all of these definitions are so far somewhat impersonal. On this account, the last part of this section delivers a different but more individual-related approach to defining knowledge based on the distinction between *personal* and *public knowledge*.

2.1.1 The Data-Information-Knowledge-Wisdom Chain

An extensive review of the data-information-knowledge-wisdom chain has already been conducted and published in [SH10a] and is also referred to for an in-depth consideration. However, a brief summary of the most important definitions will be given below.

It is with some surprise that the first reference to this chain stems from a completely different field—namely that of the dramatic arts, and in particular the words of the dramatist Thomas Stearns Eliot, who, in “The Rock”, proposes the following significant question:

> *“Where is the life we have lost in living? Where is the wisdom we have lost in knowledge? Where is the knowledge we have lost in information?”* [Eli34, p.7]

As if in response to this issue, two different branches in the field of information technology—*information science* and *knowledge management*—continued to strengthen the definitions along this chain. While Harlan Cleveland [Cle82], the information scientist, proposed the three level hierarchy information, knowledge, and wisdom, Milan Zeleny [Zel87] and Russell L. Ackhoff [Ack89], two pioneers of organisational theory and knowledge management, defined an extended four and five level hierarchy: data, information, knowledge, (understanding,) and wisdom.

Data. Zeleny defines data (and information) to be *“piecemeal, partial, and atomised by their very nature”* [Zel87, p.60] and capable of being generated without direct human interpretation. Ackhoff adds to this definition by identifying data as *symbols* and products of observation [Ack89, p.3]. Building on these statements, Gene Bellinger et al. [BCM04] characterise data as raw—simply existing without any meaning of itself.

Information. From a knowledge management perspective, coined by Ackhoff, information is the next link in this chain due to the fact that information is inferred from data and contained in descriptions [Ack89, p.3]. Speaking as an information scientist, Cleveland details information as a special intangible resource that is expandable, compressible, substitutable, transportable, diffusive, and shareable all at once [Cle82, pp.36f].

Others like Helmut Willke et al. [WKM01, pp.8f] argue that information requires context—typically a systemic one—which is why information can never be exchanged between different systems due to the fact that as soon as the systemic context is lost information, therefore, degenerates to data. The one and only prerequisite making such an exchange possible would be two systems with identical relevance criteria, which is—to all intents and purposes—impossible.

Moving further along the data-information-knowledge-wisdom-chain, the two famous Japanese knowledge management scientists Ikujiro Nonaka and Hirotaka Takeuchi deliver the next link—characterising information as *"necessary medium or material for eliciting and constructing knowledge"* [NT95, p.58].

Knowledge. In contrast to data and information, knowledge (and wisdom) are *"holistic, related to and expressed through systemic network patterns, integrative by definition"* [Zel87, p.59]; moreover knowledge is not just a processing of information but a coordination of actions [Zel87, p.61].

Nonaka and Takeuchi use three phrases to define knowledge: contrasts of information and knowledge are, in accordance with Zeleny, expressed by *"knowledge is about beliefs and commitment"* and *"knowledge [...] is about action"* while the third phrase—*"knowledge is about meaning"*—generally describes knowledge [NT95, p.58].

Revisiting the systemic perspective, to proceed from information to knowledge a second context is required [WKM01, p.11]. In contrast to the first context—formed by relevance criteria—the second is established by patterns of experiences that have been stored within a dedicated and essential memory.

Understanding & Wisdom. Understanding and wisdom finally complete this chain. However, a concise definition is not easy to shape which is why the different lifespans of the concepts are used in contrast to each other: *"Knowledge has a longer lifespan, although inevitably it too becomes obsolete. Understanding has an aura of permanence about it. Wisdom, unless lost, is permanent; it becomes a permanent endowment of the race."* [Ack89, p.9]. Understanding, also—just like information and knowledge—focuses on efficiency, while wisdom adds value by requiring judgement [Ack89, p.9].

A helpful means of summarising the previous definitions is provided by the conventional view of the data-information-knowledge-wisdom-chain as described by Syed Ahsan and Abad Shah [AS06]:

> *"Data is seen as simple facts that can be structured to become information. Information, in turn, becomes knowledge if it is interpreted, put into context, or when meaning is added to it. [...] Finally, when values and commitment guide intelligent behaviour, behaviour may be said to be based on wisdom. "* [AS06, p.272]

In addition, these definitions can be enhanced by three basic transitions along the chain—as suggested by Gene Bellinger et al. [BCM04]—describing the shift from data to information as *understanding relations*, the rise from information to knowledge as *understanding patterns*, and finally the step from knowledge to wisdom as *understanding principles*.

2.1.2 Common Taxonomies of Knowledge

Besides being aware that knowledge can and has to be distinguished from data, information, and wisdom, one of the biggest challenges in defining knowledge—and hence in defining what has to be learnt—can be attributed to the superior layer of knowledge structures. These knowledge structures determine different kinds of knowledge, and therefore considerably influence the outcomes of learning [BP94, p.20]. Put another way, this results in a redefinition of the question of *what* has to be learnt into a question of an appropriate decision within different *taxonomies of knowledge*.

Know-That and Know-How

One of the basic differentiations of knowledge is the subtle but crucial distinction between *knowing-that* and *knowing-how*. Interestingly, using the definitions and sources outlined in the previous section, a very similar differentiation has already been made by Milan Zeleny to distinguish between data, information, knowledge, and wisdom, as shown in table 2.2.

However, even though Zeleny assigns know-how to information and know-what to knowledge, the label know-how is used to define different

	Management	Metaphor
Data	Muddling Through	Know-Nothing
Information	Efficiency (measurement and search)	Know-How
Knowledge	Effectiveness (decision making)	Know-What
Wisdom	Explicability (judgement)	Know-Why

Table 2.2: Association of management descriptions and metaphors with data, information, knowledge, and wisdom [Zel87, p.60]

types of knowledge within this taxonomy of knowledge. This vividly illustrates a common problem within the area of information and knowledge management, although profound definitions for and differentiations of, particularly, information and knowledge (or information and knowledge management likewise) exist, the concepts are not always used precisely or in an appropriate matter. Therefore it is quite likely that what will be referred to as knowledge in the following should actually be classified as information when applying the distinctions given in the previous section correctly. Nevertheless, terms and concepts such as know-how will be used as introduced and classified in literature within this work—even if they contradict previous definitions and findings.

Know-that or know-how is, in other words, the difference between somebody who has knowledge about something and is, therefore, able to find the correct answer, and somebody who is intelligent enough to find the correct answer [BP94, p.20]. Using professional terminology, this is the discrimination between *declarative* and *procedural knowledge*:

Declarative Knowledge is commonly also referred to as *static* or *factual knowledge* [BP94, p.20]. To be concise, declarative knowledge is the knowledge of facts about the world [And76, p.78]. By definition, *knowing-that* can be represented in two ways: either propositionally—that is by the content of a linguistic expression—or figuratively. Today's cognitive psychology envisions declarative knowledge as a structure of nodes interrelated with each other. A focus on declarative knowledge was—and very often still is—the predominant model of facilitating and acquiring knowledge [BP94, pp.20f].

Procedural Knowledge is, in contrast, classified as *dynamic knowledge*, that is knowledge about how to do something [And76, p.78]. Three characteristics constitute knowing-how: 1) a clear goal-orientation, 2) decomposing the overall goal into sub-goals, and 3) the choice and description of all actions to implement the sub-goals. However, it has to be noted that according to the principles of *gestalt psychology*—where an ensemble is more than just the sum of all single pieces—procedural knowledge cannot be substituted by a number of declarative statements.

This kind of knowledge, or the abilities connected, outrank declarative knowledge since it is not the reproduction but the independent production of knowledge that is considered to be intelligent. [BP94, p.22]

Tacit, Implicit and Explicit Knowledge

Scientifically dealing with knowledge, there is no way around Michael Polanyi's famous differentiation between *tacit* and *explicit* knowledge. Building upon the already very fundamental distinction of know-that and know-how, this definition takes it to the next level and incorporates a human being's consciousness. Polanyi succeeded in demonstrating that humans actually *know* things without being consciously aware of knowing, even when explicitly questioned [Pol67, pp.4f]:

> *"We know more than we can tell."* [Pol67, p.4]

This kind of knowledge is called *tacit knowledge*. According to Polanyi, tacit knowledge always involves two things: the two terms of tacit knowledge—which is the proximal (a term denoting what we have knowledge but cannot tell) and the distal (the term that attends to the proximal)—and a logical relation between those two. Four aspects constitute this relation and express a particular connection between those two terms of tacit knowing: 1) the phenomenal structure of tacit knowing, 2) the functional relation and structure, 3) the semantic aspect, and 4) the ontological aspect [Pol09, pp.11ff]. Summarising Polanyi's explanations, Peter Baumgartner and Sabine Payr define tacit knowledge as an essential element of recognising and understanding—crucial for all forms of theoretical and practical knowledge—that becomes apparent if a human being is able to do something without being capable

Tacit Knowledge	Explicit Knowledge
Subjective	Objective
Knowledge of experiences (body)	Knowledge of rationality (mind)
Simultaneous knowledge (here and now)	Sequential knowledge (there and then)
Analogue knowledge (practice)	Digital knowledge (theory)

Table 2.3: Differentiation between tacit and explicit knowledge [NT95, p.61]

of explaining how, or has a skill without being able to indicate what this ability actually is [BP94, pp.30ff].

In contrast, *explicit knowledge* is easy to grasp—it is the conscious knowledge of facts. To strengthen the differences, it has to be noted that the attempt to explicitly formalise all tacit knowing is destined to fail; knowledge, for instance, such as that required to identify problems—mathematical or of another nature—requires tacit knowledge that cannot be codified or documented [Pol09, pp.20f].

This distinction of *tacit* and *explicit knowledge* was later consolidated by the work of Ikujiro Nonaka and Hirotaka Takeuchi. Their distinction between tacit and explicit knowledge is shown in table 2.3. To define not only knowledge but knowledge creation, Nonaka and Takeuchi unite tacit and explicit knowledge in one dimension—called the epistemological dimension— and added a second determining dimension—the ontological dimension—as shown in figure 2.2.

Other contributors, such as Thomas J. Beckman [Bec99], also start with the work of Polanyi, but add a third kind of knowledge—*implicit knowledge*. Since a distinction is not easy to be found, Beckman employs the accessibility of knowledge as a decision criterion [Bec99, pp.1ff]:

- *Tacit knowledge* is only indirectly accessible and always involves *"difficulty through knowledge elicitation and observation of behaviour"*.

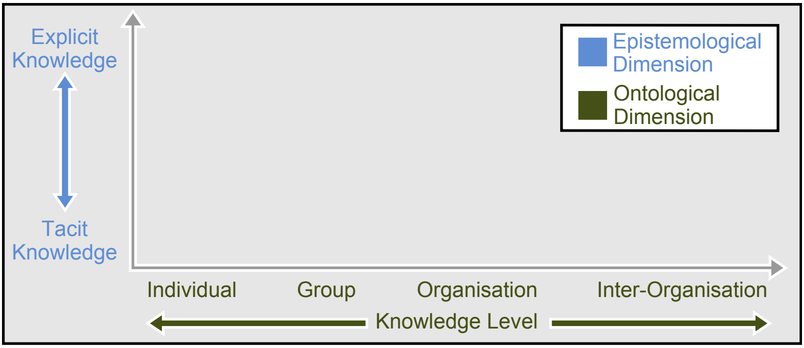

Figure 2.2: Two dimensions of knowledge creation [NT95, p.57]

- In contrast, *implicit knowledge* is accessible more easily through discussions or the querying of the knowledge carrier. However, this kind of knowledge has to be located before it can be communicated.
- Obviously, *explicit knowledge* is characterised by its direct accessibility and, very often, a documentation into formal knowledge sources.

To recap, these two basic differentiations—*know-that* and *know-how* as well as *tacit, implicit* and *explicit knowledge*—can be referred to as orthogonal, which is why they cannot be easily assigned to each other.

2.1.3 A Resource-Based Classification of Knowledge

What is unconsidered so far is that knowledge is—according to developmental psychology—the result of human actions and cognition [RE08, p.13] and, therefore, indispensably connected to a human being. To be more precise, knowledge is inseparably linked to the fact *that* and *how* human beings interact with their environment in order to learn. Human understanding and cognition is a slow development—but, hence, a steady change. [RE08, p.18]

This emphasis on changing processes and dynamics is given by the *theory of structural genetics* as proposed by Thomas Bernhard Seiler [Sei01]—again, building on Piaget's genetic epistemology. According to this theory, human acting and thinking is neither predefined in a complete pattern nor originated from a simple piecewise transformation of reality but instead evolves in the course of a constant development and changing process [Sei01, pp.16f].

Therefore, if knowledge is the result of human perception, it is also based on individual epistemological structures, and needs, at least in part, to be objectified and made publicly accessible. This leads to the distinction between *personal knowledge* and *public knowledge* [RE08, pp.19f] that respects the individual character of knowledge.

Personal Knowledge

As indicated by the term itself, *personal knowledge* is for the moment only available and accessible for the individual it is connected to. Nevertheless, it has to be noted that personal knowledge is a collective term for different types of knowledge [RE08, pp.20ff]—building on each other as pictured in table 2.4:

Enactive Knowledge is the basic part of personal knowledge which has its origins in physical actions. Enactive knowledge, also called practical knowledge, appears in activities, actions, and problem solving.

Pictographic Knowledge typically builds on enactive knowledge, is however independent from perception and actions. Pictographic knowledge is based on figurative beliefs and experiences of relations—that is internalised perception. It is also preconceptual and can therefore not be expressed linguistically as well.

Conceptual Knowledge is essential in order to develop cognitive action. This kind of personal knowledge arises through various transformations of enactive and pictographic knowledge and becomes apparent in complex structures. It is capable of being used consciously and can be explicitly expressed.

Conceptual knowledge is the most complex form and also the one most commonly referred to when talking about knowledge in every day language.

	is ... of being used consciously	is linguistically
Conceptual Knowledge	capable	expressible
Pictographic Knowledge	in parts capable through beliefs	in general not expressible
Enactive Knowledge	no longer capable	not expressible

Table 2.4: Personal knowledge [RE08, p.21]

Public Knowledge

In contrast to personal knowledge, *public knowledge* is not inseparable from an individual and is therefore publicly available. Public knowledge can be shared due to the fact that it can be materialised. There are two different kinds of public knowledge [RE08, pp.21f]:

Collective Knowledge stems from when humans negotiate, consolidate, standardise, and systematically represent meanings. Knowledge can be objectivised, however, it is important to realise that this formalisation brings with it a change of state. Being formalised, knowledge is only a potential nature—a sort of "frozen knowledge"—and needs to be reactivated through use by individuals. Nevertheless, collective knowledge subsists on interaction and is therefore not static but dynamic.

Formalised Knowledge is collective knowledge that has been transformed again—according to defined criteria and assignment rules—to the extent that data comes into existence and can be electronically processed.

Table 2.5 shows that subtypes of public knowledge—just like the subtypes of personal knowledge—build on each other. In addition, the appropriate link to the traditional data-information-knowledge-wisdom-chain is included here.

The society we live in—a knowledge society—at first builds on knowledge that has only been defined as public knowledge because knowledge is defined as a productive factor [RE08, pp.22f]. However, facets of learning as discussed in chapter 1.1 bring personal knowledge and its importance into focus.

	is transformed	is further processed	is also called
Collective Knowledge	in characters	by human dialogue	information
Formalised Knowledge	according to rules	in electronic form	data

Table 2.5: Public knowledge [RE08, p.22]

What should become clear from this section, is that knowledge is one of the basic ingredients for every successful learning process. However, the sole possession of knowledge is not sufficient. Instead, learning is about gaining knowledge *and*, most notably, making competent use of this knowledge. The learning process, therefore, involves not only the mediation of knowledge but also the acquisition of competences [BP94, p.52] such as the competences to perform, to reflect, and to design[3].

Of course, learning is—at least for most of us—neither justified by itself nor just amusement. Instead learning and the application of what has been learnt is the key to achieving success, in both personal as well as professional respect. In other words, human beings (should) work with the knowledge that has been acquired.

2.2 Working with Knowledge

Working with knowledge is essential in order to learn. It cannot be denied that almost every human action is in a way *knowledge-based* due to the fact that it is based on personal experiences, knowledge, and skills [RE08, p.12].

There are, however, some who are required to work intensively with knowledge to be able to master the requirements of their working environment. This kind of work is called *knowledge work*. Knowledge work has be to be distinguished from knowledge-based work: whereas almost every skilled work is knowledge-based, knowledge work can be

[3]For an extended consideration of competences as desired learning outcome see [BP94, pp.52ff].

characterised by the fact that required knowledge is not just acquired and used once [WKM01, p.4].

For that reason, the *process of knowledge work* is examined next, followed by a brief consideration of those who actually work with knowledge—the so-called *knowledge workers.*

2.2.1 The Process of Knowledge Work

To fully encompass the characteristics, quality, and opportunities of knowledge work, it needs to be understood as a comprehensive *process.* In general, defining or treating something as a process implies imposing a formal structure on it—that is identifying a beginning, an end, and intermediate steps in-between. Additionally, a *process orientation* entails the demand to improve the performance. [Dav05, p.61]

Using the formal and structured paradigm of a process for something as flexible and often unpredictable as knowledge work might seem contradictory at a first glance, and indeed analysing knowledge work as a process is difficult—however necessary it is to be able to improve it. [Dav05, pp.62f]

Trying to achieve this process of understanding and orientation, first of all major components of knowledge work have to be considered—that is *knowledge.* Knowledge is the main input, the major way of achieving, and the major output of knowledge work [NRSS09, p.24]. This, in turn, requires knowledge to be also conceived as a process that needs to be 1) continuously revised, 2) understood as permanently improvable, 3) is, on principle, not defined as truth but as a resource, and is 4) inseparably linked with the state of not knowing [WKM01, p.4].

Thomas H. Davenport, therefore, suggests a process orientation along the *dimensions of using knowledge*—that is knowledge creation, knowledge distribution, knowledge application—for the concerns of knowledge work [Dav05, pp.67ff]:

Knowledge Creation. The *creation of knowledge* is commonly perceived as an activity that is *"difficult if not impossible to manage as a process"* [Dav05, p.67]. Nevertheless, it seems reasonable to give knowledge workers some—but not too much—structures.

An approach already proven to be successful in delivering structure but at the same time leaving a certain amount of freedom, is to "break up" the process of knowledge creation. To do so, the basis process—such as the development of a new product—is divided into a series of stages or phases. To proceed from one stage to another, a so-called stage gate needs to be passed. In this way knowledge created within a previous stage can be evaluated before moving along the process. [Dav05, pp.67ff]

Knowledge Distribution. To be able to enforce the *sharing and distribution of knowledge*, it would be required to know what knowledge workers actually know—which is, to be honest, impossible. Trying to ensure the distribution of created knowledge, is therefore no easier than fostering the creation of new knowledge. [Dav05, p.70]

For that reason, the most encouraging approach seems to be a shift of management from managing the process of knowledge distribution to managing the external circumstances of knowledge distribution—that is the environment for distributing knowledge. This environment is, for instance, shaped by where and whom people work with. [Dav05, p.70]

Knowledge Application. Crucial to success is, of course, the *application of knowledge*. Very often, knowledge workers are primarily not supposed to create new knowledge, but to effectively apply existing knowledge [Dav05, p.71].

To be able to effectively reuse knowledge, efforts in making knowledge reusable are required. Davenport identified three crucial success factor for knowledge application: *leadership*—that is someone who is willing to manage and invest in making reuse a reality—*asset visibility*—implying that knowledge assets need to be easy to find, access, and reuse—and *asset control*—ensuring the quality of knowledge assets over time. [Dav05, pp.72f]

What has to be kept in mind through all those dimension of using knowledge, is that what makes technology interesting for knowledge work are communication and storage capabilities—serving as *knowledge enabler*. Technology can, therefore, only be a pipeline or means of storage for knowledge exchange—and is *not* responsible for knowledge creation. [DP00, p.18]

The process character of knowledge work is also emphasised by a more comprehensive definition of *dimensions for knowledge work* proposed by Susan Newell et al. [NRSS09, pp.2,26]—including the consideration of new challenges for managing knowledge work:

- ▷ First of all, *context* is of great significance for knowledge work—just as it is for learning—though often unrecognised. The consideration of social, organisational, and cultural context is indispensable to be able to develop *enabling contexts* supporting knowledge work. Enabling contexts, for instance, include structures and opportunities for collaborative work and coordination or reward and recognition systems. [NRSS09, pp.2,26]
- ▷ To be successful in managing knowledge work, the *processes of working with knowledge* need to be recognised and understood. These processes include practices and procedures for sharing, integration, translation, and transforming knowledge [NRSS09, p.26]—as described above.
- ▷ Beyond what has been said, it is essential to realise that knowledge should always be deployed for a *specific purpose* rather than being just *"good for its own sake"* [NRSS09, p.26].

Of course, alignment between all those three dimensions is crucial to facilitate successful knowledge work [NRSS09, p.2]. In the end though, facilitating knowledge work in particular implies supporting those performing knowledge work—the so-called *knowledge workers.*

2.2.2 Knowledge Workers—the Future of the Working World?

Knowledge workers, briefly stated, *"think for a living"* [Dav05, p.3]. Being more elaborate, Thomas H. Davenport depicts knowledge workers as follows:

> *"Knowledge workers have high degrees of expertise, education, or experience, and the primary purpose of their jobs involves the creation, distribution, or application of knowledge."* [Dav05, p.10]

This approach to define knowledge workers is also followed by Susan Newell et al. in stating that knowledge workers are those *"whose major* *work tasks involve the creation of new knowledge or the application of existing knowledge in new ways"* and typically have, or even need to have, a high level of education and specialist skills combined with the ability to apply these skills in practice to identify and solve problems [NRSS09, p.24].

A knowledge worker is supposed to, at least, operate within three spaces or roles: a worker—the default role of a knowledge worker, that is applying knowledge—a learner—primarily aiming at an advancement of his or her knowledge—and an expert—helping others to improve their knowledge by collaborating [Ley06]. Even more importantly, a knowledge worker *"may dynamically switch"* between those different roles [APO29, p.63]. To successfully cross those boundaries, it is required that knowledge workers have their resources or means of production—information, knowledge, and appraisement—at their command [Tof95, p.60].

Distinguishing Different Kinds of Knowledge Workers

These broad definitions, of course, apply to many workers today: *"it is likely that a quarter to a half in advanced economies are knowledge workers"* [Dav05, p.4]. Which, in turn, creates the problem that not all forms of knowledge work can be dealt with at once and not all kinds of knowledge workers can be treated equally [Dav05, p.35]. Segmentation of knowledge workers beyond the three basic roles as defined above is therefore crucial to understand all different kinds of knowledge work and workers. There are a large number of possible dimensions and, hence, a variety of conceivable classifications.

Davenport chooses to classify knowledge work and knowledge workers based on judgement and collaboration, using two dimensions[4]—the *level of interdependence* and the *complexity of work*. The resulting matrix, as shown in figure 2.3, presents four *models* or *categories for knowledge workers* [Dav05, pp.26ff]: *transaction*, *integration*, *collaboration*, and *expert*.

Different companies also implement differing classifications of knowledge workers. A few can be listed as follows:

[4]Other conceivable criteria comprise distinctions based on knowledge activity, by type of idea, a differentiation on cost and scale, on process attributes, on business criticality, or on mobility [Dav05, pp.28ff].

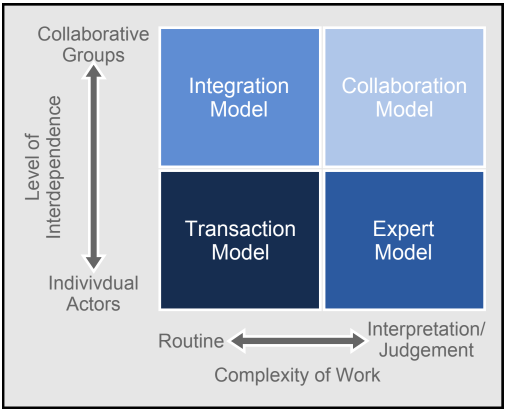

Figure 2.3: A classification structure for knowledge-intensive processes [Dav05, p.27]

- Intel[5] categorise their knowledge workers as functionalists, cube captains, nomads, global collaborators, and tech individualists.
- MWH Global[6] groups their mission-critical workers as business unit leaders, business developers, project managers, client service managers, and technologists [Dav05, pp.35ff].
- McKinsey[7] employs a quite broad approach aiming at the definition of several groups of knowledge workers and best suitable technologies to support these groups: administrator, agents, aide/apprentice, buyer, counsellor, creator, instructor, investigator, manager, performer, and sales person [MSY09].

What these distinctions show is that knowledge workers have lots of different rolls, tasks, and responsibilities. For that reason, knowledge work—and, therefore, knowledge workers—are often depicted as the *"work of the future"* [Cro07, p.8]. To unify all those existing distinctions—based on an extensive literature review and two empirical studies—Wolfgang Reinhardt et al. recently proposed ten different meaningful roles of knowledge workers [RSSD11, p.11]:

[5] Intel—`http://www.intel.com/`
[6] MWH Global—`http://www.mwhglobal.com/`
[7] McKinsey—`http://www.mckinsey.com/`

- ▷ *Controllers* are monitoring organisational performance.
- ▷ *Helpers* are people who transfer information to teach others once they negotiate a problem.
- ▷ *Learners* use existing information and practises to improve their personal skills.
- ▷ *Linkers* associate information from different sources to new information.
- ▷ *Networkers* create connections with colleagues to share information and support each other.
- ▷ *Organisers* are mainly concerned with personal or organisational planning activities.
- ▷ *Retrievers* search and collect information on a given topic.
- ▷ *Sharers* disseminate information.
- ▷ *Solvers* are creative in finding or providing solutions to problems.
- ▷ *Trackers* are monitoring and reacting to critical personal or organisational actions.

All this being said, knowledge workers seem to share more than just some common characteristics with today's learners. Drawing on the definitions above, it becomes obvious that knowledge workers cannot just be qualified once. Knowledge workers, therefore, depend on *lifelong learning* (cf. chapter 1.1.3) and are required to be experts in dealing with knowledge, its acquisition—formal and informal (cf. chapter 1.1.1)—and environment [Rei08, p.49]. Most importantly, however, this emphasises that knowledge workers are able to take charge of their own learning [Cro07, p.XIX]. Recalling the abilities necessary depicted as *meta-learning* (cf. chapter 1.3.2), the following skills were suggested as indispensable companions: self-empowerment, knowing and choosing the best way to learn as well as the best sources of learning, continuous reflection, and personal knowledge management.

As a consequence, knowledge workers can also be depicted as learners.

3 Management in Learning

"Half of what is known today was not known 10 years ago. The amount of knowledge in the world has doubled in the past 10 years and is doubling every 18 months."

George Siemens [Sie05b]

Referring to George Siemens's quotation, the amount of what can be learnt is huge. Therefore—now that what learners actually learn has been examined—literally the next step is to think about ways of managing what has been gathered by learning.

> *" [...] the real, controlling resource and the absolutely decisive 'factor of production' is now neither capital nor land nor labor. It is knowledge."* [Dru94, p.6]

Knowledge is considered to be one of the most—or even *the* most—important resource of today's economy, which is why it should be appropriately managed. *Management*—in particular within the German-speaking world—is commonly used in single-edge manner in business terms. However, the adding of a management view brings along a chance to change the perspective on knowledge and learning in order to keep pace with the growing requirements in many learning and working environments [RE08, p.13]—still acknowledging humans as being in the centre of processes dealing with knowledge.

To begin with, *knowledge management* is defined using a quite common mantra of knowledge management engineers: Knowledge management, in general, has the purpose and objective of ensuring the delivery of the *right information* to the *right person* at the *right time*. A mantra that, at a glance, seems to be tenable and appropriate for knowledge

Origin	Goal	Type of Knowledge	Pillar
engineering science	solving knowledge problems with technological means	public knowledge: data	technology
business economics	managing knowledge based on benefit and performance	public knowledge: information	organisation
sociology	describing knowledge from a social and systemic perspective	public and personal knowledge	culture
psychology	understanding and utilising individual knowledge processes	in particular personal knowledge	human beings

Table 3.1: Development Lines of Knowledge Management [RE08, p.26]

management in almost all conceivable kinds of different settings. Nevertheless, most of the classical literature on knowledge management is concerned with knowledge management within an organisational context.

Therefore, this chapter initially takes a closer look at knowledge management by consulting traditional *schools of knowledge management*. Subsequently, the second part of this chapter examines attempts *to team learning and knowledge management* in order to identify how learning can benefit from the addition of a management perspective.

3.1 Schools of Knowledge Management

Knowledge Management mainly arose as part of general management theories in the 1990s. Nevertheless, different lines of development as shown in table 3.1 contributed to the area of knowledge management—each bringing along different objectives, taking care of different types of knowledge, and building on different pillars.

This being said, knowledge management is comprised of processes of representing, communicating, generating, and using knowledge in all its facets and pursues the professionalising and optimising of those processes—both in commission of organisations and for the benefit of engaged humans [RM04, p.3]. Several traditional *schools of knowledge management* deliver helpful guidelines on how to efficiently and effectively manage knowledge. A selection[1] of the most important—and those considered to be most useful—schools of knowledge management will be briefly introduced within this section.

3.1.1 Knowledge Management according to Nonaka and Takeuchi

The two Japanese scientists Ikujiro Nonaka and Hirotaka Takeuchi—who have already been referred to in relation to their definition of knowledge (cf. chapter 2.1)—are often depicted as co-founders of knowledge management. Their thoughts and findings—published in "The Knowledge-Creating Company" in 1995 [NT95] and, hence, dealing with knowledge management within organisations—are one of the foundations for many subsequent publications and for current entrepreneurial decisions; their work on knowledge creation has become an international standard throughout the whole domain of knowledge management.

According to Nonaka and Takeuchi, knowledge creation is *"the mobilisation and conversion of tacit knowledge"* [NT95, p.56]. Knowledge is, therefore, created through a continuous transformation of tacit and explicit knowledge *along* the ontological dimension of knowledge (cf. figure 2.2, p.62). This transformation results in the four modes of the *SECI model*—referred to as *socialisation, externalisation, combination*, and *internalisation* [NT95, pp.62ff]:

Socialisation is the mode of converting *tacit* to *tacit* knowledge. New tacit knowledge is typically acquired during the process of sharing with others—that is by observation, imitation, or practice. Knowledge gathered within this process is, therefore, called *sympathised knowledge.*

Externalisation is the transformation from *tacit* to *explicit* knowledge. This mode is *"typically seen in the process of concept creation*

[1] An extensive review as already been carried out and published in [SH10a].

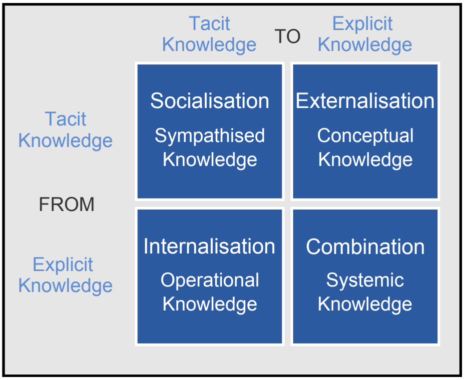

Figure 3.1: The four modes of knowledge conversion [NT95, p.62,72]

and is triggered by dialogue or collective reflection" [NT95, p.64] and results in *conceptual knowledge*.

Combination is the mode of transferring *explicit* to *explicit* knowledge. This transformation occurs when existing information is sorted, added, systematised, combined, or categorised and, therefore, gains new value. Hence, the created knowledge is referred to as *systemic knowledge*.

Internalisation is the conversion of *explicit* to *tacit* knowledge. In the course of internalising, every knowledge asset gathered within the processes of socialisation, externalisation, and combination is adapted and integrated into an individual's knowledge base—creating *operational knowledge*.

The transformation process itself and the types of knowledge created within each mode are shown in figure 3.1; the knowledge spiral resulting from the continuous and dynamic interaction of these modes is shown in figure 3.2.

Later on, the concept of *Ba* was added in order to *"offer an integrating conceptual metaphor for the SECI model of dynamic knowledge conversions"* [NK98, p.45]. Ba is designed to be a shared space to exchange knowledge—hence, *"if knowledge is separated from ba, it turns into information, which can then be communicated independently from ba"* [NK98, p.41].

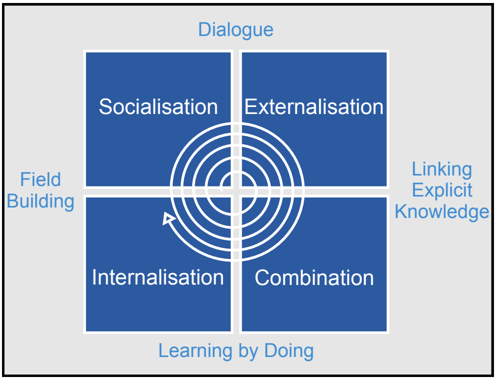

Figure 3.2: The knowledge spiral [NT95, p.71]

3.1.2 Knowledge Management according to Davenport and Prusak

A theory putting knowledge workers (cf. chapter 2.2.2) in the centre has been established by Thomas H. Davenport and Laurence Prusak—which is why these findings can be of particular assistance in discussing management for learners. Ten general principles provide the foundation of this theory [Dav96]:

1) Knowledge management is expensive (but so is stupidity!).

2) Effective management of knowledge requires hybrid solutions involving both people and technology.

3) Knowledge management is highly political.

4) Knowledge management requires knowledge managers.

5) Knowledge management benefits more from maps than models, more from markets than hierarchies.

6) Sharing and using knowledge are often unnatural acts.

7) Knowledge management means improving knowledge work processes.

8) Access to knowledge is only the beginning.

9) Knowledge management never ends.

10) Knowledge management requires a knowledge contract.

To be more precise, Davenport and Prusak divide the knowledge management process into three sub-processes—*knowledge generation*, *knowledge codification and coordination*, and *knowledge transfer* [DP00, p.51]:

Knowledge Generation. The process of *knowledge generation* is concerned with the conscious and intentional generation of knowledge and can be further divided into five modes: acquisition, dedicated resources, fusion, adaptation, and knowledge networking [DP00, pp.52ff].

Knowledge Codification and Coordination. The aim of *codifying and coordinating knowledge* is *"to put organizational knowledge into a form that makes it accessible to those who need it"* [DP00, p.68]. In order to do so, basic principles of knowledge codification, guidelines on mapping and modelling knowledge, as well as guidelines on codifying knowledge into systems need to be respected—each of them taking into account the different types of knowledge (cf. chapter 2.1). [DP00, pp.68ff]

Knowledge Transfer. A *transfer of knowledge* will always happen within organisations—no matter if the process is managed or not. Nevertheless, deliberate strategies for a knowledge transfer are important to encourage and create space for a possible knowledge transfer which can be guided as well as spontaneous. [DP00, pp.88ff]

3.1.3 Knowledge Management according to Probst, Raub, and Romhardt

While the previous two representatives are internationally spread, the theory described in this section seems to be most prevalent in the German-speaking world. In cooperation with many German, and also international, companies Gilbert Probst, Steffen Raub, and Kai

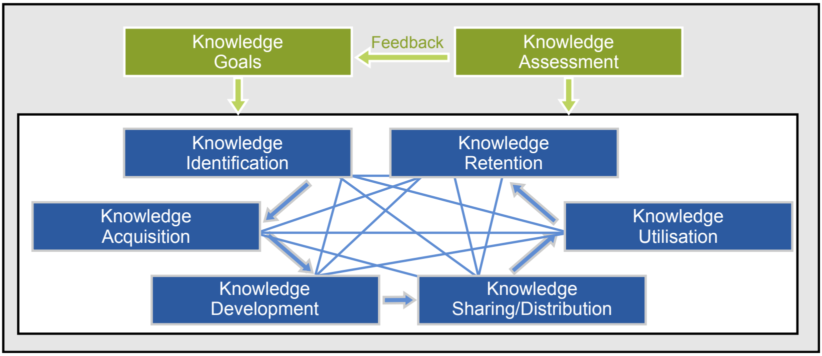

Figure 3.3: Building blocks of knowledge management [PRR00, p.34]

Romhardt developed a best-practise model for knowledge management [PRR00].

To summarise, this model is based on eight *building blocks* for knowledge management and their connection as shown in figure 3.3. It is comprised of six core processes of knowledge management describing and addressing the main operational problems: *knowledge identification*, *knowledge acquisition*, *knowledge development*, *knowledge sharing and distribution*, *knowledge utilization*, and *knowledge retention*. In addition, it is also deemed indispensable to embed a successful knowledge management implementation within an overall (organisational) structure. The building block model meets this demand by adding two additional building blocks—that is *knowledge goals* and *knowledge assessment*—to complete the best-practise model.

Probst, Raub, and Romhardt are convinced that *"knowledge management can be applied to individuals, groups, or organizational structures"* [PRR00, p.37]. Of course, this model is explicitly derived from different organisational settings. Nevertheless, Probst, Raub, and Romhardt explicitly emphasise that it is *knowledge*—and not a particular management strategy—that has been placed at the centre as *"sole structuring principle"* [PRR00, p.35].

3.1.4 Other Schools and Contributors

There is, of course, a large number of current theories regarding how to manage knowledge from which the models just introduced have been selected. This includes a reasonable number of valuable contributions that, unfortunately, cannot all be named and covered in depth[2]. However, to encourage a broader view, some of these are selected below and briefly described:

Business Process Oriented Knowledge Management. The precise implementation of a management strategy—*business process oriented knowledge management*—has to a great extent been examined by Peter Heisig [Hei01, Hei05]. According to his approach the key to successful knowledge management rests on encouraging the minimisation of barriers to knowledge management and, therefore, an integration of knowledge management tasks with daily tasks and processes [Hei01].

Peter Heisig also proposes a model for business process oriented knowledge management—the GPO-WM ®—including a reference model, a procedure model, and tools supporting the analysis as well the creation of solutions [Hei05].

Learning Organisations. Another contributor attracting interest is Peter Senge who developed the notion of *learning organisations*. A learning organisation is *"an organisation that is continually expanding its capacity to create its future"* [Sen06, p.14].

Senge identifies four disciplines—*personal mastery*, *mental models*, *shared visions*, and *team learning*—that need to be regarded as central aspects of every learning organisation. Of most importance, however, is that these disciplines are developed as an ensemble which in turn makes the fifth discipline—*systems thinking*—the most important factor for successfully bringing a learning organisation into existence. [Sen06]

Communities of Practice. A more open and pragmatic approach to knowledge management are the so-called *communities of practice*—originating, amongst other sources, from publications of

[2] For further information about this subject see [AL01] which provides a broad review of knowledge management and knowledge management systems.

John Seely Brown, Paul Duguid, and Estee Solomon Gray. Brown and Duguid identify the opportunities of communities of practice and determine how companies should envision themselves—that is as *"a community-of-communities, acknowledging in the process the many noncanonical communities in its midst"* [BD91, p.53]. Brown and Gray describe how companies can learn to foster and support communities of practice in order to facilitate the sharing of knowledge [BG95].

Additionally, communities of practice were also significantly influenced by Etienne Wenger and his work. Wenger proposes *"a framework that considers learning in social terms"* [Wen02, p.9] in his book "Communities of Practice". An integration of the components of meaning, practise, community, and identity will—according to Wenger's theory—apply a social theory of learning and, therefore, establish the seminal concept for communities of practice. Subsequent publications—such as "Cultivating Communities of Practice" [WMS02]—provide advice on how to successfully develop and facilitate different kinds of communities.

3.2 Merging Learning and Knowledge Management?

As previously mentioned (cf. chapter 2), *learning* and *knowledge* are different perspectives on the same phenomenon [RE08, p.3]. Thus if learning and knowledge go hand in hand, *knowledge management* is inconceivable without learning, while learning—in particular modern learning in terms of self-directed, lifelong, and technology enhanced learning—in turn entails aspects of knowledge management [Rei09, p.107]. In conclusion, those two previously clearly separated fields can no longer be considered individually but need to be merged.

According to Andrea Back et al., e-learning has been established as a superordinate concept for technology supported knowledge management *and* learning in practice—also due to the fact that technological systems often qualify for e-learning *and* knowledge management [BBSS01, p.60]. This particular is confirmed by trends in learning such as mobile learning[3], microlearning[4], rapid e-learning[5], or e-learning 2.0 (cf. chapter 1.2.3).

> *"The implications of knowledge management for e-learning are huge. Rather than simply relying on instruction, we can use well-structured information as well as productivity enhancing tools to help people learn and improve their performance."* [Ros01, p.109]

This remark by Marc J. Rosenberg looks at knowledge management from the perspective of learning and builds on the observations previously made regarding the fact that learning aims to build and manage a *body of knowledge*. It is therefore likely that knowledge management delivers assistance for mastering learning and, in particular, information and knowledge acquired during the learning process as well.

To incrementally determine the implications of knowledge management for learning, the following steps are taken: Firstly, general *differences and commonalities* are revealed. Secondly, *transfers of knowledge management models*—as introduced above—are examined to explore possibilities for integration. Finally, a conclusion is reached which proposes the establishment of an *approach to the merge* of these two disciplines.

3.2.1 Differences and Commonalities

Following the examination of the roots of knowledge management and learning, it has become clear that learning and knowledge management are the result of two independent developments (cf. chapters 1.1 and 3.1). It is, therefore, quite valuable to proceed on the assumption that these fields differ in various aspects. For that reason, divergences of knowledge management and learning are initially set out.

[3] Mobile learning initially refers to the use of mobile devices in learning. A more open and pragmatic definition using the four dimensions *place*, *device*, *time*, and *material* has been proposed in [HHS11, p.160].

[4] Microlearning—as well as mircoteaching, microcontent, and microknowledge—is a didactical method based on the principle of learning in small steps [Res]. A comprehensive definition may be built on the dimensions of time, content, curriculum, form, process, mediality, and learning type [Hug05, p.9].

[5] Rapid e-learning is a combination of rapid prototyping—a software development method—and e-learning. Basically, rapid e-learning is identified by ease of development and short timeframes—in terms of development as well as learning units [DV04, p.3].

How Learning and Knowledge Management Differ

Learning and knowledge management, in general, follow two different perspectives or paradigms: *Knowledge management* takes on an *organisational* perspective and primarily addresses (the lack of) *sharing* knowledge. In contrast, learning focuses an *individual acquisition* of knowledge. Moreover—according to Andreas Schmidt's findings—learning and knowledge management are basically separated due to a limited and isolated consideration of *context*[6]. [Sch05, pp.203f]

Apart from this general differentiation, Ilke Nübel clustered six crucial divergences [Nüb05, pp.119ff] among learning and knowledge management:

Organisational Anchorage and Strategic Alignment. Learning or e-learning is typically located in the human resource department or maybe a separate corporate training unit. In contrast, the responsibilities for knowledge management are assigned to the executive department of strategy (or similar) or directly passed to single business units. The *strategic alignment* of e-learning is, usually, loosely coupled, whereas alignment for knowledge management is tight. [BBSS01, p.68]

This separation, of course, facilitates a side by side existence without influencing each other and already hinders interchange and communication [Nüb05, p.119].

Objective Targets. As a result of these completely different alignments, e-learning and knowledge management are assigned differentiating *objective targets*: Where e-learning is fostered to reduce costs[7], knowledge management is implemented to improve professional knowledge. [Nüb05, pp.123f]

Role Concept. Another result of those differing alignments are different *roles for responsible people*: a chief learning officer is in charge

[6] These findings were the foundation for the EU project "Learning in Process" (LIP). LIP aimed at an *"integration of working and learning on a process level and learning management, knowledge management, human capital management and collaboration solutions on a technical level"* [Sch05, p.205]. LIP was later followed by the comprehensive project APOSDLE (cf. chapter 11.1.2).

[7] This narrow focus on costs is perceived to be a relic of the e-learning hype at the beginning of the century that will, hopefully, soon vanish.

of learning, whereas a chief knowledge officer controls knowledge management [BBSS01, p.68]. Where further roles in knowledge management—such as knowledge agents or knowledge brokers—are easy to find, learning is usually limited to tutoring as an additional role and is less structured [Nüb05, p.128].

Therefore, to be able to merge learning and knowledge management a close collaboration or even a consolidation of differing roles is required [Nüb05, p.129].

Consideration of Human, Technology, and Organisation. Considering knowledge management within organisations, humans, technology, and organisation are the pillars for this kind of knowledge management. In contrast, learning within organisations very often lacks the consideration of organisational aspects such as an alignment with the overall strategy. [Nüb05, pp.124f]

This, in turn, results in differing acceptance rates of knowledge management and learning throughout the organisation. [Nüb05, p.124]

Preparation and Utilisation of Content. An important and vital difference is to be found in *preparing content*. Whereas content in learning is persistent, instructionally designed, often externally built, and composed in comprehensive courses, content in knowledge management is short-lived, editorially designed, definitely internally built, and composed of single documents. [BBSS01, p.68][Nüb05, pp.126f]

Moreover, learning and knowledge management also differ in terms of *processing time* and *utilisation*. Learning content is generally worked through outside the working environment and over an extended period of time. In contrast, content in knowledge management is typically integrated into the working environment and worked through in short ad hoc units. [BBSS01, p.68][Nüb05, pp.126f]

Personalisation and Control of Success in Learning Processes. Learning content is—if at all—slightly personalised. Usually, general learning units are assigned to a number of learners.

For knowledge management, however, a strong trend towards individually tailored units is developing. [BBSS01, p.68]

Concerning *success control*, learning and knowledge management, again, vary significantly. While control and assessment is an inevitable part of learning, evaluation is not assigned a similar importance in knowledge management. [Nüb05, pp.129f]

Nevertheless though they are different, knowledge management and learning are supposed to have a common ground due to the considerable interrelation of knowledge and learning. Additionally, the divergences previously examined also bring along opportunities and potential for integration that has not been acted upon yet [Nüb05, p.119]. Therefore, possible commonalities are considered next.

What Knowledge Management and Learning Share

From a general organisational perspective, learning and knowledge management obviously have the same purpose—that is to foster learning and competence development within organisations [Sch05, p.203]. As a consequence, it is reasonable to look closer and learn more about commonalities of knowledge management and (e-)learning [Nüb05, pp.132ff]:

Knowledge and Learning. It has been mentioned repeatedly that learning and knowledge management involve *knowledge* as an essential aspect. Both foster the successful *acquisition of knowledge*—which is nothing but the acquisition of competences and skills. [Bac02, p.309]

Flexible Provision of Knowledge and Learning Units. Learning and knowledge management are often required in order to react to short-term requests and needs. Therefore, both facilitate the *flexible and on demand provision* of knowledge and learning units to be able to satisfy the thirst for knowledge of learners, intellectuals, and users. [Nüb05, pp.132f]

Employment of Portals. Corporate *portals* are, by now, the standard means of implementing knowledge management as well as learning. Even though learning and knowledge management portals might differ due to an integration of various functionalities, they share common basic features such as *personalisation*, *aggregation of information*, *single sign-on*, as well as *constant and global availability*. [Nüb05, pp.133ff]

These common features clearly suggest an integration into a so-called learning and knowledge portal—in turn fostering a closer integration of knowledge management and learning itself. [Nüb05, p.136][Bac02, p.310][BBSS01, pp.230ff]

Utilisation of Communication and Cooperation Tools. Both, learning and knowledge management, essentially build on communication and cooperation to be successfully implemented. Hence, *tools for communication and cooperation* such as *chat*, *forums and newsgroups*, or *application sharing* can be used jointly—for instance, integrated in a combined learning and knowledge portal. [Nüb05, pp.136ff]

Importance of Communities. Utilising and essentially building on communication and cooperation confirms the *importance of communities* in both fields [Nüb05, p.139].

The importance of a social aspect in learning is beyond debate—learning, though often very individual, is always social (cf. chapters 1.1.2 and 1.3.1). The same importance of communities and, hence, a social aspect can be undeniably attested to knowledge management and is apparent in all knowledge management models (cf. section 3.1).

Requirements for Implementation, Obstacles and Challenges. Finally, there are *requirements* to be met when aiming at a successful implementation of learning and knowledge management within an organisation: comprehensive *management support*, an appropriate *information policy*, a *vision* for implementation, precise and focussed *objectives*, as well as a *consideration* of an existing—or the *development* of a new—*knowledge and learning culture*. [Nüb05, pp.145ff]

All these requirements are, of course, not easily implemented. Several challenges and obstacles need to be negotiated, of which gaining the necessary *user acceptance* is considered to be the greatest challenge. [Nüb05, pp.147f]

It has been shown that—even though differences exist and cannot be eliminated—knowledge management and learning are a lot closer than maybe expected at first sight: Creating knowledge—as is supposed to occur in knowledge management—is simply not possible without individuals learning [Bac02, p.312]. In turn, flexible knowledge management strategies can be of assistance in mastering learning [DK02, pp.300f][8]. As a result it seems reasonable to consider a *transfer of existing knowledge management models* to the learning context.

3.2.2 Transferring Knowledge Management Models to Learning

A transfer of prevalent knowledge management models has been examined in several research projects and settings. Therefore, three transfers of knowledge management models as introduced above are presented in what follows.

SECI in Learning

Darrell Woelk and Shailesh Agarwal [WA02] investigated the integration of learning and knowledge management by applying the context of learning to the findings of Ikurijo Nonaka and Hirotaka Takeuchi (cf. section 3.1.1). Recalling the transfer of tacit and explicit knowledge as defined by these two Japanese scientists, *socialisation*, *externalisation*, *combination*, and *internalisation* are identified as the processes that need to be followed to complete the original SECI model.

However, enhancing this knowledge management model with a learning context, Woelk and Agarwal suggest a fifth and sixth phase to complete this model: *cognition*—depicting the application of knowledge exchanged in other phases—and *feedback*—completing the learning cycle [WA02, pp.1035f]. Moreover, a *knowledge repository* has been placed at the centre of all these transformations and four crucial roles within the whole process have been defined: knowledge holder, knowledge seeker, knowledge organiser, and instructional designer.

[8] Precise and more detailed examinations of what learning can add to knowledge management and vice versa can, for instance, be found in [DK02, pp.300ff] and [BBSS01, pp.60ff]. For an investigation of opportunities in a comprehensive consideration and treatment of knowledge management and learning see [Nüb05, pp.149ff].

To implement the claimed merger of e-learning and knowledge management, the now six phases are then enhanced with learning activities to improve the overall process [WA02, p.2]:

Socialisation is enhanced with competency and skill measurements—helping to identify people with suitable interests, knowledge, and skills.

Externalisation as the knowledge capturing process is broadened with the intention of teaching knowledge after being captured.

Combination , whereby the reorganisation of knowledge, is expanded using pedagogic techniques that are supposed to be embedded within knowledge.

Internalisation is, again, enhanced with competency and skill measurements—which amounts to assessment in learning—to ensure that learners actually learn what has been fostered.

Cognition is defined as on-demand support in learning—providing new knowledge assets and training at the moment it is needed.

Feedback completes the new model by offering assessment and response for learners.

However, overall, these enhancements are—even though proven to be of assistance in four business scenarios [WA02, pp.1037ff]—considered to be a weak integration of e-learning, or learning in general, and knowledge management.

Another concretion of the SECI model which takes into account learning activities is proposed by Ilke Nübel [Nüb05]. As shown in table 3.2, Nübel added a learning context to the SECI model by assigning general learning activities that foster knowledge creation and conversion within the different phases of this model. Obviously, this implementation basically integrates communication activities for learning. This is, for sure, a good start, but there is more to learning than “just” communication.

Building Blocks for Learning

Gise Ruprecht [Rup06] examined e-learning as an integral part of knowledge management and identified e-learning components within

SECI model	Learning Activities
socialisation	communities, face-to-face-meetings
externalisation	exchange in communities via forums, chats
combination	exchange in communities via forums, chats
internalisation	application of what has been learned to a specific context

Table 3.2: Learning activities fostering knowledge creation and conversion within the SECI model [Nüb05, p.235]

the *building blocks* of knowledge management as defined by Gilbert Probst et al. (cf. section 3.1.3).

Ruprecht suggests a combination of e-learning and knowledge management to successfully implement e-learning within an organisation. Important activities to introduce e-learning are, therefore, assigned to pairs of building blocks for knowledge management [Rup06, pp.94ff]:

Knowledge Goals and Identification. To successfully implement e-learning, existing *demands for e-learning* have to be gathered first. This activity is assigned to the building blocks *knowledge goals* and *knowledge identification*. [Rup06, p.94]

Within these knowledge management activities it, therefore, has to be determined what learning scenarios are suitable to learn the knowledge identified as a knowledge goal—whereas these scenarios may vary for different audiences. In turn, this requires an answer to the question whether e-learning is at all qualified to convey this particular knowledge. [Rup06, p.95]

Knowledge Acquisition and Development. If the qualification of and need for e-learning have been successfully determined, the *acquisition of content* is what then needs to be focussed on. This preparation activity for learning can be found within the building blocks *knowledge acquisition* and *knowledge development*. [Rup06, p.95]

E-learning fosters and simplifies the external acquisition of knowledge—in particular concerning the possible variety and flexibility of acquired content. Developing new content—that is new knowledge—using the e-learning infrastructure is especially recommended due to the fact that e-learning is subsequently useful in supporting a rapid distribution of new knowledge within an organisation. [Rup06, p.96]

Knowledge Distribution and Utilisation. What is of crucial importance to allow and facilitate an improvement of an organisation's workforce, is an *integration* of e-learning and knowledge management. This need for integration can, in particular, be found within the building blocks *knowledge distribution* and *knowledge utilisation*. [Rup06, p.97]

To be successful, existing knowledge has to be available and easily accessible throughout an organisation. A utilisation of learning modules in combination with knowledge management facilitates the general availability of knowledge. In this way learners and experts are regularly able to use tools and integrate them into their individual toolbox. [Rup06, p.96]

Knowledge Retention and Assessment. Finally, if what has been built, acquired, and integrated is not preserved, assessed and, if necessary, revised, all endeavours count for nothing. In other words, *evaluation*, that can be found in the building blocks *knowledge retention* and *knowledge assessment*, is crucial. [Rup06, p.96]

Concerning learning, content, appropriateness, currentness, necessity as well as effectiveness have to be continuously monitored and evaluated [Rup06, p.96].

In conclusion, the management of learning is already included in the model of knowledge management according to Probst et al. However, as shown above (cf. section 3.2.1), there are far too many differences to rely upon a natural integration of knowledge management and learning.

Communities of Practise in Learning

A model of knowledge management to be classified in particular as an integration of learning and knowledge management are *communities of practise*. However, due its vague, or at least unstructured, definition and various implementations, transfers are not as easy to depict as has been the case for the two previous models.

Nevertheless, approaches employing communities of practise for an educational purpose can be found. To give an impression of their variety, two opposed approaches have been selected:

- *E-MEMORAe2.0* an e-learning environment—proposed by Adeline Leblanc and Marie-Hélène Abel—in particular fosters *"knowledge capitalisation in the context of organisations"* [LA08, p.111] and, therefore, facilitates organisational learning and innovation.

  To reach this goal the organisational memory was designed around two subtypes of memory: individual memory and group memory—in turn, consisting of team, project, and organisation memory. Hence, E-MEMORAe2.0 is built to allow access, sharing, and capitalisation of knowledge within and in-between those different memories. In particular, knowledge exchange is enabled by the use of shared ontologies[9]—that is a domain and an application ontology. [LA08, pp.111f]

- Maria Chiara Pettenati and Maria Ranieri [PR06] propose a *reference model for communities of practise* in particular focussing on informal learning.

  The framework itself is built as a circular combination of four layers: The outermost layer is a social networking layer that is supposed to foster informal learning and collaboration by building a shared social grounding. Moving inwards, organisation and collaboration management specifically support group activities and, finally, reflexivity forms the nucleus—supporting the fundamental abilities of self-awareness with the community. [PR06, pp.349f]

Both selected and most of the existing proposal are, however, only implemented in specific environments and, therefore, hard to generalise. This is in accordance with the observations of Etienne Wenger himself who states that *"learning cannot be designed: it can only be designed for—that is facilitated or frustrated"* [Wen02, p.229].

[9] An ontology is defined as *"a set of representational primitives with which to model a domain of knowledge or discourse"* whereas information about meaning, constraints, and the application of those primitives is included within a correct definition [Gru09].

3.2.3 Merging two Disciplines—a Proposal

As shown in brief above, there are various approaches and attempts to merge learning and knowledge management. In summary, it is no easy task to integrate learning and knowledge management. Unfortunately, most of those approaches are coined by one side of this merger: Where half of them try to integrate learning into knowledge management—and sometimes even perceive e-learning just as an add-on to knowledge management [Hüt06, p.13]—the other half looks at this integration the other way round and tries to integrate knowledge management into learning.

The so-called *Munich Model* for knowledge management integrates the three central components of *humans*, *organisation*, and *technology*—including corresponding tasks—and, therefore, is what is called a holistic model [RRM00, pp.15f]. As a result, this model in particular attempts to take into account psychological requirements of knowledge processes [RR01, p.3]. Therefore, this conception for knowledge management is proposed as a true consolidation of learning and knowledge management—applicable and implementable within both domains and benefiting from each other.

The Munich Model to Knowledge Management

The foundation of the Munich Model is built by learning goals, an understanding of knowledge *"as a variable state between information and acting"* [RR01, p.2], and the conviction that knowledge and learning are two fundamental categories within the life of individuals *and* organisations. Additionally, communities are depicted as the germ cells of knowledge management according to this model [RR01, p.2]. The Munich model, therefore, explicitly aims at a combination of the organisational and individual learning cycle as defined by Peter M. Senge et al. [Sen94, pp.17ff]. The organisational learning cycle is, according to Senge, shaped by *guiding ideas*, *theory, methods, and tools*, as well as *innovation in infrastructure*, whereas the individual learning cycle is built by *awareness and sensibilities*, *attitudes and beliefs*, as well as *skills and capabilities.* These components and their combination are shown in figure 3.4.

The Munich model integrates an object-oriented perspective on knowledge—closely adhering knowledge to information—and a process-

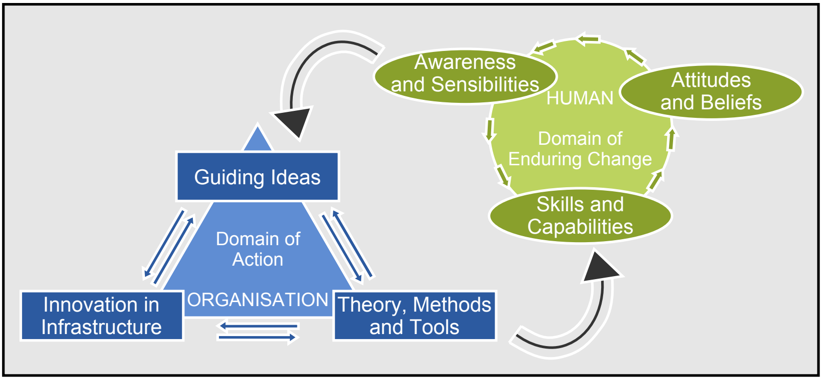

Figure 3.4: Combination of organisational and individual learning cycles [Sen94, p.42] (illustration based on [RR01, p.12])

oriented perspective—transferring knowledge to action. Similar to *building blocks of knowledge management* as proposed by Gilbert Probst et al., this results in four different *core knowledge processes* which make up the model—where all processes are designed to affect individual as well as organisational procedures and interests [RR01, pp.22ff]:

Knowledge Representation describes the attempt to make knowledge visible, tangible, accessible, and understandable—that is to identify, preserve, codify, process, and document knowledge [Nüb05, p.64]. Processes of knowledge representation, therefore, have the potential to transfer knowledge to a technically manageable state. Hence, knowledge representation initiates a movement from knowledge to information. Technology and information management are, thus, important components of knowledge representation. [RR01, pp.22f]

Concerning individuals and psychological aspects, these processes rely upon individuals' willingness to reveal their knowledge—which, in turn, builds on the awareness or a metacognition of existing knowledge and gaps within the knowledge base [RR01, p.23]. Knowledge representation is limited by an individual's nature, contextuality, and limitations of visible representations [Nüb05, pp.65f].

Knowledge Utilisation tries to make knowledge applicable so that decisions, methods, and actions can be taken. In other words, processes of knowledge utilisation have the power to inseparably connect knowledge to knowledge carriers and associated contexts. For this reason knowledge moves towards actions within processes of knowledge utilisation, a movement which can be found, in particular, within human resources development and competence management. [RR01, pp.23f]

However, to be able to actually use knowledge, individuals have to be capable to conquer the potential inertia of knowledge and be willing to leave familiar paths [RR01, p.24].

Knowledge Communication represents the approach to exchanging, sharing, distributing, and connecting knowledge—bringing knowledge into visible action. As a consequence, processes of knowledge communication are *pure* knowledge movements that can either be supported by technology or not. The closer those movements are to actions, the more intense the resulting interaction between individuals. [RR01, pp.24f]

Communication is a core aspect of human life. However, successful communication requires reciprocity and usually some personal benefit. Knowledge communication reveals whether individuals are willing to share information and whether they are capable of doing so. [RR01, p.25]

Knowledge Generation comprises the transformation of the resource of information into knowledge—that is the construction of knowledge and new ideas, individually as well as collectively. This is why processes of knowledge generation are the foundation of *every* knowledge movement—actually creating what is intended to be moved. [RR01, pp.25f]

Generating knowledge essentially builds on humans' abilities to learn—that is to transfer experiences to knowledge, to realise the unexpected, and to constructively create something new. All previously named barriers, therefore, influence—or may hinder—the successful creation of knowledge. [RR01, p.26]

All four processes and their interplay within the Munich Model of knowledge management are shown in figure 3.5. Processes more aligned

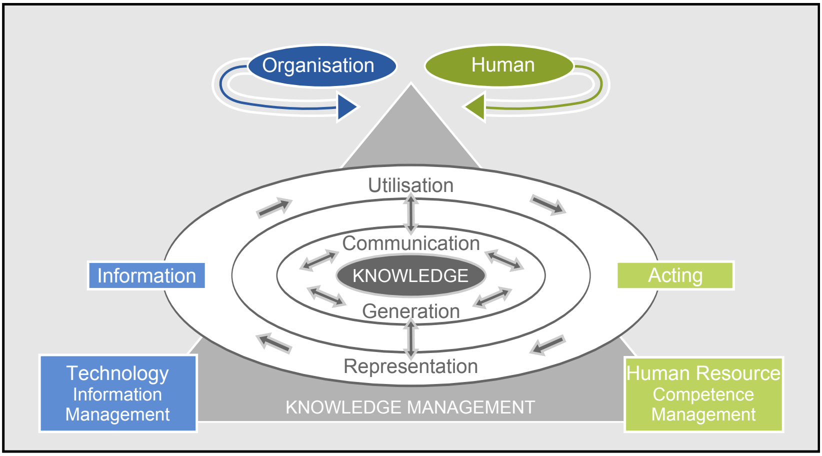

Figure 3.5: Processes of knowledge management within the Munich Model [RR01, p.27]

with an organisation build on *information* as well as *technology* and are, therefore, assigned to the area of *information management*. In contrast, processes more aligned to individual human beings are a matter of *acting*, or more generally *human resources*, and are also known as *competence development*.

In summary, the Munich Model offers the opportunity to integrate technical oriented information management and a human-centred competence management [RR01, p.2]. It is, therefore, closely related to e-learning systems—in particular, competence management systems[10]. The Munich Model intends to be a heuristic model—delivering an orientation framework and a common basis of understanding for interdisciplinary research, cooperation, and collaboration. The management of knowledge is embedded within a superior understanding of individuals,

[10] Where learning management systems are widely used and in particular in school and university settings, competence management systems are a variation of an e-learning system that recently started to spread to organisational settings. Competence management systems support human resources and development in gathering employees' competencies and selecting appropriate educational programs or new positions within an organisation [KSL+11, p.4]

groups and organisations—which is why it is especially beneficial in relation to the scope of this work. [RR01, p.19]

It has been shown that knowledge management and learning can mutually add value and benefit. The Munich Model revealed four core processes of knowledge that can be found throughout the domains of learning and knowledge management.

In conclusion, it can be said that there is a perceivable approximation of learning and knowledge. This shift becomes visible, among others, in recent developments derived from both sides: *e-learning 2.0* (cf. chapter 1.2.3) and *enterprise 2.0*[11]—both of which foster the utilisation of social software and, therefore, approach each other with flexible structures and the participation of *all users* or *learners*. Moreover, various projects—such as Learning in Process (LIP, cf. section 3.2.1) [Sch05, Sch04]—and technical solutions—such as the implementation of a knowledge content management system [GK02]—have shown for either side the value of an integration.

From the perspective of learning, an appreciation of learning as a process of personal growth—requiring individual acting, organisation, and management—is, however, a consideration that is up to this point absent. As a consequence, the next chapter takes a closer look at *personalised learning*.

[11] The term "enterprise 2.0" was initially coined by Andrew McAfee who simply defined enterprise 2.0 as the *"the use of emergent social software platforms within companies, or between companies and their partners or customers"* [McA27]. McAfee uses the acronym SLATES to define the six core components of enterprise 2.0 processes—that is *search*, *links*, *authoring*, *tags*, *extensions*, and *signals* [McA06].

4 Personalised Learning

"Personalisation is seen as the key approach to handle the plethora of information in today's knowledge-based society."

Martin Ebner et al. [EST+11, p.22]

There are several important trends in current technology: trends towards simplification, the idea of using technology "invisibly" in the background, and approaches to the ubiquity of technology [Dow09]. However, the most significant movement is a trend towards *personalisation* in technology.

> *"[Personalised technology] is yours, responds to your needs, it learns about you, it presents resources and services that are tailored to your particular needs and your particular style."* [Dow09]

This trend is, among others, reflected by *user centric media*—implying *"high quality media content generated, distributed, and experienced by end-users* [Use07, p.9] and acknowledging the end-user as the *"largest content producer and consumer of the future"* [Use07, p.11] (cf. chapter 6). Switching the focus from a well-defined group of users and specifically designed software to user centric applications essentially suiting individuals, brings with it a number of research and design challenges that have been identified by the Information Society and Media Directorate-General of the European Commission[1] [Use07]: 1) user generated content creation, management, and consumption systems, 2)

[1] Information Society and Media Directorate-General of the European Commission—
`http://ec.europa.eu/dgs/information_society/`

user centric media services in the extended home, 3) user communities systems and platforms, 4) personalised access to media systems, 5) novel networked media systems to support human creativity at the crossroads of information and communication technology and arts and design research, 6) policy, regulatory, and legal issues, and 7) test beds.

Challenge number one covers the aim of this work, namely *user generated content management and consumptions systems*—however with a focus on content in learning and, hence, learners. As a consequence, this chapter is dedicated to personalisation in learning—that is *personalised learning* or *personal learning.*

> *"Personalised learning [...] reflects learners' interests, preferred approaches, abilities and choices, and [allows] tailored access to materials and content"* [DfI08, p.33]

More precisely, personal learning is not just an adaptation regarding personal style but *"the placing of the control of learning itself into the hands of the learner"* [Dow05]. Nevertheless, personal learning is not considered to be isolated but represents *"the midway in a range of learning"* [Dow09]—whereas the range of learning is defined by the two dimensions *individual vs. group* and *self-study vs. collaboration.* This midway, hence, portrays learning as learning *"by yourself but in connection with or connected to other people"* [Dow09] and setting your own agenda, defining what to learn and what resources to use but doing so in cooperation and exchange with others. In conclusion, personal learning is *"owned by the learner"* [Dow13].

Personalised learning also connects and sums up the findings of the previous chapters: It is, accordingly, *self-directed* (cf. chapter 1.1.2) and can occur throughout the continuum of *lifelong learning* (cf. chapter 1.1.3). It would currently be identified as *technologically supported* (cf. chapter 1.2) with various tools for learning. Of course, personalised learning fosters the individual improvement of *knowledge* (cf. chapter 2), which in turn immediately raises the need for strategies supporting learners—the question that concerns *management in learning* (cf. chapter 3). The current chapter aligns the focus of this work by zooming in on a single learner, focussing on the *shift of responsibilities* to individual learners.

This approach begins by considering *challenges in personalised learning* resulting from that shift of responsibilities, and presents an approach to meeting these challenges which shows how the *change of perspectives* from organisational to personal knowledge management offers assistance for personalised learning. In summary, this chapter is, however, not explicitly dedicated to the terms “knowledge management” or “information management”. Instead, the essence of this chapter is what could also be phrased as *personal learning management* or ”methods to unfold one’s own knowledge potential” [RE08, p.14]. Hence, existing *tools for personalised learning* are examined in the last part of this chapter to get an idea of existing possibilities for supporting individual learners.

4.1 Challenges in Personalised Learning

Describing challenges in personal learning, this section tries to answer the question “what is special in personalised learning?” and “what are the most common pitfalls in personalised learning?” Straight forward, one might say that personal learning is special and leads to several pitfalls because a learner is on his or her own. This answer is however only partially adequate and requires supplementing by a closer look at the challenges in personalised learning.

We have learnt that even though learning is self-directed and personal, learners do not learn on their own but are always embedded in a social context. However, being embedded within such a social context is not identical to what would be called guided learning. Where guided learning offers pre-defined selections of material and recommendations on how to reach a learning goal, personal learning is centred around the interests of a single learner. In turn, this also implies that the learner has *“the choice of subjects, materials, learning styles”* [Dow13, p.23]. Therefore, “being on one’s own” as stated above refers to those decisions that ultimately have to be made by a learner him- or herself. There are, of course, several degrees or manifestations of personalised learning. A structured programme would for instance determine the subject and material but still leave the choice of learning styles, whereas a certain qualification might be reached with material and learning styles free of choice. However, *pure* personal learning will hand *all* those decisions to a learner.

Consequently, to be equipped to make those decisions a learner needs to be aware of possible choices. This scope of opportunities is, firstly,

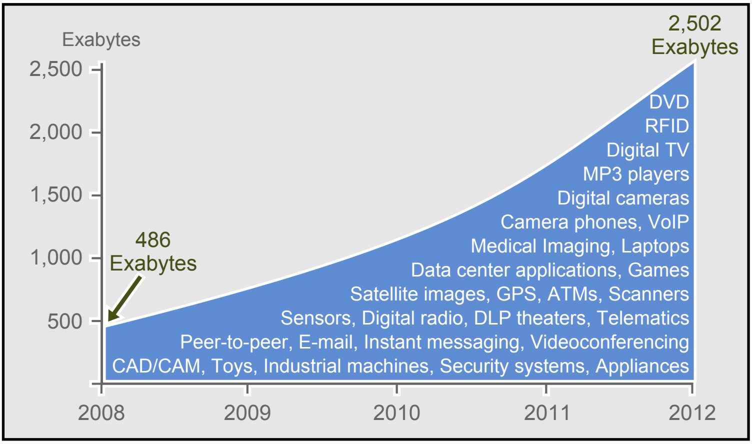

Figure 4.1: Digital information created and replicated worldwide [GCM+03, p.3][EMC09]

determined by a learner's *environment* which actually needs to be described as a variable due to its fluid and changing character [Dow10, p.27]. Additionally, the scope of opportunities is substantially shaped by the *information available* to a learner. As already described in the introduction of this work, concerning available information every learner is immediately confronted with a mass of extant information and thus meets what is called *information overload*, which describes the struggle caused by the scale of information they are faced with.

To give an impression of forms of information as they exist today, figure 4.1 shows the amount of digital information created and replicated worldwide based on a 2009 statistic, including a forecast in that year for 2012[2]. This figure reveals a fivefold growth in only four years [EMC09]. While not all of this information will be available to a single learner, this figure shows, however, the huge explosion of available information in general that learners have to deal with. Viewing this figure, the question of how this explosion came about arises, and can, among others reasons, be attributed to a change in media production:

[2]A live ticker of information created since 2011 can, for instance, be followed at `http://www.emc.com/leadership/programs/digital-universe.htm`

Traditional Media Production. Since the days of Johannes Gutenberg[3] producers of media were forced to account for the costs of their productions in advance—and hope that their invention would be profitable and customers would buy their media (books, films, etc.). Therefore, the quality of those media items was of extreme importance because only a certain quality level could—at least to some extent—assure the sale of produced media items. In other words, there was and still is a *filter for quality.* [Shi18]

New Media Production. What happened due to the rise and spreading of the internet is a considerable lowering of this filter for quality. Production costs almost completely dissolved [Shi18]. By drawing on (largely) freely available resources basically everybody is now able to produce media and publish it to the world (for instance using blogs[4] or platforms for sharing such as YouTube or facebook[5]).

As a result of those changes a learner is presented with the challenge of selecting information and, additionally, the problem of assessing the quality of that information.

> *"In an environment where information is ubiquitous and needs only to be located, there is a greater premium on skills that support fast and accurate access to information and on the ability to assess that information. "* [Edu09]

To be able to successfully accomplish those tasks, more precise information on the problem itself is required. Very often, information overload is referred to as *one* general problem. However, Nicholas G. Carr [Car07] argues that there are two different types of information overload that need to be distinguished and, by implication, dealt with—*situational overload* and *ambient overload.* This distinction of information is employed to identify the two major challenges of personalised

[3] Johannes Gutenberg invented movable type printing which is printing based on the individual components of text (lower and upper case letters, punctuation marks etc.). His masterpiece was the the 42-line bible. For more information on Johannes Gutenberg and his invention see `http://www.gutenberg.de/english/index.htm`.

[4] A blog can, for instance, be created within minutes using blogger—`http://www.blogger.com/`.

[5] facebook—`http://www.facebook.com/`

learning addressed within the scope of this work: *finding the needle in the haystack* and *keeping learning at a glance.*

4.1.1 Finding the Needle in the Haystack

The problem that is typically addressed when referring to information overload is what is called "finding the needle in the haystack" and can be defined as situational overload.

Situational Overload is caused by too much noise and refers to the so-called "needle-in-the-haystack" problem. This figurative problem implies that a particular piece of information—hidden in a large amount of other information—is needed. The challenge, therefore, is *"to pinpoint the required information, to extract the needle from the haystack, and to do it as quickly as possible"*. [Car07]

Concerning personalised learning, this challenge signifies the following problem: at a certain point of time during learning, a learner realises that he or she requires a specific piece of information to answer a particular question or to be able to continue with the current task. The required information might be a piece of information that our learner has already searched for, selected, and assessed a while ago or a question that was not presented to the learner previously but which needs to be answered immediately.

To cope with this kind of information overload, first of all, learning needs to be interrupted to find this information—which is unpleasant and hinders achieving a particular learning goal. The difficulty is, however, to find the appropriate information even if this piece of information has already been in the learner's hands once. Regarding the typical current situation of an individual learner, learning nowadays builds on a variety of tools and sources of information, which are, unfortunately, not universally accessible. Additionally, the human capacity for remembering is not as precise as we would wish for, so that this piece of information may not necessarily be readily recalled. Therefore, the selection of possible sources and a search within those sources (regardless of whether it is technologically supported or manually performed) needs to be repeated until the search is finally successful and the required piece of information is located.

As a consequence, this challenge in particular takes up one of the research questions of this work: an improvement of the support for *retrieving* personal information in learning.

4.1.2 Keeping Learning at a Glance

An even more important kind of information overload that is, unfortunately, very likely to be disregarded and is, in addition, hard to deal with concerns the ideal situation of keeping one's own learning at glance. This problem is referred to as ambient overload.

Ambient Overload is, in contrast to situational overload, caused by too many signals. This kind of overload occurs when there is so much information of immediate interests that one feels overwhelmed by *"the never-ending pressure of trying to keep up with it"*. [Car07]

In personal learning, ambient information overload causes severe damage. The primer objective in constructivism and connectivism that have been identified as advisable learning theories (cf. chapter 1.1) is the creation of new personal knowledge by actively constructing in relation to existing personal knowledge, to previous experiences, etc. It is essential that learners are *"capable of putting together information from different sources to construct complex meanings"* (cf. chapter 1.1).

If selecting and assessing information demands a learner's complete attention, resources to comprehend, understand, and connect those single pieces of information are missing. However, constructing comprehensive interrelations and preserving the overall view of what has been learnt is essential. As a consequence, learners stunt their ability to actively gain additional value, a deeper understanding, and new knowledge and finally loose the *overall view of learning*.

For that reason, this second major challenge in personalised learning is also embodied in one of the three research issue to be addressed within the scope of this work. An overall view of learning asks for an improvement of support for *managing* personal information in learning.

To quote Clay Shirky, *"if you have the same problem for a long time maybe it is not a problem—it is a fact!"* [Shi18]. For that reason, learners learning in a personalised way—and basically all other learners too—have to find a way to deal with those existing facts. As a consequence, meeting those challenges is what is identified as a decisive foundation for successful personalised learning.

> *"The best we can manage is to teach students how to learn, and to encourage them to manage their own learning"* [Dow10, p.28]

In other words, personalised learning requires an appropriate organisation and management of one's own learning. A concept addressing this request and, therefore, presenting a possible solution to this challenges, is *personal knowledge management.*

4.2 Changing the Perspective: from Organisational to Personal Knowledge Management

Recalling the definition of *management*, the term is commonly only used in economic terms where management stands for coordinated actions to guide and control organisations. However, "to manage" also comprises of successfully making a plan, mastering a tool, or competently accomplishing a difficult challenge. There is, thus, an increased demand for *personal knowledge management.* In particular, complex occupational fields liable to changing dynamics [RRM00, p.17] yearn for knowledge management on an individual level[6].

Learning fits into this picture in two ways: In a broader sense, organisational as well as individual knowledge management are always learning processes to reach pre-defined goals—pursuing high standards and raising the question of how to guide and support these processes [RRM00, p.22]. Moreover, learning is an area demonstrating a high level of dynamics, as referred to above.

Recollecting the previous definition of (organisational) knowledge management in chapter 3, knowledge management arose from different development lines (cf. table 3.1, p.74), builds on models from *engineering science*, benefits from *business economic* objectives, consults

[6] Personal and individual knowledge management are used interchangeably within the scope of this work.

theories in *sociology*, and considers *pedagogical-psychological* aspects [Rei05, p.10]. Since personal knowledge management is in particular concerned with an individual human being, it demands a focus on the considerable repertoire of pedagogical-psychological aspects [RE08, p.17][Rei05, p.11] that will now be explored under *roots of personal knowledge management.*

4.2.1 Roots of Personal Knowledge Management

The requirement to consider in particular pedagogical-psychological aspects, results in the close relation of personal knowledge management and *meta-cognition* as well as *learning strategies* [Rei05, p.11]:

Meta-Cognition is, by definition, a pooling of several abilities: 1) knowing one's own knowledge, 2) reflecting on one's own thinking, 3) observing and controlling one's problem solving, and 4) effectively organising necessary processes as well as utilities of learning. Meta-cognition, therefore, is comprised of two components—*meta-cognitive knowledge* and *meta-cognitive strategies.* [RE08, p.29][Rei05, p.11]

Ideally, meta-cognition needs no explicit actions but proceeds subconsciously. For that reason, meta-cognition is the prerequisite for the successful application of learning strategies. [RE08, p.30]

Learning Strategies assume that humans are, in general, able to consciously control their thinking and learning processes. As already outlined in chapter 1.1.2, learning strategies comprise cognitive, meta-cognitive, motivational, resource-based strategies as well as strategies for social interaction [Kil08, pp.4ff][NDH$^+$08, pp.72ff][Fri99, pp.9f][vHWSV00, pp.25f][LL03, pp.48ff]—whereas cognitive and meta-cognitive strategies establish the major part of those strategies [RE08, p.30].

The perspective of individual knowledge management can also be employed as a useful pattern for learning strategies and their application in various contexts [Rei05, p.5].

As a consequence, meta-cognition delivers a *frame* for personal knowledge management built of two superior components—*knowledge* *design* and *knowledge assessment* [Rei05, pp.11f]—whereas learning strategies assist in building this frame.

Knowledge Design. To be able to individually manage knowledge, certain preconditions have to be met, which means knowing what the requirements are for an appropriate *knowledge design*. Initially definitions of *knowledge goals* to be achieved and *knowledge processes* to be followed to accomplish those goals have to be found. [Rei05, p.11]

All activities for a knowledge design are mega-cognitive. Required learning strategies cover strategies for target analysis, strategies for time management, strategies to reveal knowledge gaps or related problems, and strategies for situation analysis—such as resource planning. [Rei05, p.11]

Knowledge Assessment. To ensure reaching what has been previously defined, *knowledge assessment* is essential. Accomplishments have to be screened and assessed afterwards or, even better, alongside knowledge processes. [Rei05, p.11]

Learning strategies of assistance are basically all formative and summative strategies for self-evaluation—such as self-control strategies. [Rei05, p.11]

Of course, this frame is very general. Nevertheless, the combination of meta-cognition and learning strategies forms the central foundation for personal knowledge management beyond blatant innovations [RE08, p.31]. Building on these descriptions and the basic definition of meta-cognition—relying on a certain self-awareness—it has to be noted that, in contrast to learning processes, personal knowledge management can *never* happen unconsciously or be practised implicitly [Rei05, p.12]. Hence, this frame is reflected in *processes of personal knowledge management*.

4.2.2 Processes in Personal Knowledge Management

In the light of these previous explanations and in particular the differentiation of personal and public knowledge, outlined in chapter 2.1.3, knowledge management turns into an *integrative task*—combining two fundamental ways of managing knowledge: the management of objectified, formalised—respectively public—knowledge *and* the management of idiosyncratic—and hence personal—knowledge. While the former can be achieved employing the traditional approach of planning, management, and control, the latter, in contrast, requires the encouragement of human abilities, preparedness, exchange, and design processes. [SR04, p.21].

In chapter 3.2.3 the Munich Model for knowledge management has been introduced as a bridge to merge organisational management theories and models with the area of learning. Recalling some details, the distinguishing feature of this model is its orientation towards psychological aspects of knowledge processes—allowing an organisational as well as an individual perspective [Rei05, p.12]. It seems, therefore, reasonable to transfer this model to the area of personal knowledge management.

Recalling its description, the Munich Model comprises of four core processes: *knowledge representation*, *knowledge utilisation*, *knowledge communication*, and *knowledge generation*. Transferring this model to personal knowledge management, these four core processes are extended by the additional process category *stress and failure management* to be able to comprehend personal knowledge management. Furthermore, the overall control loop adds the process categories of *knowledge goals* and *knowledge evaluation*[7]. The control loop—and its similarity to building blocks of knowledge management as proposed by Gilbert Probst et al. (cf. chapter 3.1.3)—are shown in figure 4.2.

In conclusion, seven categories of processes build this model for personal knowledge management, whereas—just as for organisational knowledge management—categories are neither selective nor independent but closely linked [RRM00, p.26]. In the following, each process category is examined and defined for its application in personal knowledge management—with particular reference to personal and public knowledge as subjacent taxonomy for knowledge[8].

[7] In fact the processes of knowledge goals and knowledge evaluation are already part of the organisational knowledge management control loop [RRM00, p.18].

[8] A detailed description of learning strategies that can be used within those process categories is omitted due to reasons of scope and space. Further information can be found in [RRM00, pp.33ff] and [Rei05, pp.12ff].

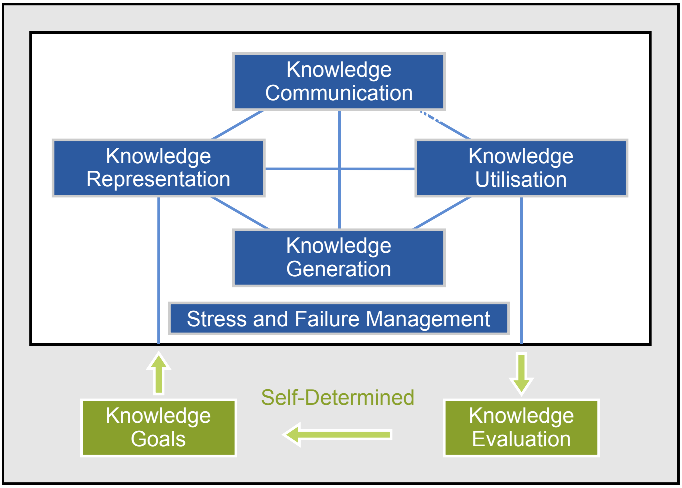

Figure 4.2: Process categories of personal knowledge management based on the Munich Model for knowledge management [RRM00, p.26]

Knowledge Goals are, sequentially considered, the starting point for personal knowledge management. A self dependent determination of objectives for personal knowledge management is comprised of a *target*, *time*, and *situation analysis*—which constitutes a *knowledge design* (cf. section 4.2.1) [RRM00, p.26].

To be more precise, a target analysis breaks down complex objectives into simpler targets—including short- and long-term objectives—and orders those goals according to their relevance. Even though such an analysis is meant to be self-determined, other-directed goals are likely to influence these decisions. Building upon this first analysis, a time analysis assigns appropriate time periods for each tasks, whereas a situation analysis determines circumstances such as the scope for decision-making and action. [RRM00, pp.34f]

Knowledge Evaluation is already introduced in the beginning of process categories because it is supposed to take place continuously and to *accompany* all other processes of personal knowledge management. In conjunction with knowledge goals, knowledge evaluation depicts the frame for the core processes of personal knowledge management and reflects the general frame as defined in the previous section.

Basically, knowledge evaluation is a formative and summative *assessment of knowledge* (cf. section 4.2.1) [RRM00, p.27]. Formative assessment is, in particular, of importance *during* all four core processes to control if or to which extent previously defined goals have already been reached. In contrast, summative assessment occurs *after* completing processes of personal knowledge management[9]. Results of a summative assessment are then supposed to improve subsequent processes of personal knowledge management. [RRM00, pp.39f]

Knowledge Representation is composed of processes of *knowledge diagnosis* and processes to *identify sources of information.* A knowledge diagnosis will, typically, reveal previous knowledge and subsequently determine remaining information needs. Similarly, sources of information are obviously identified by an information search and a detection of suitable information carriers. [RRM00, pp.27,43f]

Refining this description to consider personal and public knowledge, knowledge representation is comprised of two different processes: 1) *materialising personal knowledge* and 2) *restructuring existing public knowledge.* In other words, processes of the first category transfer personal knowledge to a visible or audible format and, therefore, create public knowledge. This newly represented knowledge is now independent from the previous knowledge carrier and the contexts of knowledge development. In contrast, processes of the second category use existing public knowledge to create a new, still public, representation of knowledge. [Rei05, pp.12f]

Knowledge Generation is the most comprehensive process category—actually transforming information to personal knowledge. This means that knowledge generation is *information processing*:

[9] It should also be noted that a strict sequence in—and therefore a complete finalisation of—personal knowledge management as assumed for this description of process categories is neither likely to happen nor desired. Instead single projects or phases are supposed to be concluded.

information has to be understood—in particular, taking into account the multimedia character of information—structured, boiled down to its core essence, and combined with previous knowledge. [RRM00, pp.27f,48ff]

Proceeding to types of knowledge, knowledge generation signifies the *construction* of new personal knowledge—which, in turn, implies that learning processes take place. Applying a constructivist perspective, knowledge is developed through acting or by gathering information—if comprehensive and transformational processes follow the initial gathering of information. [Rei05, pp.14f]

Knowledge Utilisation can be depicted as what is actually important in personal knowledge management—ultimately, if acquired knowledge cannot be utilised, personal knowledge management has to be considered a failure. Unfortunately, external variables or incentives to actively use knowledge are hard to grasp. Self-directed learning (cf. chapter 1.1.2), however, has been identified as one of the key factors to *prevent inert knowledge*. [RRM00, p.28f,64f]

Just as for organisational management, knowledge utilisation entails processes *applying knowledge* in decisions, measures, and activities. [Rei05, p.13]

Knowledge Communication involves a number of different processes—for instance exchange, mediation, construction, etc.—however all building on communication and interaction processes. Important structures and rules resulting in successful communication and interaction are, among others, rules for feedback and communication, planing and control principles, and common quality standards for exchange. [RRM00, pp.28,56ff]

In summary, personal as well as public knowledge are involved in processes of *information distribution*. This distribution can occur through various channels: Public knowledge can be distributed via traditional media—such as a notice board, newspaper, journals, etc.—or using technical tools—for instance e-mail, forums, blogs. In contrast, personal knowledge can be passed on by communication or within collaboration settings. To distribute personal knowledge in the same way as public knowledge, personal knowledge first has to be converted to public knowledge (cf. knowledge representation). [Rei05, p.14]

Stress and Failure Management is, again, a superior category contributing to a successful performance and accomplishment of all core process categories. Basically, stress and failure management builds on a *control of motivation.* [RRM00, p.29]

In addition to facilitative objectives and distinct interests, it is certainly motivation that drives personal knowledge management—and whose preservation can be a challenge. It is, therefore, important to gain a certain *acceptance of possible faults* as chances to learn. Equally important are *strategies* to emotionally and cognitively cope with information overload. [RRM00, pp.69f]

In summary, processes of personal knowledge management foster communication, cooperation, and collaboration in dealing with knowledge and try to facilitate processes of searching, documentation, and sharing of knowledge [Rei09, p.102].

Personal knowledge management, thus, also essentially builds on the transformational ability of knowledge within those processes to be able to be communicated and shared. These desired transformations are mental. For that reason, mental basic principles are employed to structure those transformations: 1) cognitive basic principles—the principle of *elaboration*, the principle of *(re)structuring*, and the principle of *flexibilisation*—, 2) meta-cognitive basic principles—the principles of *planning*, *(self-)monitoring*, *assessment*, and *regulation*—, and 3) *emotional-motivational* phenomena—that are *feelings*, *moods*, *motivation*, and *interests.*

These basic principles can also be employed to provide a *formal description of personal knowledge management.* [Rei09, p.103][RE08, pp.44ff]

4.2.3 Personal Knowledge Management: A Formal Definition

Building on (meta-)cognition and learning strategies, personal knowledge management is comprised of *"multifaceted concepts, methods, and* *tools"* serving individuals in 1) accessing personal knowledge and knowledge of others—namely public knowledge—, 2) selecting information relevant for action, 3) reflecting, 4) integrating new knowledge into their knowledge base, and 5) enhancing their personal knowledge [Rei09, p.102].

More specific but still generally applicable definitions of personal knowledge management are, however, hard to find and small in number. Basic definitions picture personal knowledge management as *"a collection of processes that an individual needs to carry out in order to gather, classify, store, search, and retrieve knowledge in his or her daily activities"* [Tsu02, p.6] or *"a conceptual framework to organise and integrate information that we, as individuals, feel is important so that it becomes part of our personal knowledge base"* [FH15, p.7] and attest that personal knowledge management fosters *"the development and utilisation of personal knowledge and competencies"* [Pir10, p.81].

However most of the time, a set of skills required for personal knowledge management is used to actually define personal knowledge management. Eric Tsui identified different sets of skills that have previously been proposed in literature [Tsu02, pp.7f]—for instance retrieving, evaluating/assessing, organising, analysing, presenting, securing, and collaborating around information.

For that reason and to be able to give a deeper definition, a formal description of personal knowledge management, as defined by Gabi Reinmann and Martin Eppler [RE08, pp.35ff], is employed for the scope of this work[10]. Reinmann and Eppler define a two-part description of personal knowledge management ultimately influencing all methods for personal knowledge management. The two parts of this comprehensive description—a *model* and a *grid of requirements*—will now be examined, again with reference to personal and public knowledge.

A Model for Personal Knowledge Management.

In general, the model for personal knowledge management defined by Reinmann and Eppler is shaped by three fundamental distinctions—

[10] Even though this description actually focuses on the part of human reality that is important for humans within organisations, it is a psychological model which places an individual and his or her experience as the main object of focus [RE08, p.35]—which is why it is nevertheless considered useful within the scope of this work.

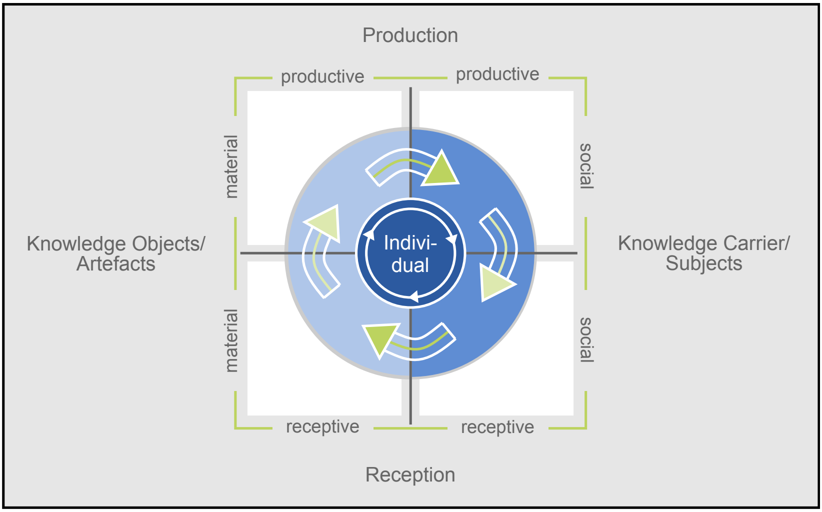

Figure 4.3: A model of personal knowledge management [RE08, p.42]

resulting in three dimension of this model as shown in figure 4.3 [Rei09, p.103]:

- Starting generically, *the inside*—referring to a person his or herself including personal knowledge (that is the *individual* in figure 4.3)—and *the outside*—comprising everything else—needs to be differentiated. In more detail, "everything else" can be further defined as the *knowledge environment* of an individual being that contains partners of social interaction as well as different types of media—that is public knowledge. This distinction is of prime importance for an individual to be able to actively interact with the surrounding environment. [RE08, pp.35f][Rei09, p.103]

- Continuing the development of this model, the knowledge environment has to be further divided by a differentiation of humans—who are *knowledge carriers* or subjects—and things or objects—that are *knowledge objects* or artefacts. [Rei09, p.103]

  This means that knowledge objects constitute our *material knowledge environment* and, that way, the public knowledge available through books, journals, encyclopaedias, databases, economic data, guides etc. In contrast, the people within one's knowledge environment make an individual's *social knowledge environment* involving teachers, lecturers, classmate, fellow students, etc. and *their* personal knowledge—which an individual might gain access to through social interaction. It is, however, important to notice that these different knowledge environments are not separated but connected through a continuous exchange. [RE08, pp.36ff]

- Finally, the third distinction is delivered by the way an individual interacts with his or her environment. Information can either be perceived as *receptive* for gathering new information or knowledge or used *productively* to create new knowledge or information artefacts. [Rei09, p.103]

  Again, knowledge reception and knowledge production cannot be completely separated. Both require an exchange within an individual's knowledge environment. However, participating in another person's personal knowledge or the material knowledge environment is a receptive perception of the knowledge environment, whereas a productive interaction is shaped by an active sharing of one's own personal knowledge with others—either through social interaction or by producing knowledge artefacts that can be reused as knowledge objects by somebody else. [RE08, pp.38ff]

The illustration of these distinctions in figure 4.3 also depicts transitions within this model as determined by processes of personal knowledge management described in the previous section.

Defining a Grid of Requirements

Defining a model for personal knowledge management is considered to be a first important step towards the successful implementation of personal knowledge management. However, recalling processes of personal knowledge management, it has already been stated that goals to be achieved are of prime importance to assure this accomplishment.

The description of Eppler and Reinmann, therefore, includes a *grid of requirements* as shown in figure 4.4 to define general objectives of

Figure 4.4: Grid of requirements for personal knowledge management [RE08, p.54]

personal knowledge management—again using two basic distinctions [Rei09, p.104]:

- ▷ The *nature of a problem* to be solved with personal knowledge management is the determining factor. If there is an acute problem or question that needs to be answered immediately, objectives are what is called *operational goals* and contribute to or result in an enhancement of performance. In contrast, if skills and knowledge are scheduled to be achieved in the long term to be able to cope with future problems, *strategic goals* are set to foster the acquisition of competences. [Rei09, p.104][RE08, pp.50f]

  Again, operational and strategic goals as well as performance and competence are not independent from each other. Instead succeeding or failing in solving an operational goal will lead to certain competences, whereas existing competences that have been acquired by achieving strategic goals are, in turn, reflected in solving operational goals. Performance and competence are, therefore, mutually dependent. [RE08, p.51]

- Moreover, the *degree of familiarity* influences the definition of goals. If all requirements are already established, the solution can be designed *efficiently* and *focus* on those requirements. In contrast, a yet unspecified problem that will be elaborated during its solution asks for an *innovative* solution *expanding* existing horizons. If a solution is actually innovative or efficient it is, naturally, subject to personal valuation. [Rei09, p.104][RE08, pp.52ff]

The resulting *grid of requirements* (cf. figure 4.4) delivers a four-field matrix depicting different approaches to sharpen goals of personal knowledge management: 1) convergent problem solving—that is a directed downsizing of the target area—, 2) divergent problem solving—requiring a purposeful expansion of the target area—, 3) the development of professional competences, and 4) the development of key competences [RE08, pp.52f].

To fully encompass personal knowledge management and its complexity, these two parts that are connected with each other. Where the introduced model provides a description language to fully *comprehend* all processes of personal knowledge management, the grid of requirements enhances the overall design with the possibility of *analysing* perceived requirements and selecting appropriate means [RE08, p.36]. This meaningful combination is shown in figure 4.5.

4.3 Talking Tools

The descriptions of personal knowledge management and, therefore, the description of possible means of assistance for achieving personalised learning were based on *basic principles*—such as principles of cognition and mega-cognition (cf. section 4.2.1)—resuming perspectives on knowledge, personal knowledge management, and personalised learning on a more abstract level. *Methods* are a concretion of those basic principles that can be transformed into behavioural patterns such as mind

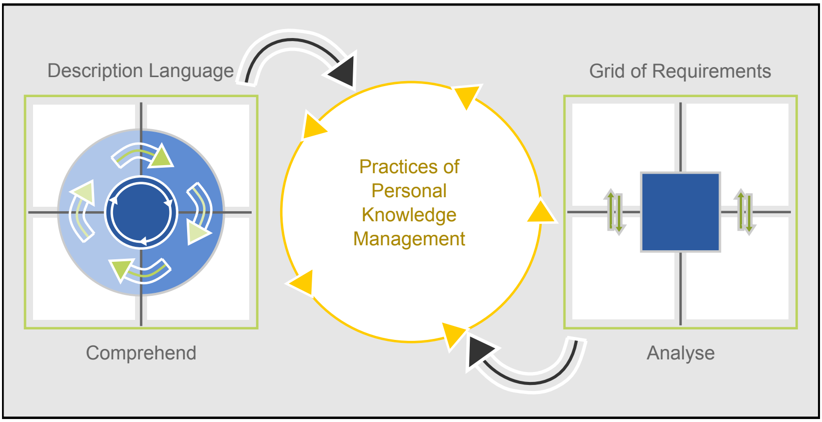

Figure 4.5: A description of personal knowledge management [RE08, p.58]

mapping[11]. Finally, *tools* are directly applicable utilities to realise one or more different methods. [RE08, p.58]

Therefore, in contrast to the previous sections—dealing with concepts for individuals to improve their own learning and organisation or management of learning—this section tries to respond to the issue of how to support individuals in doing so from the outside—that is by providing appropriate tools.

> *"The practice of learning and teaching is not predetermined, but always related to the tools and systems used in the process.* [SH08, p.1]

Tools for learning—as discussed in chapter 1.4—cover a wide range of applications. However, tools for learning in general were typically designed *"both within the existing paradigm of education [...] but also as management systems to maintain institutional control"* [Att07, p.46]. In contrast, *tools for personalised learning* employ a different design paradigm and focus on a learner and his needs [SK09, p.12].

Depending on individual preferences, ways of working, and different approaches to organisation, basically almost every technological tool

[11] Methods of personalised learning in general are too widespread to be precisely defined. For an extensive consideration of theoretical methods in personal knowledge management see [RE08, pp.57ff].

able to store information can be used to support personalised learning[12]. Social software is, for instance, one such popular support[13]. Essential to all such tools is their active construction of knowledge within those tools. Recalling the learning theories as defined in chapter 1.1, these tools build in particular on ideas of *constructivism*: Rather than just being transferred by delivering an appropriate input, knowledge is the result of an active construction process.

To be considered next are examples of opposite types of tools for personalised learning: Where *e-portfolios* are primarily developed through pedagogic processes [Att07, p.57] and, therefore, didactically grounded, *personal learning environments* are neither a new didactic model nor a concrete method to support personalised learning but a technological concept [SK09, p.6].

4.3.1 E-Portfolios

Traditional portfolios have been used extensively in education and training for many years. A portfolio, generally speaking, is a container used to store particular artefacts. Hence, an artist would collect outstanding pieces of his or her work in a portfolio and a mix of different shares will be collected within a share portfolio. [Bau12, p.7]

Essentially, *e-portfolios* evolved from traditional portfolios [Cla08]. An e-portfolio is, therefore, a digital form of such a container [Bau12, p.7], typically web-based, that transfers all features of a traditional portfolio to a digital environment [Kal09, p.36]. For that reason, e-portfolios can be characterised as a *didactically grounded* tool for personalised learning.

Technically, an e-portfolio is a *specific content management system*, since—just as for all content management systems—reading and writing access rights assigned to different users and groups of users are crucial [Bau12, p.7]. This also implies, that access is—at least very often and in particular in learning settings—granted by (educational) institutions, whereas structure and features are determined by the software used for the e-portfolio system [Kal09, p.36].

[12] To give an impression of the variety of settings, possibilities and tools used within this scope see [O'D10].

[13] Gabi Reinmann, for instance, presents a concept to use blogs for personal knowledge management within a university or school context [Rei08, pp.50ff].

> *"An electronic portfolio provides an environment where students can: collect their work in a digital archive; select specific pieces of work (hyperlink to artefacts) to highlight specific achievements; reflect on the learning demonstrated in the portfolio, in either text or multimedia form; set goals for future learning (or direction) to improve; and celebrate achievement through sharing this work with an audience, whether real or virtual."* [Bar06]

A Taxonomy for E-Portfolios

There is, literally, an incredible number of different e-portfolios varying in purpose, scope, and realisation. George Lorenzo and John C. Ittelson, for instance, identify and focus on three types of portfolios—student, teacher, and institutional e-portfolios [LI05]—whereas Wolf Hilzensauer and Veronika Hornung-Prähauser already consider six different types—development, teaching, career, application, language, and subject or course portfolios [HHP06, pp.7f]. Even more comprehensive lists include the assessment portfolio, application portfolio, development portfolio, hybrid portfolio, interdisciplinary (unit) portfolio, learning portfolio, presentation, showcase or best practice portfolio, process or time sequenced portfolio, reflection portfolio, and working portfolio [Bau12, p.9].

To keep track of all these manifestations, it is helpful to identify *categories of e-portfolios*. However, previously there has not been an accepted and comprehensive systematic categorisation or even taxonomy for e-portfolios[14], which is why Peter Baumgartner et al. [BHZ09, Bau12] took on the challenge of developing a profound comprehensive taxonomy for e-portfolio systems. This taxonomy can be described based on several distinctive features:

Basic Types To iteratively set up the taxonomy three basic types of e-portfolios have been identified: *reflection*, *development*, and *presentation portfolios*.

[14] An extensive literature review on meta description of and classifications for e-portfolios has been conducted by Peter Baumgartner et al. as part of their nationally funded research project "E-Portfolio in Universities". They identified eleven important definition approaches to (partially) classify e-portfolios. However, none of them provided a complete taxonomy. For more details see [Bau12].

Portfolio Category	Basic Type	Ownership	Orientation
learning product portfolio	reflection	personal	product
learning process portfolio	reflection	personal	process
assessment portfolio	reflection	institutional	product
curriculum portfolio	reflection	institutional	process
qualification portfolio	development	personal	product
competence portfolio	development	personal	process
job portfolio	development	institutional	product
career portfolio	development	institutional	process
application portfolio	presentation	personal	product
self-promotion portfolio	presentation	personal	process
showcase portfolio	presentation	institutional	product
representation portfolio	presentation	institutional	process

Table 4.1: A taxonomy for e-portfolios [BHZ09, p.6]

Features Classes To complete the taxonomy, firstly, *ownership*—personal or institutional ownership—and, secondly, *orientation*—product or process orientation—were added to the description system as crucial distinctive features [BHZ09, pp.3ff]. To reach the final classification, an additional seven significant classes were taken into consideration: time, feedback, relation to the world, activities, artefacts, view, and relation [BHZ09, p.5] [15].

This, finally, resulted in a taxonomy of twelve categories for e-portfolios as shown in table 4.1. It is worthwhile mentioning that *reflection portfolios* can be determined as the category of e-portfolios that is particularly useful within the context of learning [BHZ09, p.5].

Dimensions of Working with an E-Portfolio

While helpful, this taxonomy is still rather general. Hence, a more precise definition of requirements to be implemented is needed to be

[15] For more details on the process of selection and consolidation see [Bau12, pp.46ff].

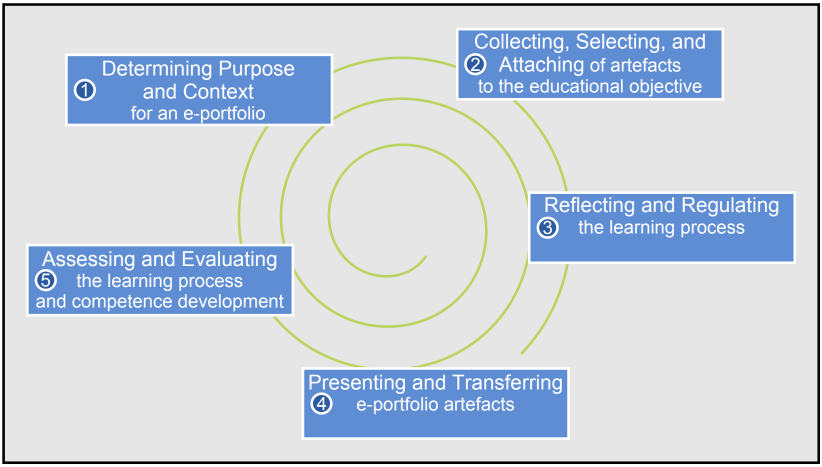

Figure 4.6: Dimensions of working with an e-portfolio [HHP06, p.5]

able to define a system as an e-portfolio system. For a start, Helen C. Barrett defines some generic tool requirements [Bar12]: e-portfolio systems need to allow digital archiving, electronic documentation of learning, presentation of (parts of) the portfolio, and assessment.

Additionally considering the process of actually building an e-portfolio, Wolf Hilzensauer and Veronika Hornung-Prähauser identified five different steps that need to be followed in order to successfully work with an e-portfolio [HHP06, pp.5ff] shown in figure 4.6: 1) determining purpose and context, 2) collecting, selecting, and attaching, 3) reflecting and regulating, 4) presenting and passing on, 5) assessing and evaluating. In accordance with Barrett, steps 2) - 5) need to be supported by a complete e-portfolio system.

A more detailed method to select an appropriate e-portfolio system has been constructed by Peter Baumgartner et al. [BHZ09]. Building on their own taxonomy as well as taking into account the results of a literature review and evaluations of 25 experts, Baumgartner et al. developed a list of criteria that need—or are at least desired—to be met by e-portfolio systems. This list of criteria contains 27 criteria points in all and is divided into five *meta categories*: 1) collecting, organising, and selecting, 2) reflecting, examining, proofing, and planning, 3) displaying and publishing, 4) administrating, implementing, and adapting, and 5) usability [BHZ09, pp.8f]. Others such as Douglas Love et al. identified five levels of maturing for e-portfolios: 1) scrapbook, 2) curriculum vitae, 3) curriculum collaboration between student and faculty, 4) mentoring leading to mastery, and 5) authentic evidence as the authoritative evidence for assessment, evaluation, and reporting [LMG04].

Nevertheless, to be able to classify tools within personalised learning, a categorisation of dimensions as proposed by Barrett as well as Hilzensauer and Hornung-Prähauser is recommended—and, therefore, also adopted within the scope of this work.

At the same time, it should however be noted that all these requirements only depict functionalities for software and, therefore, represent an *objective* relation to the world. There is, however, more than just an objective relation to the world: the personal use of an e-portfolio—and, hence, a *subjective* relation to the world—and the scenario the e-portfolio system is actually used in—the so-called *social* relation to the world. To try to build and apply the comprehensive concept of e-portfolios, it is crucial to consider all three relations or validity claims—even though only one of them, the objective claims, can be universally collected. [Bau12, pp.11ff]

Tools and Tool Kits

Finally, with regards to technical implementations, the number of tools and tools kits that can be used as e-portfolio systems is, at least, just as large as the possible characteristics and forms of e-portfolios. Among other reasons, this is because of the fact that not only systems explicitly declared as e-portfolio systems can be employed as e-portfolios. Possibilities are conceivably widespread. Starting from rather general to more specific systems, the following tools can be used as e-portfolios [Hae]: standardised templates—such as the iste[16] Microsoft Office templates—blog systems, web-based content management systems, learning management systems, or, finally, specialised e-portfolio systems.

[16] The International Society for Technology in Education (iste) provides different sets of templates, suitable for a digital or paper-based e-portfolio: `http://electronicportfolios.org/nets.html`.

A *categorisation of e-portfolio tools* supporting these assumptions is, for instance, provided by Helen C. Barrett [Bar07]—where e-portfolio tools range from (simple) authoring tools such as Adobe Acrobat to prominent e-portfolio software like Elgg[17] and Mahara[18] or specialised hosted services like PebblePad[19].

Interestingly, the evaluation of 12 e-portfolios systems according to Baumgartner's list of criteria—outlined above—revealed Mahara and PebblePad to be the best balanced products[20]. These results are, for instance, confirmed by Igor Balaban and Goran Bubas [BB10] who decided in favour of Mahara after evaluating Mahara and Elgg within a university environment as part of a two-stage study[21].

4.3.2 Personal Learning Environments

The term *Personal Learning Environment* (PLE) had its first recorded appearance during the 2004 JISC[22] CETIS[23] conference[24] [Kal09, p.31]. The participants of this conference argued that a learner or researcher has various "personal" learning environments—each of them likely to influence the others. However, a link or connection between those environments is missing. Therefore, to avoid ending up with completely divergent environments, an integrated *Personal Learning and Research Environment* (PLRE) has been proposed. Overall, the vision evolved that someday PLRE will not just be a browser but located on one's personal computer—even though collections of bookmarks, e-mails, calender, etc. were already confirmed as being very basic PLREs. [LPB+04]

[17] Elgg—http://elgg.org/

[18] Mahara—https://mahara.org/

[19] PebblePad—http://www.pebblelearning.co.uk/

[20] It should be mentioned that the evaluation is based on a market review conducted from November 2007 to January 2008 [BHZ09, p.9].

[21] Stage one of this study compared Mahara and Elgg based on the opinion of 54 students, whereas the second continued to evaluate the general usefulness of Mahara in more depth with 172 students. As a result of this study, Mahara was introduced at the faculty of organisation and informatics in the University of Zagreb. [BB10, p.332,335]

[22] Joint Information Systems Committee (JISC)—http://www.jisc.ac.uk/

[23] Centre for Educational Technology and Interoperability Standards (CETIS)—http://jisc.cetis.ac.uk/

[24] A conference website is no longer available. However, summary slides—http://www.jisc.ac.uk/uploaded_documents/PersonalLearningppt.ppt—and session notes—www.elearning.ac.uk/resources/PLEsessionnotes.doc—still document this appearance.

The PLRE was proposed as a point of intersection or *interface* between existing information, learning, and research environments. In the meantime, using the label PLE is more prevalent than the original notation of a PLRE. [Kal09, p.32]

In summary, a PL(R)E is, therefore, simply *the* individual knowledge and learning environment [Rei08, p.55]. PLEs are also characterised as *multidimensional spaces* [vH06] or the *central node* of a network [Dow10, p.30]. Even though there is no single, widely accepted definition [Edu09, p.2], PLEs can be depicted as *"a type of e-learning system that is structured on a model of e-learning itself rather than a model of the institution"* [Wil04]—and, therefore, builds on a design pattern opposed to the dominant design in educational systems so far [WLJ$^+$07].

Put simply, the idea is to *"push learning decisions down to the hierarchy or out to the edges of the network"* because *"those who are closest to the situation are in the best position to make decisions about it."* [Dow10, p.28]. In other words, the main intention of PLEs is a shift of control [Edu09, p.2] or, respectively, transferring *"the control of learning itself into the hands of the learner"*[Dow05]—bringing along a personalisation of content.

A Conceptual Foundation for Personal Learning Environments

Most often, PLEs are perceived as primarily technological concept, although bringing along important didactic and organisational consequences: a focus on the learner, his activities and needs [SK09, p.6]. PLEs are truly for learners [KSL$^+$11, p.6] and—most importantly—put self-controlled and active learners at the centre of attention [KSL$^+$11, p.5]. Hence, a PLE is *learner-centred* [Edu09, p.1]. Nevertheless, it has of course to be admitted that PLEs *are* a technological concept.

Trying to build a comprehensive concept, Sandra Schaffert and Wolf Hilzensauer identified *seven crucial aspects* illustrating important changes and challenges—and, therefore, establishing the foundation for PLEs [SH08, pp.3ff]:

Role of Learner As mentioned above, PLEs focus on learners as active and self-directed actors, also responsible for creating content. In contrast to traditional settings—where a learner is restricted to being a more or less passive consumer of what a learning management system or teachers offer—PLEs require *active participation*.

In summary, PLEs are changing the *role of a learner* and enabling the *"shift from [a] consumer to [a] 'prosumer' "* [SH08, p.4] of learning capable of self-organisation. This capacity for *self-organisation* (cf. chapter 1.1.2) is a determining success factor in this shift.

Personalisation Traditional learning systems allow for little or no personalisation[25]. If supported at all, learning content can, for instance, be presented based on prior learning tasks.

As opposed to this, the objective of personalisation in PLEs is defined as getting *"information about learning opportunities and content from multiple communities and services fitting to the learner's interest."* [SH08, p.5]. That is a personalisation of structure, tools, materials, look-and-feel, etc.—whereas sources of information are selected by the learner. This challenges a learner's abilities to 1) use social software tools, 2) cope with different learning strategies, and 3) obtain the required media literacy in advance.

Content The possibility of making intensive use of the *"bazaar of learning opportunities and content"* [SH08, p.6] is what sets PLEs apart from tools like learning management systems. Thus, this implies that PLEs not only contain content created by teachers and experts but content from a wide *community* of "peers"—that is learners with related interests, friends, colleagues, etc.

As a consequence, PLEs can strongly benefit from Open Educational resources[26]. However, this bazaar of resources, again,

[25] This claim basically applies to learning management systems. There are, of course, other approaches dealing with personalisation in learning: *intelligent tutor systems* and *adaptive hypermedia technologies*. These approaches are, however, firstly, not that widespread in traditional educational settings and, secondly, still limited to structuring and organising learning steps [SH08, p.5]. For this reason—and even though they are valuable and worth considering for different settings—these approaches are not incorporated within the scope of this work.

[26] An Open Educational resource is according to Sandra Schaffert and Wolf Hilzensauer [SH08, p.6] content that is 1) provided free of charge, 2) liberally licensed for re-use and, favourably, free from restrictions to modify, combine, and re-

heavily relies on learners who are competent in separating relevant information from invalid artefacts.

Social Involvement Collaboration is, of course, possible within more traditional educational systems—however, not the main focus [SH08, p.6]. PLEs acknowledge the importance of social involvement by fundamentally building on communities: A *"PLE always needs and builds on communities"* [SH08, p.7] to find contributors, co-actors, new sources of and new recommendations for learning content.

This philosophy—to build on members of one or more communities to successfully achieve a particular learning target—easily establishes a connection to the concepts of *Communities of Practice* (cf. chapter 3.1.4).

Ownership Looking at a learning management system, data created and provided with such a system is, usually, "sealed" within the system such that even owners of the data have only restricted access and possibilities concerning, for instance, the re-use of created content. The opposite extreme is pursued by PLEs: all available data and information *"is nearly totally open to world"* [SH08, p.7].

However, *"neither the personal data nor the copyright of individually created content is protected"* [SH08, p.7] which indispensably requires a learner's awareness for *data security*.

These first five characteristics distinctly illustrated the core of personal learning environments. In contrast, the last two characteristics—as named by Schaffert and Hilzensauer—cannot be seamlessly tied to the previous list because they are of a different kind or seem to be located on a more general level: *educational and organisational culture* deal with the surrounding environment, whereas *technological aspects* focus on the intended integration, difficulties, and a future perspective:

Educational and Organisational Culture In relation not only to personal but also *socio-cultural requirements* in educational institutions, a decisive role can be assigned to educational and organisational culture. In order for PLEs to be a successful approach

purpose it, 3) produced in an open format, 4) designed for easy re-use, and 5) developed and hosted with Open Source software.

for learning, the overall setting has to be "compatible" and qualify for utilisation. In other words, education settings are often based on completely different requirements than the ones described above. If PLEs are intended to be applied to such a setting, the setting or learning culture *has* to be adapted.

Technological Aspects PLEs were not brought into existence to replace learning management systems. It is, therefore, necessary to create a link between those two different worlds—also using complete different standards: LOM, SCORM, or IMS-LD (cf. chapter 8.2.2) for more formal settings and RSS[27], XML, or RPC[28] for more informal settings [SH08, p.8].

Two different paths for creating this link can and have been taken: 1) the integration of PLEs with existing learning managements systems or 2) the implementation of loosely-coupled tools on top of existing learning management systems.

If it has not already become obvious so far—lots of expectations are put into PLEs: PLEs are, for instance, depicted as *"the next generation environments which help to improve the learning and teaching behaviour"* [TETM09, p.997] or *"a portal to learning opportunities"* [CE08, p.2]. What is crucial is that, due to the focus of attention as defined above, facing those expectations is mainly up to the learners. However, to be able to master PLEs, students are in the need to maintain and organise their individual learning environment—a process of self-directed learning requiring a certain degree of self-awareness [Edu09, p.2] (cf. section 4.2).

Overall, PLEs in particular foster and support informal learning (cf. chapter 1.1.1), self-directed learning (cf. chapter 1.1.2), personal knowledge management activities (cf. section 4.2), and heterogeneous learning styles [Kal09, pp.58ff,79f]. It has, however, to be kept in mind that some students may not be ready for the responsibility that comes with building and managing a PLE [Edu09, p.2] and that abilities like those

[27] Really Simple Syndication (RSS)—originally RDF Site Summary (RSS 0.9, RSS 1.0) or Rich Site Summary (RSS 0.91, RSS1.0)—is an XML-based format used to syndicate web content. For more information see `http://www.rssboard.org/rss-specification`.

[28] Remote Procedure Calls (RPC) is a technique for inter-process communication allowing the execution of subroutine in different address spaces. For more information see `http://en.wikipedia.org/wiki/Remote_procedure_call`.

needed to master informal, self-directed learning or personal knowledge management cannot be taken for granted [SH08, p.5].

In summary, PLEs are depicted as defined by Graham Attwell [Att31, pp.19f]—that is 1) a collection of tools, loosely coupled for working, learning, and collaboration as well as 2) spaces to interact and communicate. As Rolf Schulmeister has summarised, *"a PLE consists of standard components whose composition is individual, however within a restricted scope"* [Sch13]—which is actually the closest we can get to a universal definition.

Mashup Personal Learning Environments—a Common Ground and Implementation

As stated above, in very general terms a PLE consists of all tools supporting the learning process in some way—for instance tools to administer learning resources, to communicate, to collaborate, and to organise learning [Kal09, p.38]. It is, therefore, a collection of tools or interoperation applications [Dow05]—however, involving specific requirements:

> *"Technically, a PLE amounts to (web) applications open to an individual and decentralised assembly of numerous different (Web2.0) applications—in contrast to an externally organised environment such as a learning management system*—and *ideally allowing lifelong access—independent from a specific educational institution.* [Rei08, p.55]

Of course without a single, widespread definition, there are different approaches to (technically) describing PLEs: Sandra Schaffert and Wolf Hilzensauer [SH08, p.1] denote PLEs as user-centred learning approach using social software tools, whereas Stephen Downes [Dow10, p.30] attests a PLE to the merging of the functions of a content management system with a social networking service.

Moving on to try and derive a requirements specification for a possible PLE, different arrangements of desired and necessary functionalities can be determined. Sandra Schön and Marco Kalz [SK09, p.6], for instance, demand capabilities to individually integrate and organise distributed information, resources, and contacts as well as opportunities for information—or activities and their results—to be applied to other online environments. More elaborate compositions of requirements exist to varying extents and depths:

- ▷ Marco Kalz et al. [KSL+11] differentiate three areas of activity for PLEs: 1) individual *subscriptions* to sources and resources as well as *presentation* of content, 2) *access* to communication and networking, and 3) *interfaces* and *tools* to work individually and collaboratively.

- ▷ On the contrary, the National Research Council Canada[29] identifies four major stages depicting the functionality of a PLE [Dow10, pp.30f]: 1) to aggregate content—where aggregation includes elements of *recommendation*, *data mining*, and *automated metadata extraction*—, 2) to organise content—including organisation through *automated clustering*—, 3) to modify or create new content, and 4) to send the content to subscribers or other web services.

- ▷ A detailed description of nine processes within a PLE—particularly considering knowledge maturing processes—is proposed by Graham Attwell et al. [ABBB08][Att31, pp.21ff][30]: 1) access and search, 2) scaffolding and aggregation, 3) manipulation, 4) analysis, 5) reflection, 6) presentation, 7) transfer, 8) sharing, and 9) networking.

- ▷ Taking a different approach for a requirement specification, Matthias Palmér et al. define six dimensions for building a web PLE along with appropriate standards: 1) screen—that is the organisation of several widgets[31] on a screen—, 2) data—ensuring data interoperability across different widgets—, 3) temporal—responsible for synchrony across all widgets—, 4) social—allowing the interaction of users—, 5) activity—fostering learning activities within a PLE—, and 6) runtime—in charge of cross-platform interoperability [PSB+09, p.33].

[29] National Research Council Canada—`http://www.nrc-cnrc.gc.ca/eng/index.html`

[30] The explanations of Graham Atwell et al. use an exemplary scenario to introduce the different operation spheres. These specific descriptions have been generalised in [AKTZ11, pp.74f].

[31] Widgets are micro applications performing a dedicated task [MC].

Glancing over these requirements, it becomes obvious that these catalogues are neither analogical nor disjointed. It can, therefore, be concluded that there is no single valid requirement specification for a personal learning environment—resulting in the need to instead define personal requirements when designing a personal learning environment.

There is, however, a common ground—to the extent that a PLE is a more or less connected collection of individually selected tools or applications supporting a learner in task of his or her choice: a *mashup*[32] environment.

In terms of adding technical details, there are numerous different ways to realise this common ground through a collection of tools and applications or, respectively, a mashup. However, to get an impression of these possibilities three exemplary implementations to realise a mashup are named: 1) a service integration of additional features into exiting learning systems—for instance using RSS feeds—, 2) the provision of an integrated user interface—a so-called *personal desktop* or *personal dashboard* combining information from different sources—, or 3) the implementation of a new framework—allowing the implementation of new application based on services integrated within the framework [SK09, pp.9f].

As a consequence, personal dashboards such as iGoogle[33] or symbalooEDU[34] provide the possibility to combine almost arbitrary websites and are, therefore, also classified as PLEs. At the same time, complex approaches such as the learner interaction scripting language (LISL)[35] that build a new framework result in a PLE, too.

[32] A mashup application is a web application combining content from multiple sources to provide all information as unique service. Mashups range from simple basic applications to more complex services—whereas complex services have to deal with *data retrieval*, *source modelling*, *data cleaning*, *data integration*, and *data visualisation*. [TSK08]

[33] iGoogle—`http://www.google.de/ig`

[34] symbalooo is actually a bookmark system—since September 2010 available as educational version: symbalooEdu. This educational version additionally allows the integration of Web2.0 tools, integration of resources, and sharing amongst each other—`http://www.symbalooedu.com/`

[35] The learner interaction scripting language (LISL) represents learning situations by activities which, in turn, consist of actions—referring to object and requiring tools. That way—using LISL—learners can build a PLE for a specific learning situation. For more details see [WMS08].

It must be taken into account that personal learning environments are a rather new concept and so are its representatives. Due to the openness characterising this concept, the development is not close to being finished and interesting features for future realisations are easily conceivable. Sandra Schaffert and Wolf Hilzensauer [SH08, pp.8f] suggest the following features for future consideration: 1) *tagging* opportunities with a focus on appropriateness for learning, 2) *visualisation* of communities and persons with similar (learning) interests, 3) new approaches to *content and network analysis*, and 4) a *technical integration* of different learning management systems.

4.3.3 Personal Learning Environments and E-Portfolios—Two Sides of the Same Story?

It should now be apparent that e-portfolios and PLEs are not alike but are instead two contrasting approaches to personalised learning:

> *"An e-portfolio is a place for reflection, for recognising learning and presenting that learning. A PLE may be seen as a tool (or set of tools) for not only presenting learning but for also (individually or collectively) developing a representation of wider knowledge sets."* [Att08]

Yet the question rises whether e-portfolios and PLEs are, at least, two sides of the same story—actually intending the same goal but reaching it differently. There is an agreement[36] in the literature that there is a connection between e-portfolios and PLEs:

E-Portfolios—an Important Part of PLEs. A personal learning environment is not just an alternative label for an e-portfolio but a more comprehensive concept—since the structure of the personal learning environment and the selection of applications and content is within the responsibility of a learner. For that reason, an e-portfolio can be part of a personal learning environment.

[36] There also a differing view depicting PLEs as primarily as data contributors for e-portfolios [Him10, pp.13,15]. It is, however, believed that this is opinion evolved from a concentration on e-portfolios and not the examination of the interrelation between PLEs and e-portfolios.

What is still missing, is a technological link of these two concepts bringing the merit of more than just the sum of two singular concepts. [Kal09, p.37][ES07, p.205,207]

Within the scope of this work a more open point of view is adopted, reflecting Graham Attwell's depiction of e-portfolios and PLEs as *"being on a developmental continuum, both technically and pedagogically"* [Att07, p.57]:

- ▷ *E-portfolios*, at the current stage of development, implicate a precise idea of how learning is supposed to take place—despite leaving several degrees of freedom to the learner—and establish a particular support for learning as assumed. Despite being represented by a range of implementations, e-portfolios are a clearly defined concept for personalised learning.
- ▷ In contrast, *personal learning environments* are a technologically focused approach for personal learning trying to minimise ideas on standards for learning and maximise the degrees of freedom for a learner. As a result, PLEs are a fuzzy concept that can be implemented by a multiplicity of differing tools.

Nevertheless, PLEs and e-portfolios contribute to *"a move from seeking to use technology to manage learning to encouraging and facilitating wider social learning processes, encouraging and valuing both informal and formal learning and recognising the different contexts in which learning takes place"*—whereas this move includes 1) placing the control in the hands of a learner and 2) providing learning with skill and competencies needed to do so [Att07, pp.57f].

Concluding the definition of personalised learning, it needs to be clarified that personal learning does *not* set out to veer away from educational institutions. Educational institutions will continue to play an important role in providing access to expertise, structuring bodies of knowledge, and enabling qualifications. There are, however, two important changes to the role of educational institutions in personalised learning [Att07, p.58]:

1) The monopoly on knowledge those educations formerly occupied no longer exits.

2) Pursuing personal learning and, hence, personalisation, institutions are now required to engage with the learner—rather than counting on learners to engage with institutional provision.

In summary, personalised learning and tools for personal learning represent *"a significant move towards [...] a new organisation of education"* that brings together personal learning in multiple contexts [Att07, p.59]. Learners have been liberated to organise and manage their own learning using their own tools for learning. As a consequence they are now required to step up and do so.

Wrapping up...

This being said, the framework for personal information management in learning has been established.

This first part of the thesis defined the scope of this work and described the space of existing solutions to be drawn from. Learners move on individual learning paths in formal and informal learning settings to acquire knowledge on their journey throughout lifelong learning and can rely on a range of different technologies and management techniques.

Two aspects—*finding the needle in the haystack* and *keeping learning at a glance*—have been identified as particular challenges in personalised learning. As a consequence, these challenges need to be addressed when building a system designed for individual learners.

5 From Theory to Practice

"In theory, there is no difference between theory and practice.
But in practice, there is."

Jan L.A. van de Snepscheut, Yogi Berra

Chapter 1 has set out the scope of this work while advancing ways to support learners and *define learning* in its many facets. Subsequently, a *definition and description of knowledge* as essence of what is actually learnt and an introduction of *knowledge workers* in chapter 2 built the foundation to introduce *knowledge management theories and models* and *management in learning* in chapter 3.

It was intentionally decided to introduce *knowledge management* rather than *information management* for the following reason: In contrast to information management, knowledge management is more a far reaching theory than a concrete technological solution. It felt important to outline non-technical aspects and to be able to take those into consideration for actually designing and building a technical system.

Of course, there is neither a single learning theory that is broad but also specific enough to suit each individual learner [Dri05, p.411] nor a single management concept easily applicable for every learner's needs—due to our natural individuality and variety. Therefore, the concept of *personalised learning*—introduced in chapter 4—brings with it more flexibility and opportunities for individualised learning and, hence, tools in learning—even though considering important processes of knowledge management.

In conclusion, these first four chapters establish a *theoretical framework for personal information management in learning.*

Building on these definitions and the foundation that has been shaped throughout these chapters, this work presents *a novel idea* *to support personalised learning* and elaborates the corresponding concept—including the overall setting, the technical foundation, and the composition of all components. As a consequence, the concept presented in this work can be described as *embedded* within the processes of personalised learning and personal knowledge management.

To further classify what it is that has been developed within the scope of this work—and will be the subject of the following chapters—possible distinctions of *knowledge management instruments* are employed [Rei05, p.16]:

Formal Level. Formally, an instrument is either a tool, a technique, or a method. A *tool* is defined as a physical or conceptual means—such as a software application or a mathematical formula—a *technique* depicts a certain usage of those tools, and principles to select those techniques are, in turn, labelled *methods*. [Roe00, p.158][Rei05, p.16]

Content-Based Level. To illustrate the intended effect of an instrument, a distinction can also be established using a certain management model—that is a content-based distinction [Rei05, p.16]. Consulting the processes of personal knowledge management introduced in section 4.2.2, an instrument can, for instance, be concerned with one or more processes of knowledge management such as knowledge representation, knowledge utilisation, knowledge communication, knowledge generation, stress and failure management, or objectives.

Problem-Based Level. Adding the perspective of how instruments actually face a knowledge problem, brings an additional problem-based level for classification. A problem can either be approached *technically*—using information and communication technologies—*structurally*—by rearranging institutional structures or conditions—*process-oriented*—that is an improvement of working and problem solving processes—or on a *mental* level—by influencing beliefs, positions, or patterns of thought and action. [Rei05, pp.16f]

That being said, this work delivers a *tool*—that is a *technical solution*—supporting several *techniques* of *personal knowledge management* for learners within an *e-learning* environment—in particular, processes of *knowledge representation* and *knowledge utilisation*.

Information Management...

Even though the theoretical framework developed within the first chapters of this work introduced and built on knowledge management and personal knowledge management for a good reason, there are several arguments why this thesis is called *information management for digital learners*:

- For a start, the overall similarity of what is labelled "personal knowledge management" and "personal information management" is demonstrated by the fact that William Jones and Harry Bruce describe the ideal of personal information management as *"always [having] the right information in the right place, the right form, and of sufficient completeness and quality to meet our current needs"* [JB05, p.2]—which is simply the common mantra for knowledge management that has been introduced at the beginning of chapter 3.

- David Elsweiler et al. argue that personal information management develops *"systems to help people manage and re-find their information effectively, without frustration"* whereas personal knowledge management is concerned with the problem of *"how employees can use their personal information collections as knowledge stores, creating in essence a repository of their knowledge for use by themselves or others"* [EMA09, pp.280f].

- Heiko Haller defines personal information management as mainly concerned with *"managing pre-existing information"*, whereas personal knowledge management tries to capture and manage a learner's internal knowledge and thoughts [Hal10, p.76].

- Moreover, Gabi Reinmann-Rothmeier and Heinz Mandl argue that solely building a on technical solution is, at best, data or information management but not knowledge management [RRM00, p.15].

- This is also in line with Thomas Collins who reasons that personal information management conveys a focus on technology whereas personal knowledge management is, in particular, concerned with the life cycle of knowledge [Col04][Böt17, p.8].

In conclusion, preference is given to employing a characterisation as *information management* rather than knowledge management for this work.

... for Digital Learners

The *target group* are *learners* as described in chapter 1—in particular active, self-directed learners in formal or informal settings throughout their journey of lifelong learning. More precisely, the learners aimed at within the scope of this work are moving and learning in a digital environment and for that very reason paraphrased as *digital learners*.

Concerning the overall setting of learning, this work aims at individual learners learning in a personalised way as described in chapter 4. To be more precise, *challenges in personalised learning* as examined in chapter 4.1 depict the problems of digital learners that need to be solved—and, hence, the research questions addressed and what is sought to be accomplished within the scope of this work.

The next part of this thesis, therefore, describes thoughts, concepts, and a proposal on how to *build a personalised learning information management system*.

Part II

Designing and Building a Personalised Learning Information Management System

6 What Learners Need

"Everyone has become a librarian, but, unfortunately few people know how to behave like a librarian; instead they behave like e-shoppers."

David Nicholas, Eti Herman [NH09, p.1]

To be able to build a *personalised learning information management system*, it is indispensable to be aware of what learners actually need and to consequently map the system to the fulfilment of these needs.

This taking into account of what users or learners actually need—instead of a simple consideration of how the system is used—is what defines a *user-centred approach* that contrasts with a system-centred approach [Wil00, p.51]. User- or human-centred design[1] is *"a design philosophy where the end user's needs, wants, and limitations are a focus at all stages within the design process and development life cycle"* [IT 12]. In contrast, *user-centred media*—which has already been introduced and utilised in chapter 4—is actually based on this definition and about the user becoming the major producer and distributor for media. Boiling user-centred design and media down to an essence, both result in a dynamically evolving application that is continuously adapted whenever users contribute their user-generated content in any form [Use07, p.11].

The system developed within the scope of this work is one such user-centred system—in its design, implementation, and the actual utilisa-

[1] User- or human-centred design is also defined by an ISO norm. In 2010 the previous standard norm, ISO 13407—`http://www.iso.org/iso/catalogue_detail.htm?csnumber=21197`—was withdrawn and substituted by ISO 9241 part 210 "human-centred design for interactive systems"—`http://www.iso.org/iso/home/store/catalogue_ics/catalogue_detail_ics.htm?csnumber=52075`. For further reading in particular concerning the issues of user-centred design for the Web see [Gar11].

tion by a learner who is creating his or her own (user-centred) learning media.

Trying to further define what learners actually need, one of the previous chapters (cf. chapter 2) has revealed that, from a very general perspective, learners set out to acquire knowledge or information as a foundation within the comprehensive taxonomy of learning (cf. figure 2.1, p.52). Being precise, learners actually pursue the gain of knowledge that is, most of the time, required to accomplish a specific task currently presented to a learner. If this information or knowledge is not already part of an individual's knowledge base—in other words, knowledge is missing–a need for information rises with the attempt to accomplish this task [Ger11, p.27].

As a consequence, the first step in successfully designing and building a personal information management system is an investigation of those needs—known as *information needs*. To succeed in a proper collection of those needs, information needs will at first be generally defined. Subsequently, information needs and related concepts—namely *information demands*, *information seeking*, and *sources of information*—are examined with a particular reference to learners individually acting within their personal learning or knowledge environment.

6.1 Information Needs—a Formal Definition

In general and economic terms a need is an *"objectified and made concrete demand for a commodity that results from a human necessity—that is from a subjectively felt shortage"* [HHR11, p.178]. What occurs *"when a person recognises a gap in his/her state of knowledge and wishes to resolve that anomaly"* is called an *information need*[2] [Nic00, p.20]:

[2] For the sake of completeness it has to be mentioned that information needs arise out of three other basic human needs that have to be distinguished from information needs: physiological needs, psychological needs, and cognitive needs. An information need is, therefore, also defined by the primary need, which is, in turn, dependent on the information need to be met. These basic human needs are, however, skipped for reasons of simplicity and are not a further subject of this work. [Nic00, p.20]

> *"The type, amount, and nature of information that is needed to accomplish a task is generally referred to as information need."* [PF88, p.609]

However, these needs cannot be gathered unambiguously. Information needs can either be analysed from the perspective of a task or from the perspective of the individual task manager [PF88, p.609]. It is, therefore, necessary to distinguish *objective* and *subjective information needs*:

Objective Information Need. The easiest and most objective way to describe information needs, is to make this description independent from an individual person [GvL08, p.133] and to base a characterisation solely on the *related task*.

An identification of important characteristics can, for instance, be grounded on two major attributes of a task: its *structuredness* and its *variability*. Using these attributes results in four different kinds of tasks and objective information needs: tasks as well as the corresponding objective information needs can be

- ▷ heavily structured and slightly variable,
- ▷ heavily structured and strongly variable,
- ▷ lightly structured and slightly variable,
- ▷ or lightly structured and strongly variable [HHR11, pp.177ff].

A structured approach to actually identifying these demands is a so-called *information need analysis*. Ironically there is, again, a number of subjective and objective techniques to collect the objective information needs [Krc10, pp.64ff]. Nevertheless, in simple terms it can be noted that the more structured and the less variable a task is, the easier it is to define the information needs [HHR11, pp.177ff].

Unfortunately for personal information management, learning is very likely to be strongly variable and, most of the time, little or less structured. For that reason an information need analysis[3]

[3] Since an information need analysis is not the appropriate measure to determine the information needs of learners within the scope of this work, the reader is referred to [HHR11, pp.180ff], [Sch08, pp.27ff], and [NH09, pp.27ff] for further reading and details on information need analyses.

turns out to be less helpful in precisely identifying a learner's needs.

Subjective Information Needs. To fully comprise information needs, objective information needs have to be differentiated from the personal information needs that are essentially affected by an individual's characteristics such as emotional and cognitive conditions: the *subjective information needs*.

Due to their personal nature, these needs can be determined by various possible causes such as the subjectively experienced variability of the difficulty to fulfil a presented task, differing cognitive abilities, the situation-dependent and varying aspiration level, divergent understandings of the fulfilment of tasks, and the environment of the responsible task manager or learner. Naturally, to be able to collect these kind of information needs, it is essential to actively incorporate the learner. In other words, successfully identifying subjective information needs always has to be user-centred. [HHR11, pp.183f]

Such an incorporation, however, sounds simpler than it actually is. One of the first authors to introduce information needs as *"personal, psychological, sometimes inexpressible, vague and unconscious condition"* [Bru05] was Robert S. Taylor. Taylor defined a *question spectrum* that is defined by four levels of questions—or, respectively, four different information needs [Tay67, p.8f]:

- ▷ The actual but inexpressible and non-formalised need for information that may, for instance, only be a vague dissatisfaction called the *visceral need*.
- ▷ A conscious within-brain description of a need—the result of trying to sharpen one's focus—referred to as *concious need*.
- ▷ The *formalised need* that can be represented by a formal statement.
- ▷ What is presented to the information system that is the *compromised need*.

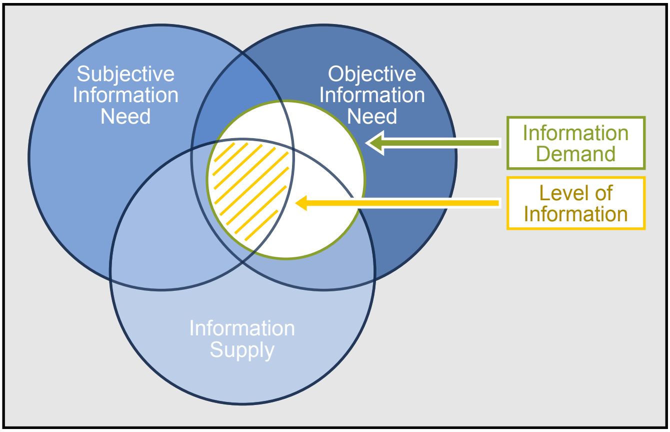

Figure 6.1: Information need and related concepts [PF88, p.609]

For this very reason, determining the subjective information need is more difficult and not as well matured as identifying the objective information needs [HHR11, p.177].

In summary, it has to be admitted that the independent specification of objective and subjective information needs is in practice difficult—if not even impossible [GvL08, p.133]. In an ideal situation subjective and objective information needs will be identical. If this is not the case, it is always due to individual reasons or a lack of structure in the tasks [PF88, p.609].

6.1.1 Different Concepts of Information

To be able to fully comprehend the concept and complexity of information needs, it is important to distinguish between three more concepts of information: *information demand*, *information supply*, and the *level of information*. The connection and overlap of all those concepts as well as objective and subjective information needs are shown in figure 6.1.

Information Demand. For a start, it is important to separate information need and information demand. The information demand, in general, is *"a request for an item of information believed to be wanted"* [Nic00, p.25].

Ideally objective and subjective information needs determine the information demand; information demand is however always a subset of the subjective information needs [PF88, p.609]. Being realistic, the information demand is usually considerably smaller than either of them [HHR11, p.177].

This difference between information needs and information demand can basically be traced back to time restrictions—not allowing for all of the information to be collected—and the process of procuring information—that is by nature sequential. Even though an accurate explanation of this correlation has not been found yet, personal characteristics such as motivation, curiosity, or pursuing an acuteness of thoughts are likely to increase subjective information needs as well as the information demand, whereas self assurance, the readiness to assume risks, or routine are supposed to reduce both. Most importantly, the impact of subjective information needs on the information demand rises with a growing variability and a low structuredness of tasks. [HHR11, pp.185f]

Recalling from the beginning of this section that learning has been determined as likely to be strongly variable and less structured, it can be concluded that subjective information needs are extremely important in personal learning and personal information management.

Information Supply. Proceeding, the sum of all information available at a given time is called *information supply* [GvL08, p.133].

In a ideal world, information demand and information supply are equal and result in an *informational balance*. An imbalance in favour of information demand is known as *paucity* or *lack of information*, whereas an imbalance in favour of information supply is called *information overload* (cf. chapter 4.1.1 and 4.1.2). [HHR11, pp.185f]

Level of Information. Finally, the overlap of these concepts as shown in figure 6.1 is the information booth or *level of information* [HHR11, pp.186f]. The better the information supply matches the information demand, the higher the level of information [HHR11, p.177].

In an ideal situation, objective and subjective information need as well as information demand and information supply are identical or, at least, aimed to be equal [PF88, p.609] and, that way, ensure the highest possible level of information.

6.1.2 Managing Information Needs

The engagement in all these concepts is the purpose of information management or the so-called *infonomics*[4]. Being precise, the objective and central issue of infonomics is the alignment those different needs as described above [GL10, p.47][Krc10, p.5]. The fostering of this alignment results in emerging dynamics that, in turn, shape the *life cycle of infonomics*.

The Life Cycle of Infonomics

The *life cycle of infonomics* as shown in figure 6.2 describes the following information-oriented processes: An appropriate information supply results in information that can be *provided* to information users via an information service. This information can then be used to satisfy a user's information needs and demands. For that, the information user interprets the information or sources of information corresponding to the intended purpose—that is nothing but his or her *requirements*—and finally *utilises* the provided information. This, in turn, results in new information that is integrated into the existing information infrastructure. That way, sources of information turn into information resources. Finally, if the information needs have not been satisfied, the information supply needs to be readjusted—that is *tailored to a user's needs*—and the life cycle starts all over again. Additionally, a new life cycle can be initiated from every position within the life cycle. [Krc10, pp.59f,103f]

As a consequence, this life cycle also needs to be represented and fostered when designing a personal learning information management system that is supposed to meet a learner's information needs. To

[4] Infonomics—a recently coined phrase—is a composite of "information" and "economics" and describes the practise of information economics. [Lan12]

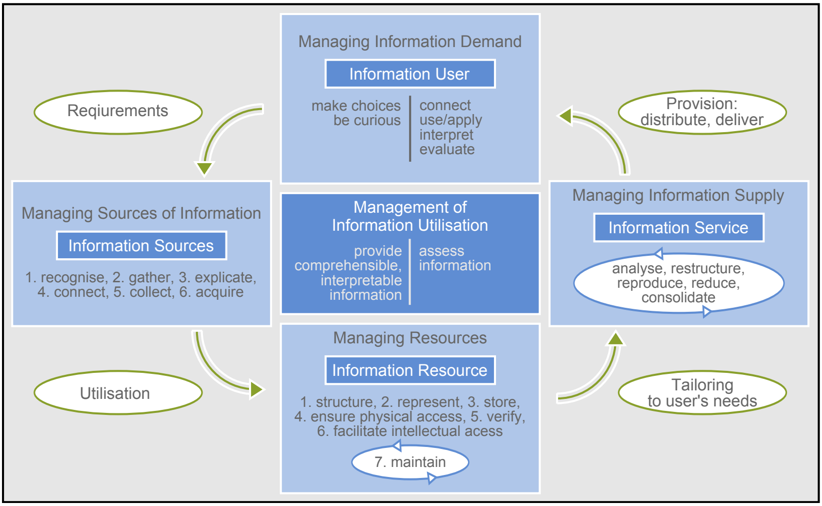

Figure 6.2: The life cycle of infonomics [Krc10, p.60]

be able to define all concepts of information within the scope of this work as precisely as possible, the *management process of infonomics* is employed additionally.

The Management Process of Infonomics.

The *management process of infonomics* as shown in figure 6.3 basically depicts the life cycle of infonomics as introduced above but is more detailed and emphasises the procedural character of infonomics. Even though this process was originally designed for an organisational determination and management of information demands, needs, and sources, it can also be utilised to determine those concepts for personal information management for one particular reason: this process is based and centred on the *users of information*.

The process starts with an information user, the occurrence of an *information need*—or actually an information demand since the need has to be expressed to be allowed to be met—and methods to determine this information need. The successful determination of the information need is followed by an identification, collection, and explication of in-

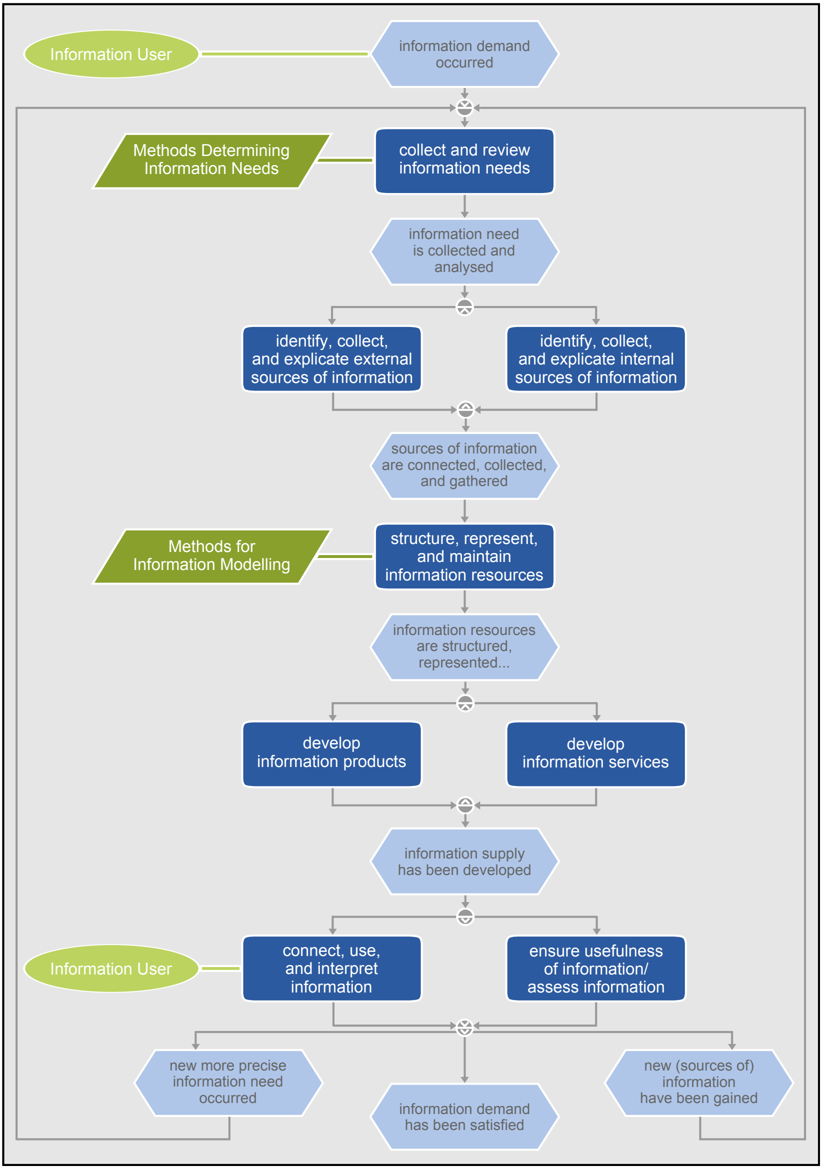

Figure 6.3: The management process of infonomics—depicted as event-driven process chain [Krc10, p.61]

ternal and external *sources of information.* Within this process, those sources that are used repeatedly turn into *information resources* that need to be represented, structured, and maintained using methods for information modelling. [Krc10, pp.61ff]

So far this management process can more or less be transferred from organisational to personal information management one-to-one. However, the next step—that is the development of the *information supply*—vitally differs in both disciplines: where organisational information management develops information products and services to be offered to the information user, personal information management—already occurring at the level of a single information user—completely relies on the identification of information resources. [Krc10, pp.61ff]

The following process steps are, again, similar for both disciplines. The gained information needs to be connected, utilised, and assessed. The whole management process finally always results in either a satisfied information need, new (sources of) information, or new—more precise—information needs. [Krc10, pp.61ff]

In summary, two elements of this management process can be extracted as crucial factors of influence for designing a personal learning information management system: 1) the *information need* or *information demand* as trigger for the whole process of (learning) information management [Krc10, p.62] and 2) the *sources of information* and *information resources* providing the necessary information.

A careful examination of these crucial factors helps to avoid *information problems* such as delayed or missing information transfer, an insufficient scope of information, too little information on goals and coherencies, the poor availability of information, time-consuming information access, hidden information, the lacking currentness of information, or incomplete information [Klo11, p.17f].

As a consequence, a learner's needs, demands, and sources are investigated next.

6.2 Information Demands or What Learners Ask For

Recalling what has just been introduced, there are two kinds of information needs: 1) the objective information need—composed of information that a task actually requires—and 2) the subjective information need—depicting what learners would really need to solve a presented task. Deepening the complexity, what a learner is able to formalise as his or her information need is a subset of those two concepts—the information demand.

Nevertheless, all three concepts share one important commonality: each of them is strongly dependent on the underlying task and its characteristics. This common ground, unfortunately, also presents the pitfall for a personal learning information management system: If all information needs are essentially based on presented tasks, these tasks need to be known to build a system that is aligned with these needs. This is, however, simply not possible. Even if the design of the system would be based on particular learning tasks and then be generalised, this attempt is doomed to failure for two main reasons: Firstly, today's environment is variable and complex—which means situations, and hence facts and tasks, change fluidly; secondly, learners themselves—also vitally influencing information needs—are changing too [Dow10, p.27]. The design of a universally usable personal learning information management system as well as the system itself, therefore cannot build on particular information needs.

Thus, it is necessary to be creative to find and extract at least some information on information needs and the corresponding information demands that can be used for the design of the desired system.

The solution to this problem that has been chosen within this work is the utilisation of a classification that has actually been built for web search queries. This classification—proposed by Andrei Z. Broder [Bro02a]—builds on the intention of the query and therefore *"the need behind the query"*. In other words, this classification depicts how learners search for information in order to actively satisfy their information needs. More precisely, Broder determines three *classes* of queries and underlying needs [Bro02a, pp.5f]:

Informational Needs rise with the general need for assumed to be static information—where *static* implies a piece of information that is not specifically created in response to these needs but already exists. Hence, a user or learner is only required to find, read, and memorise this information to satisfy his or her need. These informational needs range from extremely wide to remarkably narrow specified needs. Moreover it is very likely that the satisfaction of these needs does not require a single item but a collection of objects. [Bro02a, pp.5f]

Navigational Needs have the aim of reaching a particular site—or, more general, a particular learning object (cf. chapter 8.1). Navigational needs, therefore, always require a *known item* that is—at least to a learner's conviction—able to satisfy the current information need. This results in the fact that there is one *right* solution to this need. [Bro02a, p.5]

Transactional Needs depict a contrast to informational needs since their intend is to find something that requires further interaction. This interaction, in turn, represents the transaction defining the actual query formalising the information need. [Bro02a, p.6]

Further investigating those different information needs, Bernard J. Jansen et al. conducted a study to analyse the users' intents behind web queries [JBS08]. To do so, Jansen et al. derived attributes for each of these three classes and used those attributes in an automatic analysis of over a million and a half queries—validated by a manual classification of about 400 queries. This classification revealed that more than 80% of Web queries are informational in nature, with about 10% each being navigational and transactional.

In summary, a personal learning information management system can at best be of assistance in managing and addressing those consciously recognised needs. Every learner is still—and more than ever—required to sort out his or her own information needs [NH09, p.2]. Being aware of one's information needs can be depicted as a crucial aspect of succeeding in personalised learning and its management since these needs essentially influence a learner's actions—such as *asking* for information and *how* and *where* to search for information.

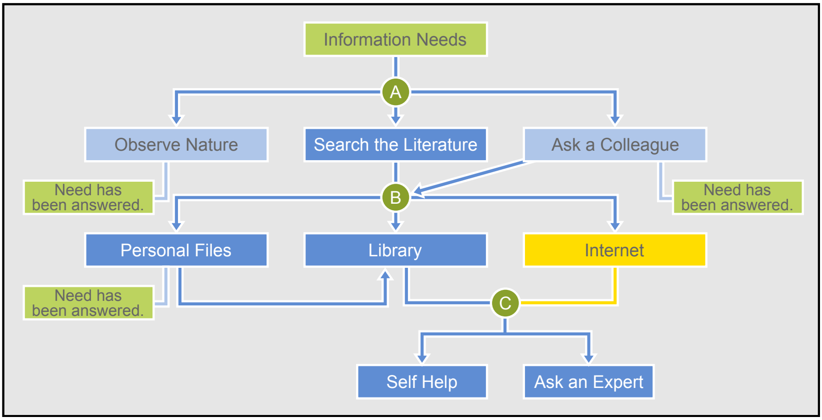

Figure 6.4: The process of pre-negotiation and pre-search decisions (illustration based on [Tay67, p.6])

6.3 Information Seeking or How Learners Search for Information

As depicted by the life cycle and management process of infonomics, what follows the collection and review of the information demands is collecting, gathering, and the connecting of sources of information. Therefore, after identifying a learner's demands the next question rising is the question of *how* learners actually search for information.

Even today [Ger11, p.10], Robert S. Taylor's process of *pre-negotiation and pre-search decisions* for question negotiation with and by librarians that has already proposed in 1968 can be of initial assistance [Tay67, pp.5ff]. This process starts with an information seeker who has *"a certain incompleteness in his picture of the world"* [Tay67, p.5] and, therefore, searches for information. According to this process—shown in figure 6.4—there are three major decisions an information seeker has to make [Tay67, pp.5ff]:

- At first (cf. decision point A in figure 6.4), the information seeker has to decide where he or she is going to find the information needed. One way is, of course, the observation of nature. However in practise, there are actually two choices to make: ask a colleague or search the literature—where all searching process that can be technically supported in a meaningful way can be grouped under the latter.

- ▷ Where asking a colleague occurs informally, searching the literature leads on to the second decision (cf. decision point B in figure 6.4) further specifying where to find the needed information: can the information be found in personal files or is the library the appropriate origin for the search?

  For the scope of this work and in a current description of this process, searching the internet is a required addition to this decision level.

- ▷ Finally, the process described by Taylor includes a third decision level (cf. decision point C in figure 6.4) where an information seeker who has previously consulted the library has to decide whether to ask a specialist for help or get the information on his or her own.

  Again, some enhancements are suggested for current consideration: including the consideration of modern information and communication technology available using the internet, this decision level is also applicable if the internet has been chosen as source of information in the previous decision level.

In general, this decision process on how to satisfy information needs is what is referred to as *information seeking behaviour* [Ger11, p.12]:

> *"Information seeking behaviour is the purposive seeking for information as a consequence of a need to satisfy some goal. In the course of seeking, the individual may interact with manual information systems (such as a newspaper or a library), or with computer-based systems (such as the World Wide Web)."* [Wil00, p.49]

In contrast, the more specific searching process—that is the interaction with a system—is what is called *information searching behaviour* [Ger11, pp.12f]:

> *"Information searching behaviour is the 'micro-level' of behaviour employed by the searcher in interacting with in-*

> *formation systems of all kinds. It consists of all the interactions with the system, whether at the level of human computer interaction [...] or at the intellectual level [...], which will also involve mental acts, such as judging the relevance of data or information retrieved. "* [Wil00, p.49]

Even though this separation can still be found in the literature, it is no longer common to be used today. Instead both terms are generally summarised as *information behaviour* [Ger11, p.13]:

> *"Information behaviour is the totality of human behaviour in relation to sources and channels of information, including both active and passive information seeking, and information use. Thus, it includes face-to-face communication with others, as well as the passive reception of information as in, for example, watching TV advertisements, without any intention to act on the information given."* [Wil00, p.49]

Nevertheless, most of the theories and models available are still depicted as *models of information seeking*—which is why models summarised under this label are examined next.

6.3.1 Human Information Behaviour or the Process of Information Seeking

In general terms, information seeking can be depicted as a special case of *problem solving*. This special problem solving process includes four steps: 1) recognising and interpreting the information problem, 2) establishing a plan of search, 3) conducting the search, and 4) evaluating the results. Of course, the process is not just run once but can be repeated if necessary [Mar69, p.54].

To put it another way, information seeking can be described as an *interaction cycle* consisting of an information need, followed by the activities of query specification, the examination of retrieval results, and, if necessary, a repetition of this interaction cycle starting with an reformulated query [Hea09b]. This description is in accordance with the *standard model* of information seeking that depicts the information seeking process as a cycle with four main activities [SE98] (as cited in [Ger11, p.16], [Hea09b]):

1) The identification of the problem to be solved—that is the recognition of a presented task and its information needs.

2) An articulation of the associated information need that is the *verbalised form* of an information need.

3) The formulation of an appropriate query and its passing on to the search engine.

4) Finally an evaluation of the results delivered by the search engine that eventually results in a query reformulation and another results evaluation cycle until the initial information need is satisfied.

In more detail, there are a number of differing and also more complex description available of the information seeking process. A similar four phase framework is, for instance, described by Ben Shneiderman, Don Byrd, and W. Bruce Croft [SBC97]. A more elaborate description—also including the acceptance of the challenge to fulfil the information need and the usage of the found information into the information seeking process—has been proposed by Gary Marchionini and Ryen White [MW07, pp.207ff]. Also there are other approaches used to explain information seeking such as information lookup versus exploratory search or navigation versus search in general (cf. chapter 10.3.1) [Hea11, pp.22f]. Nevertheless, these four steps can be found more or less consistently throughout all models of the information seeking process. For that reason, these steps are also reflected in the classic model for *information retrieval* shown in figure 6.5.

Proceeding beyond this classic information retrieval model, there are, of course, other models of the information seeking process. The most important ones will now be briefly introduced and referred to:

Basic Models. Starting chronological, Thomas D. Wilson developed a *description model* or *macro model* of the internal and external factors influencing the information seeker him or herself and, therefore, the information seeking process in 1981 [Wil81]. This model in particular emphasises different possible information seeking paths and the context of the information need—that are *physiological*, *affective*, and *cognitive needs* (cf. section 6.1)—all influencing the information seeking behaviour [Wil81, p.8]. In

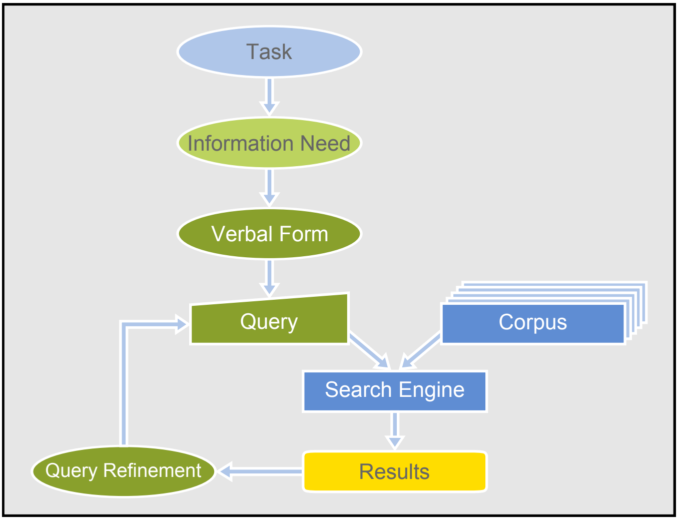

Figure 6.5: The classic model for information retrieval [Bro02a, p.4]

summary, the most important finding is constituted by the fact that the searching process cannot be detached from a seeker's social context and individual needs—and, for that reason, varies for equal tasks depending on an information seeker's context [Wil81, p.10]. [Ger11, pp.14f]

Adopting the focus of the information seeker, Donald A. Norman provided a *cognitive model* of general task performance in 1988. This model is based on a goal to be achieved and the mental model of the situation this achievement is located in. Actions that can be taken by an information seeker to accomplish this goal are *execution*—the doing—and *evaluation*—the checking. Marti Hearst depicts this model as *cognitive underpinning* for the standard model described above. [Hea09b]

Choosing a different perspective, David Ellis developed a *behavioural model* of information seeking process in 1989 [Ell89]. Based on an observation of researchers from different areas of expertise, Ellis determines six essential characteristics of the information seeking process: starting, chaining, browsing, differentiating, monitoring, and extracting [Ell89, p.178].

Dynamic Models. The standard and the basic models rely on the assumption that an information need is more or less static and that a search is conducted, reformulated until this information need is satisfied, and finally only retrieves relevant items. In contrast, dynamic models are based on the observation of seekers that revealed changing information needs during the interaction with a system. [Hea09b]

Marcia J. Bates proposed the *berrypicking model* of information seeking [Bat89]. In contrast to the basic models, this dynamic model is described by two core statements: 1) information needs and queries evolve and depend on the particular information seeker and 2) the satisfaction of a searchers information needs typically occurs through pieces of information gathered along the way—just like picking the best berries from a bush—instead of one grand best retrieved set [Bat89, p.421]. [Hea09b]

Another dynamic model has been developed based on a series of five studies with library users and, hence, learners—*information seeking in stages* as proposed by Carol C. Kuhlthau [Kuh91]. As a result of these studies, the information seeking process is divided into six stages: *initiation*, *selection*, *exploration*, *formulation*, *collection*, and *presentation*—where each of these stages is defined by feelings, thoughts, actions, and the appropriate task to be fulfilled according to the model [Kuh91, p.367].

To summarise these general examinations of the information seeking process and existing models for the scope of this work, a description of today's information seeker and the information seeking process by David Nicholas is adopted.

First of all, Nicholas suggests that information player (i-player) or *player* is the term to be employed instead of "user" because the term user is *"a tired, over-used, cheap and misused word"* [Nic00, p.31] that no longer reflects the close and complex engagement taking place between an individual and an interactive information system [Nic00, pp.31ff]. Building on this changed concept, Nicholas defines the information seeking process by identifying four important characteristics [Nic00, pp.32f]:

Information Seeking is Interactive. Today's users play a more active role in the information seeking process than they did previously: users or players are constantly looking for new routes, evaluating information, are part of the system, and perform within an information space. [Nic00, pp.32f]

Information Seeking is Recreational. Nowadays information systems are wired into our lives; in fact, information systems can be considered as an extension of our real life. Information seeking can therefore no longer be restricted to professional problem solving; instead it can also be recreational. [Nic00, p.32]

Information Seeking is Social. Recalling that "player" has been depicted as the more appropriate term for today's users, it is easy to imagine information seeking as a social action. Being more precise, information seeking is a truly social activity where every player can take on different roles such as teacher, student, journalist, or reader [Nic00, p.32]. This is in particular in line with learning, since learning—even though self-directed—is always embedded in a social context (cf. chapter 1.1.2).

Information Seeking is Competitive. Seeking information can even be depicted as an *information-chasing game*: information seekers invest—for instance time and money—and can win or lose this information-chasing game. [Nic00, p.32]

6.3.2 A Learner's Search for Information

Despite this general definition and examination of the *information seeking process* and its models, the question of how learners actually search for desired information remains unanswered. Basically, this problem challenges *tools of searching* whose utilisation can support learners in finding the appropriate information.

Search Tools and Engines

The support in finding information and the development of the corresponding tools are the concern of the research area of *information retrieval*. The common and prevalent instruments supporting the search for information in a digital environment[5]—no matter if on the Web or locally stored on a computer—are information retrieval systems also referred to as *search engines*. Considering the Web as important source of information (cf. chapter 6.4) these instruments are called *web search engines*:

> *"Web search engines are an important class of portals whose primary purpose is to support searches on a wide variety of topics across a comprehensive range of Web sites. Web search engines are a special form of information retrieval systems designed specifically for the hypermedia environment of the Web. They are the major portals for users of the Web, with 71% of Web users accessing Web search engines to locate other Web sites."* [SJ05, p.5]

Even though differing in detail, three important components can be identified and employed for a more detailed descriptions of search engines:

Crawlers. Search engines typically rely on one or more *crawlers*[6] that run through the Web on the search engine's behalf—similar to a person following links. More precisely, crawlers are programs that traverse the Web sending new or updated pages to a server where they are further processed. To do so, crawlers are provided with a starting set of uniform resource locators (URLs). Hereinafter the crawler retrieves the content of those pages and extracts and follows URLs that are found within those pages—thus repeats the retrieval process. All pages found are stored in the *page repository*. [SJ05, p.7][BYM11, p.460]

Indexer. What has been crawled during this retrieval process is subsequently processed by an *indexer* that stores the content of those Web pages by creating a so-called *index*. For that, the indexer extracts all the words from each document in the page repository [SJ05, pp.7f]. If a search engine is designed for local data, folders instead of URLs are observed for new content and files

[5] Again, even though acknowledged, analogue information and support in searching for analogue information is not considered within the scope of this work.

[6] Crawlers are also called robots, spiders, wanderers, walkers, and knowbots [SJ05, p.7].

that can be indexed. In some form, an index is always the core of an information retrieval system. Where indexes were previously just a manually designed set of categories [BYRN11, p.2], most search engines today use an inverted index—that is a list of terms associated with a list of pointers to the pages in which it occurs. Different techniques such as a stop word elimination can be used to improve the index [BYM11, p.460].

Query Engine. All this information is provided for the users employing a *query engine*. This engine receives the search request from the user, processes it, retrieves the matching documents, and provides the determined result set to the user. [SJ05, pp.7f]

To analyse the information behaviour that users show when utilising this search engines and for a better understanding of the process of searching, different methodologies have been established: Web search behaviour studies, single Web site search studies, information foraging studies, children's Web search behaviour, Web search training and learning, and Web search evaluation. Selecting one particular methodology, *Web search behaviour studies* examine why and how people search the Web and how Web search tools are used—and are, therefore, supposed to be the appropriate approach to determine how learners search for the desired information [SJ05, p.21]. Getting into more detail, there are three possibilities to study the interaction on the Web and with search engines: observations, surveys, and log file analyses [Ger11, p.20]—whereas a log file analysis is supposed to be the most objective and general one.

Query Logs and Their Analysis

Due to the reasons presented above, particular attention has been paid to *transaction logs* of search engines and their analysis. Unsurprisingly, a transaction log is a file of the communication between a system and the user of that system [Jan06, p.408]. Transaction logs in Web search are so-called *(web) query logs*:

> *"For Web searching, a transaction log is an electronic record of interactions that have occurred during a searching episode between a Web search engine and users searching for information on that Web search engine."* [Jan06, p.407]

Sometimes it is possible to determine a particular form of information seeking for users and draw inferences about information needs [Nic00, p.133]. However, first of all, these inferences are unambiguous and, secondly, those query logs are one of the most valuable assets of search engine companies. For that reason, academic researchers have very limited access to those logs [BI07, p.1]. There a just a few resources—such as the AOL query log[7]—that are publicly available.

The analysis of such a query log is called *query log analysis*[8]. In general, a query log analysis can focus on different research questions, is always a study of interaction issues, and examines searching in order to be able to isolate trends. An analysis also aims at a better *"understanding of the interactions among searcher, content, and system or the interactions between two of these structural elements"*—where an interaction can be the searching for information and a variety of transactions such as query modification, results list viewing, and the use of information objects. A comprehensive analysis always includes three major stages: 1) collection of the data, 2) preparation of the data for an analysis, and 3) the actual processing of the analysis. [Jan06, pp.409ff]

Research and analyses of query logs have been conducted for a number of different areas such as e-Commerce, general Web searching, or multimedia searching [SJ05, pp.127ff]. However, the standard parameters[9] of a query log analysis such as the number of terms per query, the use of operators, most frequently used query terms, or the number of result pages viewed [BI07, p.1] are very general and not specific enough to analyse the information behaviour of learners. Moreover, it is generally difficult to assign data to users or a category of users [Nic00, p.135]—such as learners—and a number of other problems—such as caching issues, intended or unintentional use, or the hierarchical nature of navigation [Nic00, pp.141ff]—additionally complicate the situation. Research or analyses on how learners specifically search for information are, therefore, hard to find. There are studies confirming

[7] The AOL query log is a log of the AOL search engine that has been released in August 2006. However, due to privacy issues the publication was withdrawn quickly. Nevertheless, it is still available through various mirrors. [BI07, p.2]

[8] For a detailed introduction, methodology, history, and revision of query log analysis see [Jan06] for further reading. An extensive description of a web query log analysis is also provided in [SJ05].

[9] Further details on log metrics such as measures of use, measures of satisfaction, measures of expertise and so on can for instance be found in [Nic00, pp.136ff].

that the internet is a valuable source of information [KGKF01][Ger11] and studies examining the usefulness and quality of information that can be found as a result for educational queries [GGM12]. Anja Gerstenberger [Ger11, pp.71ff] also conducted a manual evaluation of the AOL query log that could however not provide further insights into the searching behaviour of learners.

A different approach was followed by Alison J. Head who conducted an exploratory study into how students used the internet and the library for searching in a learning context. Even though this study took place in a narrowly defined setting, Head establishes some interesting findings regrading learners' information behaviour [Hea07]:

- ▷ Students accessed convenient, vetted, and aggregated online resources from course readings and the campus library Web site.
- ▷ Students accessed and used internet sites, such as Yahoo!, Google, and Wikipedia to a lesser extent.
- ▷ Students worked with professors or librarians one-on-one to narrow down searches and clarify expectations for assignments.

In summary, it is simply not possible to derive a standard information (searching or seeking) behaviour due to the diversity of settings, prerequisites, different attitudes, and the varying engagement of learners. Today, searching for information is *"unbelievably easily and expediently through a plethora of devices and platforms at [...] disposal 24 hours a day, seven days a week"* [NH09, p.5].

As a conclusion, Alison J. Head's major finding is emphasised:

> *"The student research process is more complex than a Google search and a scant perusal of a results page."* [Hea07]

Therefore, since it cannot be precisely and clearly defined *how* learners actually search and find information, the following section examines *where* to find information and describes *sources of information* and *information resources* that need to be particularly considered within the scope of this work.

6.4 Information Sources and Resources or Where Learners Find Information

To succeed in personal learning information management, it is essential to appropriately handle the *sources of information*—in particular since it is not possible to gain further insights into the information behaviour of individual learners.

A proper handling of information sources comprises of, at first, the recognition and elicitation of those sources and, subsequently, the collection and gathering of sources of information. If sources of information are used multiple times and turn into *information resources*, the handling sets even higher standards: information resources need to be verified, physical access has to be ensured, and the sources need to be maintained. Of course, in addition, ensuring the quality of information is essential [Krc10, pp.73ff].

To be able to detect those sources of information, an introductory *guideline* to these sources of information is described first.

6.4.1 A Guideline to Sources of Information

Several attempts to identify and classify sources of information can be found in the literature. According to Katrin Geist et al. [GGM12] there are four specific kinds of information sources: 1) *specialised information*—that is information published on the basis of professional work with a topical focus and educational expertise—, 2) *professional information*—that is also based on professional work but has neither a topical focus nor expertise in the educational domain, 3) and 4) user-generated content—that is published in a leisure context, either by users with or without expertise in the educational domain. [GGM12, p.3]

Approaching sources of information from a different perspective, Martin J. Eppler developed a framework for managing information quality[10] that interestingly summarises what as just been introduced above by building an *information usage cycle* from a user's point view.

[10] The information quality framework is actually composed of four major elements: 1) a vertical structure defined by four *levels of* or views on *information quality*, 2) a horizontal structure composed of the *four phases* representing the *life cycle of information*, 3) *information quality criteria* that are placed along these phases, and 4) *principles* helping to improve the quality of information in every phase

This cycle has four basic phases—*identification*, *evaluation*, *allocation*, and *application*—and each of these phases is shaped by a key question and typical activities [Epp06, p.86]:

Where is the Information Needed? is the key questions for the *identification* phase—consisting of activities locating and finding information such as clarifying the domain, listing possible sources, finding the right source, finding the relevant part of the source, and finding related information.

Can the Information be Trusted? paraphrases the *evaluation* phase that helps to ensure the soundness and relevance of information. Typical activities are judging the credibility of the sources, judging the soundness and relevance of the information, evaluating the currency and consistency, and a comparison with other sources.

Can the Information be Adapted to the Current Situation? states the issue to be resolved within the *allocation* phase. Activities of this phase help to transfer information to a new context by activities such as converting the information format, reducing the information scope, reconfiguring the information, or extending and enriching the information.

How Can the Information be Used Best? is the focus of the *application* phase where information is finally put to use. Typical activities can be described as an interacting with information, trying out the information, using the information for problem solving, and routinising the information application.

In summary, these four questions can be used and are applied as a guideline to determine the appropriate sources of information. In addition, these considerations also revealed that maintenance is one of the key aspects for successful organisational *and* personal information management. This maintenance, in particular, includes organisation and modelling. These aspects are also the substantiation of the personal learning information management system proposed within this work. At this point the reader is, therefore, referred to the general

[Epp06, p.66]. Information quality is, however, not the focus of this work, which is why [Epp06] is referred to for further reading and details of this framework.

system introduction in chapter 7 and, in particular, the proposal and development of the architecture in chapter 8 as well as the building of the repository in chapter 9.

6.4.2 Determining Information Resources

Trying to finally determine those sources of information that are supposed to be reused and are, therefore, information resources, it must be acknowledged that unfortunately today's users are likely to find themselves in an *Information Wild West* [Nic00, p.1]. As a consequence, it is important to be a little more precise and identify those sources that—at best—qualify as information resources, as these sources and resources are the ones that ought to be integrated into a personal learning information management system [Krc10, p.5].

Very generally—and independent from a specific learner's situation—the following source of information can be identified within an individual learning environment:

The Internet. The rise of the Web transformed our world from an *information-poor* into an *information-rich* world [Nic00, p.17]. It offers *"the prospect of meeting—and unearthing, all kinds of information needs"* [Nic00, p.17].

> *"The internet has become the ultimate Pandora's box. It is widely thought to be an information and communication cure-all—the information elixir of life, maybe."* [Nic00, p.xi]

The least the internet has done—besides providing information—is to *"force information needs concerns to the top of the information agenda"* [Nic00, p.1]. Additionally, the Web is also able to meet *and* trigger information needs [Nic00, p.17].

In conclusion, it is essential to allow, or even better foster, the integration of learning content from the Web into a personal learning information management system. It has however to be considered that the internet offers a variety of learning content—differing in format, accessibility, quality, and many others aspects. There is not just *one* kind of learning content to be included but *a variety of multiple learning objects* to be taken care of. As a consequence, the internet in general can be identified as an important, if not *the* most important *information resource*, providing a vast number of *sources of information* and *information resources.*

Learning Management Systems. Besides this variety of different information or learning content generally available via the internet, there is one kind of content that demands particular attention: learning content provided using *learning management systems*—that have been identified as the dominant technology to organise and deliver learning content today (cf. chapter 1.4.2).

It is therefore of interest to facilitate a special consideration of learning management systems as valuable *information resources* for learners.

Personal Local Data. By now, all the information easily available through the latest information and communication technology has been covered. However, even though it might seem obsolete to many, there is still lots of *offline information* to be considered: the least that is left to be incorporated into personalised learning is the *local data*[11] of a single learner.

Personal local data is, therefore, characterised by the fact that it is *not* available to everyone via the internet but just to a single learner who owns the data. Most importantly, personal local data has actually been created by a learner him or herself—typically within a learning scenario and for the purpose of learning or information preservation. Almost like learning content from the Web, personal local data is varying in format, quality, and other aspects.

Overall, personal local data represents an important *source of information* that surely needs to be integrated into a personal learning information management system.

This general identification of information resources is also confirmed by different studies such as [Ger11, pp.60ff], [Hea07], and [KGKF01].

[11] Of course, there is not just digitally available information that is part of a learner's personal learning information. Since this work in particular is addressing *digital learners* that is learners moving and acting within a digital environment, analogue information—being, for sure, just as important as digital information—is not further considered within the scope of this work

A detailed description of information resources used within the scope of this work will be given in chapter 9.

Summarising the findings of this chapter, *informational information needs* have been identified as the most frequent and, therefore, most important information needs and demands of a learner that have to be met in a personal learning environment (cf. section 6.2). We have learnt that learners *interactively* and *competitively* seek information in a *social* environment that can be located in a *professional as well as recreational* surrounding. To be able to perform this information seeking process, learners rely on *search engines*. Unfortunately, a particular or special usage of those search engines by learners could not be determined within the scope of this work. The general assumption is therefore made that learners perform a *complex searching process* that varies as the case arises. Finally, four guidelines to sources of information helped to extract the most important information resources for a personal learning information management system: the *internet* and *personal local data* in general as well as *learning management systems* in particular. It is, therefore, important to take into account all of these information resources when designing and building a personal learning information management system.

Altogether, it is crucial to build a *flexible* system that allows learners to include *existing information* into their personal learning information management system as well as to satisfy information needs with information that has already been integrated into this personal system. The system proposed within this work has been designed and built in order to take into account all the needs outlined above.

This system is subsequently described in the next chapter: *a personal learning information management system—a proposal*. The constituent parts of this system are the subject of chapters 8, 9, and 10.

7 A Personal Learning Information Management System—a Proposal

> *"Information plays a significant role in our daily professional and personal lifes and we are constantly challenged to take charge of the information that we need for work, fun and everyday decisions and tasks."*
>
> Harry Bruce [Bru05]

If one tries to derive a simple core essence from the findings of the previous chapters, then a learner's desire to learn results in particular information needs that have to be met to successfully accomplish tasks and acquire new knowledge. This situation in combination with two transitions that have already been quoted more than once—the transition to a knowledge-based society and the digital transition of our world—has led to a situation where learners are involved in matters once exclusively the focus of librarians or archivists [NH09, p.2]:

> *"We all sort out information ourselves, have at our beck and call vast amounts of data, are responsible for the organisation and archiving of information and even search for it on the behalf of others."* [NH09, p.2]

In an ideal world, this organisation would result in the fact that we always have *"the right information in the right place, in the right form, and of sufficient completeness and quality to perform the current activity"* [Jon04]. Unfortunately, this ideal is *"far from reality for most people"* [Jon07]: Information is usually scattered—across different locations, different devices, in different forms, and with different organisational schemes [Jon04]. A further difficulty is that we may need to consult the same piece of information multiple times during the learning process to completely satisfy an information need or we may find information that is useful for a future task but not the one we are currently accomplishing [Jon04]. Consequently we keep information for a simple reason: we think it is or will be useful at a future time that requires us to find this information yet again [Bru05].

This individual engagement with such "general" pieces of information turns these general information into *personal information*. Getting more explicit, personal information actually has several senses: 1) the information people keep for their personal use, 2) information about a person—possibly kept by and under the control of others, and 3) the information experienced by someone [Jon07, p.10]. The kind of personal information that is explicitly the focus of this work is the *information that people keep for their personal use*.

The process of turning pieces of information into personal information as just described leads to a number of challenges and decisions a learner has to face during his or her daily learning process. Therefore, *personal information management* can and should be applied to help a learner facing those challenges and to organise this process—that is to acquire, organise, maintain, and retrieve information on a daily basis [Jon07, p.1]. For that reason, *personal information management* and its specifics are now examined closely, followed by the proposal of the *personal learning information management system* that has been designed and built within the scope of this work and implements personal information strategies.

7.1 Personal Information Management

Broadly defined, personal information management (PIM) can be depicted as *"the management of information going into our own memories as well as the management of external information"* [Jon07, p.4]. In very general terms, this management is based on a crucial responsibility:

> *"[Personal information management] activities are an effort to establish, use, and maintain a mapping between information and need."* [Jon07, p.68]

Hence, personal information management is designed to facilitate the accomplishment of a number of challenges and decisions a learner has to face: starting with the initial challenge to find the information—that is the concern of the area of *information retrieval*—a learner is subsequently faced with the challenge of managing information for personal re-use—that is keeping things found. This challenge, naturally, includes what is referred to as keeping decision: the fundamental decision if an information is worth keeping or should be ignored. Obviously, making these decisions is a permanent balancing act between the danger of keeping useless information and missing useful information. [Jon04]

These two challenges, again, establish a connection to the research questions of *managing* and *retrieving information* that this work is concerned with—and, as a consequence, also the challenges of personalised learning identified previously (cf. chapter 4.1).

However most importantly, even though learners can benefit from singular information actions, these single steps are not sufficient. Instead those actions have to be guided in order to allow the intentional satisfaction of information needs—and not just happen as an accidental product that randomly meets and satisfies information needs. The processes of managing and guiding information—that are *"the methods and procedures by which we handle, categorise and retrieve information on a day-to-day basis"* [Lan88, p.55]—are referred to as personal information management. In contrast to *personal information processing* that is actually just *performance acting*, personal information management can also be described as leadership or *guidance action* [Klo11, p.24]:

> *"Personal information management is guidance action by the information worker himself that establishes essential structures, responsibilities, and techniques for information action."* [Klo11, p.25]

Personal information management—just like *knowledge management* (cf. chapter 3)—tries to ensure that a learner is able to locate the information needed at the time when it is required [Klo11, p.25][Jon07, p.3][ET96, pp.79ff]. In other words, personal information has to be retained for later access and use [Bru05] to prevent information problems and allow effective and efficient information actions [Klo11, p.24f]. The *"unparalleled access to digital information"* [EMA09, p.280] requires an appropriate information behaviour to cope with all this information—or, even better, the filtering, selection, and organisation of just those pieces of personal information that are relevant.

To give an overview of possible personal information management activities that are actually widespread and individually variable, a classification of those activities will first be presented.

7.1.1 A Classification of Personal Information Management Activities

Personal information management creates a framework within which personalised information processing takes place [Klo11, p.25]; it comprises of *"a set of actions that attempt to bring order"* [Bru05]. This order is trying to be established and preserved by two kinds of actions or behaviour: 1) actions to keep information—that is the storing and organisation of the information—and 2) actions to manage and use information sources constituting a *personal information collection* [Bru05] (cf. section 7.1.2). In more detail, personal information management in particular includes three different types of activities [Jon07, pp.12ff]:

Finding and Re-Finding Activities help to move from a need to the suitable information satisfying this need. A need is very often packaged into a piece of information or corresponds with a particular task. All efforts—such as seeking, searching, browsing, or scanning—spent to satisfy these information needs can be summarised as *finding activities*. Finding includes re-finding—an act of finding that may require the repeating of actions to find information already performed previously. The appropriate information can be found internally—for instance in a *personal information collection* (cf. section 7.1.2)—or externally—that is elsewhere; information may also have been used before. Finding, thus, puts the focus on the outcome of these activities. [Jon07, pp.14f]

Keeping Activities are the opposite of finding activities. These activities comprise of all decisions and actions occurring when a learner encounters information. Most of the information we encounter can safely be ignored. There is however information that might be useful to satisfy an information need not established at the time this information is encountered but at a future date. If the decision has been made to keep the information, a decision has to be made *how* to keep the information. This second decision is crucial to enable a future *re-finding* of the information and requires addressing the *"multi-faceted nature of an anticipated information need"* (cf. section 7.1.3). [Jon07, pp.15f]

M-Level Activities comprise a number of activities that are referred to as *mapping* or *meta activities*. These actions in particular connect the information need to suitable information satisfying these needs. More precisely, the following "Ms" are m-level activities [Jon07, pp.16ff]:

Mapping is, in general, the combination of an information need and the appropriate information—either an internal memory or an observable external representation. [Jon07, pp.16f]

Meta-Level activities basically describe "a step back" to comprehend one's own personal information management and gain insights that can be used to improve one's personal information management. These activities also include a consideration of different personal information management strategies. [Jon07, p.17]

Maintaining and Organising is the actual implementation of the meta-level activities such as the initial realisation of the selected organisation strategy, its update, and a maintenance of all information items. [Jon07, p.17]

Managing in personal information management involves the management of privacy and security issues as well as the distribution of items within a personal information collection. [Jon07, p.17]

Measuring stands for efficient, accurate, and objective ways to evaluate one's own personal information behaviour—which is nothing more than the ability to maintain, organise, and manage one's own information behaviour as described above. [Jon07, p.17]

Manipulation, Making Sense, and Using Information is essential in personal information management for using information as *"the powerful extension to our limited ability to keep 'things in mind' "*. [Jon07, p.17]

All three kinds of activities are needed and essential for successful personal information management. In addition, these different activities cannot be clearly separated from each other but are likely to have a large overlap. [Jon07, p.19]

In summary, personal information management focuses on *"the information within an individual's collection"* [EMA09, p.281]—that are *personal information collections*—and, in turn, the *personal anticipated information need*—the need that those collections are built upon.

7.1.2 The Personal Space of Information and Personal Information Collections

In response to all those challenges in personalised learning, individuals create a *personalised subset of the information world* that can be used if an information need occurs and needs to be satisfied [Bru05]. This subset is the so-called *personal space of information* [Jon07]. An individual has just one personal space of information that includes almost everything:

> *"A personal space of information for a person includes all the information items that are, at least nominally, under that person's control.* [Jon07, p.10]

The personal space of information, therefore, comprises a person's books, paper documents, digital files, emails, and references to or copies of web pages visited. An individual is able to have some sort of control over his or her personal space of information—complete control is, however, illusionary. [Jon07, pp.10f]

In contrast, a *personal information collection (PIC)* is defined as a *"managed subset"* [Jon07, p.11] of this personal space of information. Items included into a personal information collection typically share a particular format and are accessed through a particular application. A personal information collection comprises not only information objects but also their organising representation [Jon07, pp.11f]. In other words, a personal information collection represents a personal organisation *and* a personal perspective on information—including different content in various forms, structures for representing and organising this information, and pointers to information [Bru05]:

> *"A personal information collection is defined [...] as the space we turn to first when we need information to do a task or pursue an interest. It is a collection of information sources and channels that we as individuals have acquired, cultivated, and organised over time in an response to a range of stimuli. The personal information collection is an organic and dynamic personal construct that we take with us into, and out of, the various information events that frame our daily working and personal lives."* [Bru05]

The construction of a personal information collection occurs through a combination of events and decisions. The integration of a new item into a personal information collection arises from an *information event*—that may occur as a result of information seeking or, in general, an encounter with information. Naturally, an information event always implicates the contact with an information source. This encounter is always followed by an important decision—the decision to either include the information into the personal information collection or to decide against this integration. [Bru05]

Examining this construction in more detail, the personal information management activities defined above essentially influence and coin the construction of a personal information collection: *keeping activities* affect and define the input of information, *finding* or *re-finding activities* affect the output of information from a personal information collection, and *m-level activities* influence the storage of information within a personal information collection [Jon07, pp.12f].

The ideal that should be followed when building a personal information collection is that a piece of information considered useful is integrated into the personal information collection so that it is ready to be accessed when it is needed again. As a consequence, the information behaviour creating a personal information collection is based on the anticipation of the demand that will or is, at least, likely to occur in the future—the so-called *anticipated information need.* [Bru05]

7.1.3 The Personal Anticipated Information Need

The concept of an *anticipated information need* has been used by librarians and information professionals to build information collections for a group of users for a considerably long time. In contrast to the suggestion of its label, this anticipated information need not only includes the future but also the current information needs. [Bru05]

Examining this concept at the level of an individual user or learner—who is clearly the focus of this work—results in the concept of the *personal anticipated information need* which builds on the central premise that *"people construct individual meanings within information seeking experience"* [Bru05]. Three overarching principles—as defined by Harry Bruce [Bru05]—can be used to describe this kind of information behaviour and, respectively, information need:

1) Individuals have different cognitive and affective responses to information and they assimilate information accordingly.

2) People evaluate information differently.

3) Context is crucial.

These principles are refined by five propositions finally defining the *personal anticipated information need* [Bru05]:

Personal anticipated information need is triggered by information events. When an individual faces an information source, an *information event* occurs. This information event leads to a certain *information behaviour*. In the course of this information behaviour the information source is evaluated. This evaluation results either in an *information usage*, a *delay of information usage*—that is an anticipated moment of information use in the future—or the *discarding of information.* [Bru05]

Individuals have differential sensitivity and reaction to those needs. Designing and building a personal information collection—and, hence, a personal learning information management system—strongly depends on an *individual's abilities* to 1) *make sense* of the information available, 2) *use* the information to make a decision, accomplish a task, or address an interest, 3) *understand* its future value and the implications of a delayed access, and 4) *organise* the information. [Bru05]

Personal anticipated information need only predicts future information use. The assessment of information is based on an evaluation at a particular point in time. This evaluation is however only an *estimation of the future information use*. Information originally kept may turn out to be useless, whereas information not considered useful may be needed in the future. [Bru05]

Personal anticipated information need requires investments. Determining and maintaining the personal anticipated information need demands the investment of *cognitive effort and time*. These investments are located along a *sensitivity continuum*: information that can be immediately rejected is located at one end of this continuum; on the contrary, information that can be directly applied to a particular task can be found on the opposite side of this continuum. Information behaviour on both ends of this continuum is supposed to require less or little cognitive effort and time. As opposed to this, the highest level of investment in cognitive time and effort is supposed to occur in the middle of this continuum. Individuals therefore assemble their personal information collection based on their evaluation of the *relative costs* for selecting, keeping, and rejecting information that may be useful at a future point in time. [Bru05]

Sensitivity to personal anticipated information need is critical. A user's or learner's sensitivity influences the quality of the personal anticipated information need and is, therefore, a key component of *information literacy*. In other words, information literacy intensely rest on the *accuracy* and *endurance* of the personal anticipated information need. [Bru05]

It is this particular information need—the personal anticipated information need—that personal information collections are created for. For that reason the effectiveness and quality of a personal information collection heavily depends on the personal anticipated information need and two essential dependencies [Bru05]: 1) the understanding of one's personal anticipated information need and 2) the translation of this understanding into information behaviour to acquire and manage sources of information.

In summary, personal information management comprises a number of activities to build one or more personal information collections that are based on the personal anticipated information need. These activities are widespread and research to date is far from understanding their full complexity.

William Jones [Jon07] provided an extensive review of research into how personal information management can be achieved. This summary also includes many problems that may be encountered in finding, keeping, and performing m-level activities and the support that is needed to overcome these problems[1]. However most interestingly, the consideration of these problems resulted in the identification of *information fragmentation* as a major issue of personal information management and in the proposition of an approach to bring all pieces of personal information management together: the *integration* or *unification of personal information* [Jon07, p.41].

This integration—as examined and proposed by Jones [Jon07, pp.41ff]—can be accomplished along six dimensions:

Integration across physical location. An integration of information from different physical locations is the most basic kind of integration. The digitalisation of our world beneficially influences this integration by providing various possibilities to exchange data and lowering the importance of where data is actually stored as long as it is accessible. [Jon07, pp.41f]

Integration in the means of access and organisation. Organising information facilitates an understanding of this information. Methods unifying access and organisation of information—such as an (integrated) desktop search[2]—therefore foster an information integration. [Jon07, p.42]

Integration by grouping and inter-relating of items. Creating groups of pieces of information is considered useful to control this information. A group of pieces of information can, for instance, be realised as a folder or its more flexible notion

[1] For an extensive consideration of all these problems see [Jon07, pp.22ff].

[2] An (integrated) desktop search allows the finding of data on a local system. This search includes built-in hard drives as well as external drives.—`http://en.wikipedia.org/wiki/Desktop_search`

a *collection*. These groups can, in turn, be assigned with properties to be described. [Jon07, pp.42f]

Integrative views on information. This kind of integration is desired within a group or collection of information and allows a view of all the pieces of information included. [Jon07, p.43]

Integrative facilities of data manipulation. Moving from understanding and reading information to constructing—that is writing—information, allowing data manipulation across different pieces of information is required. [Jon07, pp.43f]

Integration with the current context. The only context information consequently stored when working with digital information is the date and time of the last modification or access. This is, however, not sufficient since many other aspects of the *interaction context* are also a potential basis for unification and integration. [Jon07, p.44]

As a result, personal information management in general and these dimensions of integration in particular also lead to technical implications for designing and building an appropriate system:

> *"Personal information management, as an emerging field of inquiry, provides a very productive point of integration for research that is currently scattered across a number of disciplines including information retrieval, database management, information science, human-computer interaction, cognitive psychology, and artificial intelligence."* [Jon07, p.56]

Therefore, these six dimensions of integration are used as guideline throughout the proposition of the *personal learning information management system (PLIMS)*. In other words, PLIMS tries to achieve an integration across all of these six dimensions with its design.

7.2 PLIMS—a Personal Learning Information Management System

This section finally introduces the personal learning information management system—PLIMS—that has been developed, implemented, and evaluated within the scope of this work[3]. Summarising the previous chapters, the vision of this approach can be basically described as the provision of an environment that helps individual learners to succeed in learning—that is in mastering and administrating their learning material and learning context in order to facilitate learning insights.

To achieve this comprehensive objective, PLIMS smoothly blends into the learner's environment as established within this work so far:

PLIMS is designed as ...

... an environment supporting modern learners and fostering modern learning. Modern learners independently move, act, and learn within a digital environment throughout their life and supported by technology. Modern learning is, essentially, characterised as a dynamic and flexible process that is integrated into every aspect of a learner's life (cf. chapter 1).
PLIMS is built to support the learning style of modern learners. As suggested, PLIMS constitutes a *bounded environment* that is yet providing complete freedom of action within those boundaries to allow for flexible learning.

... an environment to manage modern learning. The appropriate management is an essential prerequisite for modern learning. The Munich Model and its four core processes—knowledge representation, knowledge utilisation, knowledge communication, and knowledge generation—provide a guideline for this support by ideally combining organisational knowledge management and a technology-focused information management with a human-centred knowledge and competence management (cf. chapter 3).
All four core processes of the Munich Model are represented within the PLIMS architecture and its core components. PLIMS, however, particularly facilitates the processes of *knowledge representation* and *knowledge utilisation* to enable an appropriate and comprehensive management in learning.

... an environment facing the challenges of personal learning. A learner individually organising his or her learning needs to overcome essential *challenges* arising from situational and ambient

[3]Parts of this section have been previously published in [SH09]

overload: finding the needle in the haystack and keeping learning at a glance (cf. chapter 4). To achieve this, the individual perspective on learning—that is the individual knowledge environment and its interrelation to everything else—needs to be acknowledged (cf. chapters 4.2 and 7.1.2).
PLIMS is especially dedicated to those challenges in personalised learning and their mastery.

... an environment able to satisfy a learner's needs. In order to satisfy their *information needs*, learners perform interactive, recreational, social, and competitive information seeking using the appropriate information resources. The internet, learning management systems, and personal local data have been identified as the most important sources of information (cf. chapter 6).
The design of PLIMS is, therefore, explicitly *user-centred* and in particular aligned to allow this kind of information seeking and to foster a consideration of these important information resources.

... an environment to build a personal information collection. A multitude of *personal information management activities*—finding and re-finding, keeping, and m-level activities—builds a learner's *personal information collections.* Such personal information collections enable and foster an *integration of fragmented information* along six different dimensions (cf. chapter 7.1).
PLIMS is a system facilitating the creation of such a *personal information collection*—allowing to perform those personal information management activities and integrating a learner's initially fragmented information.

To get a more precise idea of this targeted environment and its specifics, an everyday learning situation that PLIMS aims to improve is described in the following.

7.2.1 The Point of Departure: An Everyday Learning Situation

Just imagine the following scene: A student, for instance in the field of computer science, is attending a lecture on Web engineering. As one part of the lecture, the Semantic Web[4] and related techniques are introduced in varying depth. After presenting general aspects and thoughts behind the idea of a Semantic Web, the focus might be on the Resource Description Framework (RDF)[5] as one major component of the Semantic Web. In contrast, extensions like the Resource Description Framework Scheme[6] or the Web Ontology Language[7] are mentioned and put into context, but not described in detail.

As usual, back home, the student spends at least some time post-processing the lecture. This includes basic administrative tasks like downloading the provided slides for the lecture—if not already done in advance of the lecture—and going through notes taken, but also more advanced activities such as following forum discussions on the day's lecture.

Furthermore, our learner might feel the need to check the internet for some additional information on these just introduced subjects. This tour probably starts with looking through additionally prepared link lists provided by the lecturer through the course environment—such as a learning management system. Sticking to our scene, the link list on the Semantic Web, for sure, leads to the famous Tim Berners-Lee article on the Semantic Web[8] originally published in 2001. Continuing this

[4] The Semantic Web is a description of the Web as "Web of data" that can be understood by computers instead of just being a "Web of documents" that needs human interpretation to be apprehended. The idea of the Semantic Web has principally been coined by Tim Berners-Lee. It is currently developed further by the World Wide Web Consortium (W3C)—`http://www.w3.org/standards/semanticweb/`.

[5] The Resource Description Framework (RDF) is a standard model for data interchange which, therefore, constitutes one of the basis technologies for a Semantic Web. RDF is, basically, constituted by the definition triples—subject, relations, and objects—allowing to define and express relationships in the world. The specification of RDF is a W3C recommendation too and can be found at `http://www.w3.org/RDF/`.

[6] The Resource Description Framework Schema (RDFS) defines of a vocabulary of classes and properties—that is an ontology—to allow a formal definition and an interpretation of RDF statements. Just like RDF, RDFS is a W3C recommendation—`http://www.w3.org/TR/rdf-schema/`.

[7] The Web Ontology Language (OWL) is a family of representations to define ontologies that build on RDF and RDFS. Of course, OWL is also a W3C recommendation—`http://www.w3.org/TR/owl2-overview/`.

[8] "The Semantic Web—A new form of Web content that is meaningful to computers will unleash a revolution of new possibilities" by Tim Berners Lee can be found at `http://www.scientificamerican.com/article.cfm?id=the-semantic-web`

ramble, a visit to Wikipedia to check on more general and easily comprehensible information on the Semantic Web[9] quickly leads our learner to related articles on OWL[10] and RDFS[11]. Finally, it is also very likely that our student might then use a search engine—such as the nowadays omnipresent Google[12]—for more information and, glancing over the first hits, stumble across the book "A Semantic Web Primer" by Grigoris Antoniou and Frank van Harmelen that is freely available as PDF version[13] and has already been recommended for further reading in the lecture. The third chapter of this book turns out to be particularly useful since it provides an introduction to RDF and RDFS that is easy to grasp due to lots of introductory examples. Just by skimming through the first six pages of this chapter, our learner is immediately able to understand and recapitulate the syntax of RDF. This finding, therefore, leaves our learner with the conviction that RDF is actually not hard to understand and that he or she is now able to boil the RDF syntax down to its essentials.

The information need that our learner satisfies by doing what has just been described is an information need that has previously been identified as *informational need* (cf. chapter 6.2).

A Revisited Information Need

A few weeks later our student is attending a preparation group with fellow students to study for the upcoming exam at end of the month. Of course, among others, the Semantic Web in general, its realisation, and related techniques are discussed. Additionally, one fellow student worked through old exams and pulled out a question concerning the general understanding of RDF also asking for a simple illustration of the typical RDF syntax. Unfortunately, no one is able to answer this question directly. The group realises that there is some work left in this area because they are not as familiar with all the details as they are supposed to be.

[9] Semantic Web on Wikipedia—`http://en.wikipedia.org/wiki/Semantic_web`
[10] OWL on Wikipedia—`http://en.wikipedia.org/wiki/Web_Ontology_Language`
[11] RDFS on Wikipedia—`http://en.wikipedia.org/wiki/RDF_Schema`
[12] Google—`http://www.google.com/`
[13] "A Semantic Web Primer" by Grigoris Antoniou and Frank van Harmelen—`http://www.coma.fsb.hr/katedra/download/A%20Semantic%20Web%20Primer.pdf`

Thinking about how to answer this exam question, our learner remembers that he or she had once accessed this perfect straightforward explanation of RDF that made the subject perfectly understandable within a short time. Therefore, our learner now wishes, firstly, to consult this piece of information again and, secondly, to share this information with his or her fellow students.

In contrast to the general informational need that has been satisfied directly after the lecture, this kind of information need is what has been identified as *navigational need*.

A Typical Non-Solution

The first thought of our learner—to find this particular piece of information in the slides provided for the lecture—turns out to be wrong. Therefore, our learner is now trying to find the particular piece of information he or she can only vaguely remember—knowing this is exactly what he or she is looking for. Next on the list could be a visit to and searching of the course forums dedicated to this course. Also our learners does not have any additional locally saved files including more information about the Semantic Web or RDF in particular. In the worst case, our learners needs to restart the previously conducted search, performed soon after the actual lecture, trying to find the information he or she already had—again.

Unfortunately, this not only requires our learner to be able to conduct the same search again but also to be able to find the same results again—which is on the one hand dependent on the perhaps already updated database of the search engine and on the other hand on strategies our learner applies to select the appropriate hit from the search results.

What this scene depicts is a precise description of what has been discussed throughout the previous chapters:

> *"The wealth and diversity of digital information makes it incredible difficult to organise information in such a way that it can be re-accessed and re-used when it is needed in the future. [...] Previous research has shown that people require to re-find and re-use information regularly and the evidence suggests that this is a task that they find it both frustrating and difficult to perform."* [EMA09, p.280]

Hence, a typical scenario where the concept of PLIMS is applicable, is a learner who kept in mind that the particular piece of information satisfying the current need is *somewhere*—but, unfortunately, a concretion of "somewhere" is not possible. PLIMS tries to foster the re-finding and re-use of information that has already proven to be helpful to a learner by assisting learners in keeping information[14].

7.2.2 A Functional Description

To ease the derivation of processes and working steps that PLIMS ought to support, the popular *time-* or *self-management method* "getting things done" described by David Allen [All02] is employed. This method has actually been defined to enable learning and working in a state of mind that is called *flow*[15]—that is learning and working with a clear mind [Mus11, p.1]. The basic idea to achieve this state of mind is the practice and utilisation of a horizontal and a vertical dimension for stress-free productivity:

The Vertical Dimension delivers an orthogonal perspective for a strategic design of projects [Mus11, p.4][Bla08]:

1) *Define* that is, a specification of purpose and principles,
2) *visualise* that is, to see the perfect outcome,
3) *think* that is, nothing but brainstorming,
4) *organise* that is, components and sequences,
5) and *action* that is, a focus on the next action.

The Horizontal Dimension provides five steps to master everyday work [Mus11, p.3][Kle07]:

1) *Collect* or "getting everything together",
2) *process* or "empty your in-box",
3) *organise* or "set up a viable system",

[14] Even though this learning situation is supposed to happen at a university, PLIMS is not limited to this field of application. Instead it can be used widely and accompany a learner along his or her journey of lifelong learning.

[15] Flow is a mental state of operation in which a person is able to perform an activity fully immersed in a feeling of an energised focus, full involvement, and enjoyment in the process of the activity—`http://en.wikipedia.org/wiki/Flow_(psychology)`.

4) *review* or "keep refining and improving",
5) and *do it!* or "trust your system".

The vertical dimension serves as a guideline to human thinking, the strategic design of actions, and can be located at a *meta-level*. The horizontal dimension can be employed to define concrete steps of management and actions that need to be supported by a personal learning information management system in general and, hence, PLIMS in particular.

Interestingly, closing the circle, these steps can be applied for personal knowledge management [Mog25] and match a basic description of personal knowledge management that has already been given previously (cf. chapter 4.2.3):

> *"Personal knowledge management, therefore, comprises multifaceted concepts, methods, and tools serving individuals in 1) accessing personal knowledge and knowledge of others, 2) selecting information relevant for action, 3) reflecting, 4) integrating new knowledge into their knowledge base, and 5) enhancing their personal knowledge."* [Rei09, p.102]

As a consequence, using the horizontal dimension of "getting things done" as suggested, the following logical components can be extracted as technical component parts of PLIMS[16]: a component to *collect* and *process* all pieces of personal information, a component for the further *organisation* of this information, and finally a component enabling the *review* and *refinement* of the personal information collection.

Collecting and Processing Personal Information in PLIMS

The *collection component* is the basic part of PILMS actually building the personal information collection from pieces of personal information. To begin with, since this is the more technical part of this work, those pieces of personal information are from now on referred to as *learning objects* (definition cf. chapter 8.1).

[16] In fact, only the first four steps are implemented within PLIMS. The fifth step is represented by the learner actually using and, after all, trusting the system.

Recalling the personal information management activities that have been previously defined, a circle of activities starts with finding the appropriate learning objects to be kept in the personal information collection. To allow the re-finding of these learning objects, an appropriate keeping behaviour or method is required—also since it is widely acknowledged that learning occurs when information is *well structured*, *accurate*, and *easy to find* [Ros01, p.84].

Once more, these important actions of finding and keeping in ways that facilitate the re-finding information is what the field of information retrieval is all about [Jon04]. An information retrieval system, therefore, has the purpose of leading *"the user to those documents that will best enable him or her to satisfy his or her need for information"* [Rob81, p.10]. More precisely, information retrieval systems allow the performing of some or all of the following operations [Rob81, pp.9f]:

- ▷ The construction of representations for documents (pieces of information)—which is generally referred to as *indexing*.
- ▷ The construction of representations of information needs—that is, the *formulation* of a search or query by a user with an information need.
- ▷ A matching of representations from documents with representations of needs—that is, the actual conducting of a *search*.
- ▷ The repetition of all those processes—if desired with modifications—returning a *feedback* for the searching process.
- ▷ To enable a result of the searching process, rules of representations have to be generated—that is, the construction of an index language.

Technically examined, PLIMS constitutes an information retrieval system that is in particular implemented for building a personal information collection. As a consequence, a profound *index structure* builds the foundation for this collection component and the overall architecture of PLIMS. Thus, the PLIMS architecture builds an appropriate index structure that allows the construction of representations for documents or, respectively, learning objects:

Index of Learning Objects. Based on the *repository of learning objects*, the *main index level* is simply a representation of learning objects that, at the same time, depicts the *first tier* of the index structure.

Basically, this level is similar to known indexing components[17] and connects the whole index structure to the factual representation of information—the learning objects originally collected as files. Text-based content is supposed to be processed according to traditional full text indexing mechanisms to build an appropriate index; processing multimedia content is also desired and necessary.

A core feature of PLIMS is, however, not just collecting and traditionally storing learning objects and connected meta information but also two different kinds of additional information that build the *second tier* of the index structure:

Index of Learning Context. The collection component allows the addition of *hierarchical information* representing a learner's *context* that has been identified as essential information to allow the reuse of information.

Index of Learning References. In addition, a third level referred to as learning references allows the integration of arbitrary *non-hierarchical information* and brings even more flexibility and opportunities for personalisation.

The connection of these two index tiers and the three levels within those tiers is shown in figure 7.1. The three levels themselves are loosely connected, since the supplementary levels of learning context and learning references in the second tier are referring to nodes of the main index level. Information on learning objects constitutes the first tier as described above.

The way this index structure is built also reflects a number of findings from different areas. To name just two:

[17] There are several common index techniques that have been and still are evaluated as an area of research within the field of information retrieval. Since an evaluation of different indexing techniques is, however, not the particular subject of this work, [BYN11] is referred to for further reading.

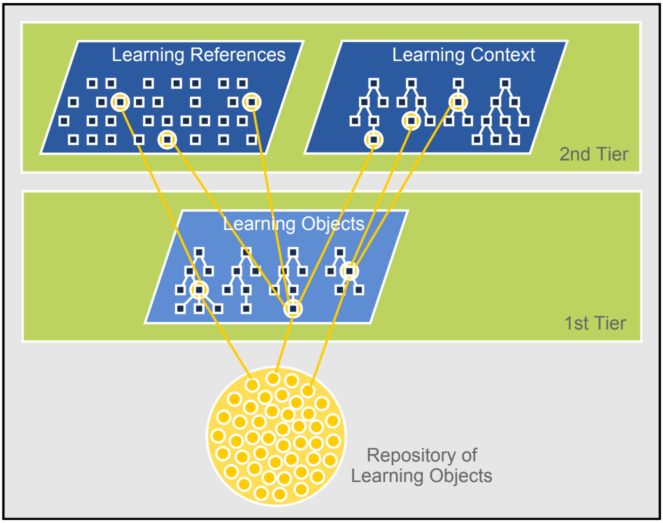

Figure 7.1: The two index tier with three index levels of the PLIMS architecture

- ▷ A connection of pieces of information like the connection of learning objects and the supplementary information within this index structure was proposed in 1945 by Vannevar Bush in his famous article "As we may think" describing the idea of *Memex*[18] [Bus45]. Bush acknowledged that the human brain works with associations and, therefore, suggests a utilisation of those naturally built associations [Bus45]—thereby, expressing the hope that *"technology might be used to extend our [...] ability to handle information"* [Jon07, p.5].

- ▷ Moreover, the proposed structure is also connected to findings from the area of *hypertext information retrieval*. Maristella Agosti et al. [ACM96] proposed a system for the automatic con-

[18] Vannevar Bush envisioned Memex as a device in which an individual stores all his books, records, and communications, and which is mechanized so that it may be consulted with exceeding speed and flexibility. It is an enlarged intimate supplement to his memory [Bus45]. This concept also greatly influenced the development of the hypertext system.

struction of hypertext for information retrieval that conceptually builds on a three level architecture: *documents*, *index terms*, and *concepts*. The utilisation of concepts as top level of the index structure enables the access to the collection of objects by navigating and browsing—which will also be applied in PLIMS (cf. chapter 10.3.1). [ACM96, pp.462f]

Hence, by using not just one but three different index levels organised in two tiers, PLIMS enables personalisation and facilitates learning insights by facilitating an individual structuring of learning.

Naturally, the logical component of PLIMS referred to as collection component facilitates the building of a personal information collection within PLIMS by including learning objects and adding supplementary information. As reasoned in chapter 6.4.2 and, for instance, confirmed by David Nicholas [Nic00, pp.16f], the internet is one of the major sources of information today. PLIMS, therefore, in particular focusses on the integration of learning objects found throughout the Web in general as well as in particular learning spaces such as learning management systems. Nevertheless the collection and integration of local data is certainly possible too.

The collection component building the repository and the underlying appropriate architecture for learning objects are the main focus of this work and considered in more detail in chapters 8 and 9.

Advancing the Organisation of Personal Information in PLIMS

Building upon the collection component and the underlying architecture of PLIMS, the *preparation component* aims to process the learning objects and the supplementary information collected in the previous stage. The basic idea is to enable the utilisation of the three different index levels to provide additional information and foster the gaining of new learning insights.

Primarily, two different options benefiting from the PLIMS architecture will be examined:

Collaboration. The preparation component is obviously a possible starting point for collaboration scenarios and social involvement with fellow learners. In particular, the often manual addition of information located in the second tier can benefit from collaborative efforts to avoid the performing of similar or equal tasks by multiple users several times.

Recommendation. Since every information within the second tier is connected with a particular node in the first tier—and ultimately a learning object—different techniques can be used to reveal connections that have not been obvious before. That way learning objects not explicitly searched—however considered relevant by PLIMS due to its information—can be recommended to the user.

A detailed—but more theoretical consideration—of this component is the subject matter of chapters 10.1 and 10.2.

Reviewing Personal Information in PLIMS

Finally the *presentation component* builds the interface of PLIMS—offering the service as a whole to the user and ensuring access to all information stored within PLIMS. Generally, access is enabled by the provision of two stages to search the personal information collection:

Basic Search Facilities. The basic access to a learner's collection is constituted by a common keyword search—similar to using search engines such as Google or Microsoft's web search engine Bing[19].

Advanced Search Facilities. In addition to this standard access, the index structure can be utilised to re-find learning objects utilising an exploratory approach. The supplementary information—for instance, a particular learning context—can be used as clue to search or as a filter to narrow down a previous search.

The PLIMS interface, technically, also connects the user to the two basic components—the collection and the preparation component—by enabling the manual collection and standard features such as a direct access, modification, and extension of learning objects and their supplementary information.

A more elaborate consideration of this component is the subject of chapter 10.3.

[19] Bing—`http://www.bing.com/`

The Technical Implementation

Initially, PLIMS was intended and also started to be implemented from scratch using suitable technologies including J2EE[20] in combination with the Spring framework[21] and the object-relational mapping library Hibernate[22].

However during the process of implementing the system from the outset, Zotero[23] became apparent. Zotero is a *personal research assistant*—provided and developed by the Roy Rosenzweig Center for History and New Media[24]—that helps a single user to *"collect, organise, cite, and share"* [Roy12] research sources.

Technically, Zotero was initially designed as a Firefox[25] extension. By now, it is however available as a standalone version that works with different browsers by using connectors[26].

As will be clear from this brief description, Zotero already brings along a number of those opportunities proposed as essential components of PLIMS. Therefore and because of the Open Source[27] character of Zotero as well as the opportunity to achieve a higher degree of maturity, the decision has been made to discard the existing parts of the autonomous implementation and to implement PLIMS by extending Zotero instead. More details on functionalities of Zotero and the technical implementation within Zotero will be given where appropriate in the next chapters.

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[20] J2EE is the Java 2 Enterprise Edition extending the Standard Edition with an API for object-relational mapping, web services, and other aspects—`http://www.oracle.com/technetwork/java/javaee/overview/index.html`.

[21] The Spring framework is an open source application framework easing the development of J2EE applications—`http://www.springsource.org/`.

[22] The object-relational mapping library Hibernate provides a framework to map an object-oriented domain model to a relational database—`http://www.hibernate.org/`.

[23] Zotero—`http://www.zotero.org`

[24] Roy Rosenzweig Center for History and New Media—`http://chnm.gmu.edu/`

[25] Firefox—`http://www.mozilla.org/firefox/`

[26] This feature and the maturity of Zotero resulted in the choosing of Zotero over similar existing approaches such as the Firefox extension Scrapbook—`http://amb.vis.ne.jp/mozilla/scrapbook/`.

[27] Open source is a philosophy promoting *"free redistribution and access to an end product's design and implementation details"* [Wik13f]. For that reason, the source code of the Zotero project is provided under the GNU Affero General Public License (version 3)—`http://www.gnu.org/licenses/agpl.html`—and can be re-used as well as easily extended.

8 An Architecture to Store Personal Information

"Three Rules of Work:
Out of clutter, find simplicity. From discord, find Harmony. In the middle of difficulty, lies opportunity."

Albert Einstein

With a growing number of data objects, *metadata* has proven to be a valuable means for the creation of organising structures or architectures—that is to discover, manage, and use learning objects [IEE15, p.ii]. Technically examined, a digital collection of objects is in very general terms referred to as a *digital library*. Consequently, metadata can be found *"at the heart of more general developments in the area of digital libraries"* [Duv01, p.591].

However acting within a learning environment and, thus, gathering learning objects, it is preferable to describe a collection of digital objects as a *learning object repository* within the scope of this work. Since learning object repositories are *"what make the learning objects discoverable"* [Dow06, p.29], they typically collect not only learning objects but also metadata for learning objects. More precisely, there are two major types of learning repositories: 1) learning object repositories containing only the learning object metadata and, that way, enabling access to learning objects that are stored in a remote location and 2) learning object repositories that include both—learning objects and the learning objects' metadata—and are therefore able to locate and deliver learning objects [Dow06, p.29].

PLIMS is designed as a learning object repository of the latter type—and, hence, contains the learning objects as well as the learning objects metadata. It is however a special learning object repository due to a single characterising feature: it is particularly designed for *one* learner.

Nevertheless, to be able to store metadata within a learning object repository, the creation of appropriate structures associated with learning objects is required [VMD07, p.90]. In conclusion, the creation of such appropriate structures is one of the major goals to be accomplished by PLIMS—of course, in addition to the initial collection of learning objects themselves.

Following the claims presented above, this chapter describes the architecture technically building PLIMS. The next section starts with delivering an appropriate introduction of *learning objects* as integral parts of PLIMS. In what follows, *metadata standards* to describe learning objects will be examined. Finally the last section of this chapter describes the architecture built for PLIMS.

8.1 The Integral Part of PLIMS: Learning Objects

As already introduced, the essential parts of the architecture proposed for PLIMS are *learning objects*—also referred to as *information items* [Jon07, p.9] or *learning resources* [VMD07, p.90]. Learning objects are also adopted as the integral part of PLIMS because conceptually they enable a range of "-abilities": accessibility, interoperability, adaptability, re-usability, durability, affordability, assessability, discoverability, interchangeability, manageability, reliability, and retrievability [McG06a, p.1f][1].

To be able to appropriately discuss *learning objects*, a definition is needed first. Existing definitions of learning objects range from universal descriptions to highly specific restrictions[2]. Starting fundamental, learning objects can be depicted as *Lego blocks* or *atoms*—little bits of information that can be put together and organised [Dow05]. Refining this figurative description, the IEEE Learning Technology Standards

[1] The view of learning objects that is taken in this work is a technical one that facilitates building on learning objects as integral parts of the PLIMS architecture. Those interested in learning objects from the position of someone who is aiming to create own learning objects are therefore referred to [Smi04].

[2] The historic foundations as well as a comprehensive review on existing definitions, provided by David A. Wiley, can be found in [Wil02].

Committee (IEEE LTSC) defines a learning object as *"any entity—digital or non-digital—that may be used for learning, education, or training"* [IEE15, p.5].

Within the scope of this work, this general definition is used along with David A. Wiley's understanding of a learning object as *"any digital resource that can be reused to support learning"* [Wil02, p.6]. This conjunction restricts learning objects to digital objects and emphasises the thought of actually reusing learning objects—which is also significant for our scenario:

> *"A learning object comprises a chunk of content material, which can be re-used or shared in different learning situations."* [CF07, p.271]

Previous extensive research on learning objects implicated a vocabulary of synonyms and specialised terms for learning objects. Rory McGreal closely examined this vocabulary [McG04] and adapted his results into a terminology for learning objects as shown in table 8.1. This terminology emphasises that adopting such a universal definition implies a great variety of feasible learning objects—whereas *"the most basic learning object is understandable on its own and and coherent, which means without references to other learning objects"* [Red03, p.1] and, therefore, represents *"the most essential unit"* [Red03] whose further fragmentation is not reasonable [Kno04, p.222].

Nevertheless in the context of this work and particularly when referring to related work, no distinction will be drawn between those different labellings. They are all used as synonyms—also due to the fact that whether a digital object is actually a learning object is always determined based on its use and not on its nature [McG06a, p.10][3].

Thinking about the number and variety of possible learning objects, the demand for a classification or taxonomy of learning objects rises. A preliminary taxonomy of learning object types putting focus on instructional design theory is included in David A. Wiley's remarks on learning objects [Wil02], while Giselher H.J. Redeker presents a didactic taxonomy for knowledge units particularly considering a learner's

[3] There are, of course, also other views on this particular issue. Erik Duval and Wayne Hodging, for instance, presented a taxonomy for learning objects that classifies raw media element as not specific to the field of learning [DH06, p.74]. However within the scope of this work we stick to the general definition given by Stephen Downes [McG06a, p.10].

Anything	Anything Digital	Anything for Learning	Specific Learning Environment
Asset	Content Object	Educational Object	Reusable Learning Object
Component	Information Object	Learning Object	Unit of Learning
Learning Resource	Knowledge Object		Unit of Study
	Media Object		
	Raw Media Element		
	Reusable Information Object		

Table 8.1: Terminology for learning objects according to Rory McGreal [McG04, p.23]

role in respective learning [Red03]. These two orthogonal taxonomies have subsequently been combined by Vito Nicola Convertini et al. [CAM+06] to form the OSEL taxonomy[4] for the classification of learning objects [CAM+06]. This taxonomy—a join of the two previously named taxonomies by Wiley and Redeker—is shown in table 8.2. Using this taxonomy, learning objects can be divided and consolidated into nine different classes [CAM+06, pp.132f]:

- *B-simple* learning objects are fundamental and receptive learning objects. More precisely, learning objects of this class are *non-interactive*—therefore allow no group activities—and are composed by a single content that is, in turn, constituted by a single element or media such as an image or text file.

- *B-passive* learning objects are still non-interactive. However, in contrast to b-simple learning objects, the content is composed

[4] The Open Source E-Learning Project (OSEL project) is a research project that *"started from the necessity to create a taxonomic classification for the management of the learning objects repository used by the LCMS platforms"* [CAM+06]. By now, the OSEL project is sustainably continued by the spin-off Osel Consulting— `http://www.osel.it/`.

	Fundamental	**Combined-Closed**	**Combined-Open**
Receptive	receptive-basic, B-simple	receptive-closed, B-passive	receptive-open, B-active
Internally Interactive	interactive-basic, T-simple	interactive-closed, T-passive	interactive-open, T-active
Cooperative	cooperative-basic, W-simple	cooperative-closed, W-passive	cooperative-open, W-active

Table 8.2: Taxonomy of learning objects as a combination of Wiley's preliminary taxonomy of learning object types (horizontal) and Redeker's educational taxonomy (vertical) [CAM+06, p.132]

by at least two elements that are internally combined such as an image with a textual description.

- Finally, *b-active* learning objects—again being non-interactive—are constituted by a combination of many internal and external elements. Nevertheless, this combination is still required to depict a single learning content. Such a combination can, for instance, be formed by a number of different images that are described by summarising textual description and where at least one of these images is not local but can be found in the Web.

- Building upon this basic layer, *t-simple* learning objects are *interactive* and constituted by at least two different contents—represented in or by a single element. Even though being interactive, t-simple learning objects—just like all t* learning objects—allow no group activities. To take a simple example, a website containing only a text and linking to another website—that is, again, only containing text—can both be combined to a single t-simple learning object.

- *T-passive* learning objects are subsequently formed by two internal contents composed by the combination of at least two elements. Using the previous example, neither websites are allowed to just contain text to form a t-passive learning object.

▷ Concluding this layer, *t-active* learning objects are combined-open and internally interactive. The resulting learning object is, therefore, constituted *"by many internal and external contents having many elements combined among them"* [CAM+06, p.132].

▷ The third layer starts with *w-simple* learning objects that finally allow *group activities*. A w-simple learning object is therefore interactive, has at least two internal contents, and enables cooperation. Such a learning object can, for instance, be a text-only website including a link to another text only website that requires a brainstorming activity through an offered communication service.

▷ As for b* and t* learning objects, *w-passive* learning objects revoke the prerequisite of being just one content and, therefore, allow different content types such as websites with text and images linking to each other and requiring a cooperative activity.

▷ To conclude, *w-active* learning objects are interactive learning objects composed by many internal and external elements and their combination—this time also including cooperative activities.

For the purpose of this work, the OSEL taxonomy is used to delimit boundaries and set the focus on learning objects that can be part of the PLIMS repository. Learning objects that can be included within the PLIMS repository are *receptive* as well as *internally interactive* learning objects. The focus is, however, on b-simple, b-passive, t-simple, and t-passive learning objects—that are *fundamental* and *combined-closed* learning objects. Hence, the granularity of learning objects that PLIMS aims at are *basic learning objects*—in contrast to more complex learning units, courses, or learning sequences that will have to be disassembled to be integrated into PLIMS (cf. chapter 9.2.3).

Having set the focus for a subset of learning objects[5], the next step is the capturing of these learning objects and the extraction of the necessary information for the construction of the architecture. As already

[5]Even though this focus strongly influences the technical design and resulting possibilities of PLIMS, it does not naturally restrict the integration of such a learning object by a learner into PLIMS. By accepting some restrictions, learners can manually integrate a number of learning objects that PLIMS might not have been designed for.

reasoned, proceeding to implement the description and management of information resources in general and learning object in particular, metadata is considered to be a primary tool [DHSW02, p.9]: *"metadata is essential for addressing learning objects"* [McG04, p.22] and should, therefore, be used to describe learning objects [VMD07, p.90]. For that reason, *metadata standards* are examined next.

8.2 Metadata to Describe Learning Objects

To be able to use digital content—also known as learning objects—users or learners have to be able to locate and identify these (learning) objects. The descriptive data allowing this identification by providing information about these objects is commonly referred to as *metadata* [Duv01, p.591]. Giving a basic definition, metadata can be described as information about an object—no matter if physical or digital [IEE15, p.ii]. Metadata is, for that reason, often paraphrased as "data about data" or "information about information". Metadata is structured information that *"describes, explains, locates, or otherwise helps retrieving, using, or managing a resource"* [VMD07, p.89] and, therefore, facilitates the search, evaluation, acquisition, and utilisation of (learning) objects [IEE15, p.5]. Even though surely belonging to a certain object, once extracted, metadata is actually detached from the learning object [VMD07, p.89].

As will be apparent, there is a number of commonly known *metadata elements*. As a consequence, a standardisation of this variety of elements is desired. This request is answered by a number of different *metadata standards* that have been developed so far. Standards in general and these metadata standards in particular provide an order and differing subsets of metadata elements by following a number of general principles such as modularity and extensibility[6]. All in all, metadata and, in turn, metadata standards help to *"create order in the chaos"* [DHSW02].

Providing such an order for a number of individually collected learning objects is clearly one of the primary objectives of PLIMS. Consequently, existing metadata standards serve as a guideline in deciding

[6]Actually, metadata standards follow a larger number of principles and practicalities that have been described in detail by Erik Duval et al. in [DHSW02].

what information should be extracted from learning objects to be integrated into the PLIMS index structure. Consulting the wealth of existing metadata standards three groups can be identified and will now be examined[7]: *universal metadata standards*, *learning-specific metadata standards*, and *subject-specific metadata standards.*

8.2.1 Universal Metadata Standards

The first group of metadata standards comprises the most general and, therefore, universally applicable metadata standards. More precisely, universal standards are characterised by their suitability to different fields of application. Different standards step up to meet this demand.

Common Librarian Standards

Starting to think about metadata and metadata standards, there is one group of standards that has been around and in use for a considerably long time and, hence, immediately crosses one's mind: the standards arising from librarianship.

Standards for Library Catalogues. Library catalogues have been around for a long time and are actually a natural companion to collections of bibliographic items such as books. A *library catalogue* is a comprehensive and organised list of a library's content—that is an enumeration of all resources of a library [Far13c]. A bibliographic item within a library catalogue can be any information entity such as maps, periodical archives, artwork, computer files, microfilm, and, of course, books. Today, library catalogues are commonly available via an *online public access catalogue (OPAC)*. In summary, the need to establish and maintain library catalogues apparently implicates the necessity for standardisation. Indeed, there are several standards that are shared by almost all libraries today. [Tol13] [Wik13e]

Machine Readable Cataloguing. One of the most common family of international standards for library catalogues is that of the *Machine Readable Cataloguing (MARC)* standards[8] that have been

[7] Parts of chapter have already been published in [SH10b].
[8] Machine Readable Cataloguing (MARC)—`http://www.loc.gov/marc/`

developed during the 1960s. MARC standards are *metadata transmission standard* and not content standards [The20].

There is a number of different versions with the family of MARC; the current and common version is *MARC 21* [The20]. MARC 21 formats are standards for the representation and communication of bibliographic and related information in machine-readable form. To achieve this, MARC 21 defines not only one but five different formats: a bibliographic format, the authority format, the holdings format, a classification format, and a community format—each of them defining specifications and allowing encodings as suggested by their collective label. A single MARC cataloguing record involves three elements: 1) the record structure that follows an international standard for information interchange[9], 2) the content designation, and 3) the data content of the record that is typically defined by content standards outside the format. [MAR18]

Being an international standard, MARC can be associated with a number of other standards: MARC served as model for the German equivalent—the *Maschinelles Austauschformat für Bibliotheken* (MAB)[10]. Moreover, there are uni- and bidirectional mappings between MARC 21 and a number of different other metadata standards.

All in all, MARC is a very comprehensive and quite complicated standard. Therefore, the Metadata Objects Description Schema has been created as a simplification.

Metadata Object Description Schema. As already suggested, this scheme is a derivative of the MARC format. Therefore, just like MARC, the *Metadata Objects Description Schema (MODS)*[11] is a XML-based description scheme for bibliographic items. However, MODS has been designed as compromise between the com-

[9] There are different information interchange standards that can be chosen such as ANSI Z39.2—`http://www.niso.org/apps/group_public/project/details.php?project_id=91`—or ISO 2709—`http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=41319`.

[10] Maschinelles Austauschformat für Bibliotheken (MAB)—`http://www.d-nb.de/standardisierung/formate/mab.htm`

[11] Metadata Objects Description Schema (MODS)—`http://www.loc.gov/standards/mods/`

plexity of the MARC format and the simplicity of the Dublin Core standard (cf. section 8.2.1, Dublin Core).

In its current version[12] MODS defines 20 top level elements that each have, in turn, a number of possible sub elements and attributes[13]. A single MODS record contains a number of top level elements; single records can be grouped within a MODS records collection. In contrast to the numerical codes in MARC, elements and attributes in MODS are labelled. [The19]

Due to its design and origin, MODS can be easily converted to MARC and Dublin Core—as well as vice versa—by using already prepared XSLT scripts[14] [The19]. Nevertheless, by now, MODS is only supported by a few reference management systems like JabRef[15] or Zotero (cf. chapter 7.2.2).

Standards for Digital Archives. The class of standards introduced so far have been explicitly designed for library catalogues and, therefore, traditional, non-digital libraries. In view of this, another group of standards needs to be examined: standards for digital archives that explicitly spotlight electronic documents.

Metadata Encoding & Transmission Standard. One of most prevalent standards for digital archives and digital libraries is the *Metadata Encoding & Transmission Standard (METS)*[16]. Just like MARC and MODS, METS is maintained by the Network Development and MARC Standards Office of the Library of Congress[17].

METS aims *"to convey the metadata necessary for both the management of digital objects within a repository and the exchange of such objects between repositories"* [Dig10, p.15]. METS, hence, tries to accompany digital objects throughout their life cycle by

[12] At this point in time MODS is available in version 3.4.

[13] A detailed outline of all possible top level elements, sub elements, and attributes can be found at `http://www.loc.gov/standards/mods/mods-outline.html`.

[14] The different conversion scripts are freely available at `http://www.loc.gov/standards/mods/mods-conversions.html`.

[15] JabRef reference manager—`http://jabref.sourceforge.net/`

[16] Metadata Encoding & Transmission Standard (METS)—`http://www.loc.gov/standards/mets/`

[17] Standards at the Library of Congress—`http://www.loc.gov/standards/`

delivering an appropriate structure. More precisely, this structure is defined by a METS document that contains seven sections: the header, descriptive metadata, administrative metadata, a file section, a structural map, structural links, and technical metadata [Dig10, pp.18ff]. Again, as indicated by the standard's name, each of these sections may internally use a different content metadata format itself. [The29]

Metadata Standards for Long-Term Preservation of Electronic Resources. In addition to this first standard and related approaches, there are a number of standards that should be mentioned as well: in particular those concerned with the long-term preservation of electronic resources such as *LMER* and *PREMIS*.

The *Long-Term Preservation Metadata for Electronic Resources(LMER)*[18] is not a general data model for long-term preservation metadata but rather an exchange format [Ste05, p.4]. Focusing on the long-term preservation, LMER adds metadata about the system environment needed to re-use the digital object at a future date. LMER has also been combined with METS to present the *Universal Object Format (UOF)* [Ste06, p.553].

By now, the *Preservation Metadata Implementation Strategies (PREMIS)*[19] can, however, be depicted as the international standard for metadata supporting the preservation and long-term usability of digital objects. To allow such a long-term preservation, the PREMIS Data Dictionary defines a core set of semantic units[20] that repositories should be able to recognise and deal with in order to perform their preservation functions. Even though preservation activities vary, the following activities can be named as typical actions: actions to ensure that digital objects remain

[18] The Long-Term Preservation Metadata for Electronic Resources (LMER)—`http://www.dnb.de/DE/Standardisierung/LMER/lmer_node.html`

[19] The Preservation Metadata Implementation Strategies (PREMIS)—`http://www.loc.gov/standards/premis/`

[20] In contrast to defining metadata elements, PREMIS defines semantic units. This distinction is considered to be crucial: *"A semantic unit is a piece of information or knowledge. A metadata element is a defined way of representing that information in a metadata record, schema or database."* [Cap01, p.5] Those units, however, have a direct mapping to metadata elements.

viable and renderable as well as actions to prevent inadvertent alteration and to document legitimate changes. PREMIS can, therefore, be defined as a subset of all possible metadata. [Cap01, p.4]

It needs to be emphasised that PREMIS *"does not specify how metadata should be represented in any system, it only defines what the system needs to know and should be able to export to other systems"* [Cap01, p.5]. To facilitate this understanding, the PREMIS data model includes five different entities—intellectual entities, objects, events, rights, and agents—and relationship between those entities [PRE12, pp.5f]. [The27]

Further General Metadata Standards. Finally, there is a third group of metadata standards that can in the broadest sense be referred to as related to the librarian department: standards from the book industry and standards for reference management systems.

Book Industry Standards. Looking at traditional libraries again and apprehending the items within such a library from a marketing perspective, the book industry is also in the market for standardisation. A standard accompanying bookselling along the whole commercialisation chain is the *Online Information Exchange (ONIX)* standard[21].

ONIX is a standard family maintained by EDItEUR[22] that has been developed to consistently provide metadata on books for publishers, retailers, and all of their partners. With the release of version 3.0, ONIX has been expanded to be able to appropriately deal with e-books and other digital products as well. [EDI09]

Like all the other standards introduced above, ONIX is a XML-based metadata standard that defines metadata elements for the description of books and ebooks. To support the implementation of this standards, EDItEUR provides schemas in different

[21] Online Information Exchange standard—`http://www.editeur.org/8/ONIX/`

[22] EDItEUR is the international group coordinating the development of the standards infrastructure for electronic commerce in the book, e-book and serials sectors—`http://www.editeur.org/`

formats[23] validating the structure and—if applicable—the code values of ONIX definitions.

Standards for Reference Management Systems. Ultimately looking at the librarian department from a personal perspective—that is from the perspective of a researcher or learner—the need to manage a personal collection of bibliographic items or references is a natural need of researchers and learners. Consequently, standards for reference management systems facilitate the management of those references itself as well as an exchange—no matter if an exchange between two learners or a change of management programmes that requires a transfer of existing data.

There are a number of general standards for reference management systems and a subset among these has emerged as common standards—that are supported by almost all reference management systems:

- BibTeX[24]
- the EndNote Tagged Import Format[25]
- the Research Information System (RIS) format[26]

All of these standards are actually standardised tag formats that enable citation programs to exchange data by providing different entry types for bibliographic items that each have different metadata elements to be added. Using these standards in combination with programs supporting these standards, (personal) references can be gathered, processed, and stored.

In summary, universally applicable metadata standards deliver valuable insights. However, even though being used throughout different

[23] EDItEUR provides XML schemas implementing the ONIX standard in three different XML-based format allowing such a specification: DTD—Document Type Definition, cf. `http://en.wikipedia.org/wiki/Document_Type_Definition`—XSD—XML Schema, cf. `http://en.wikipedia.org/wiki/XSD`—and RELAX NG—REgular LAnguage for XML Next Generation, cf. `http://en.wikipedia.org/wiki/RELAX_NG`. For a further definition of these standards it is simply referred to the introducing articles cited above.

[24] BibTeX—`http://www.bibtex.org/`

[25] EndNote Tagged Import Format—`http://en.wikipedia.org/wiki/EndNote`

[26] Research Information System (RIS) format—`http://www.refman.com/support/risformat_intro.asp`

fields and providing comprehensive possibilities, all of these standards rose from librarianship and are, therefore, coined and characterised by perspectives, peculiarities, and settings from this domain. As a consequence, there remained the need for a general, universally applicable metadata standards. Due to this fact, *Dublin Core* was created.

The Dublin Core Standard

The Dublin Core (DC) standard is provided and maintained by the *Dublin Core Metadata Initiative* (DCMI)[27]. The DCMI has been founded as request of researchers interested in the provision and development of information in 1994 [Wik13b]; the name "Dublin" simply refers to Dublin, Ohio where the first metadata workshop[28] was hosted [Wik13c]. The DCMI claims to offer *"simple standards to facilitate the finding, sharing and management of information"* [DCM13] to be their mission:

> *"[Dublin Core is a] small language for making a particular class of statements about resources."* [DCM13]

Hence, at first *15 core elements* have been provided as basic set of metadata elements. This basic set—the *Dublin Core Metadata Element Set (DCMES)*[29]—released in 2001 has been formalised in three different standards: the ISO standard 15836:2009[30], the ANSI/NISO standard Z39.85-2007[31], and the IETF RFC standard 5013[32]. [DCM13]

Dublin Core Metadata Sets and Terms. By now these original terms have been refined and an advanced set is provided as an expansion of the DCMES: the *DCMI Metadata Terms*[33]. This extended set of metadata elements includes 55 terms in sum that can be clustered into six groups:

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[27] The Dublin Core (DC) Standard and the Dublin Core Metadata Initiative—`http://dublincore.org/`

[28] All information about the first OCLC/NCSA metadata workshop—"The Essential Elements of Network Object Description" can be found at `http://dublincore.org/workshops/dc1/`.

[29] Dublin Core Metadata Element Set—`http://dublincore.org/documents/dces/`

[30] ISO standard 15836:2009—`http://www.iso.org/iso/catalogue_detail.htm?csnumber=52142`

[31] ANSI/NISO standard Z39.85-2007—`http://www.niso.org/standards/z39-85-2007/`

[32] IETF RFC standard 5013—`http://www.ietf.org/rfc/rfc5013`

[33] DCMI Metadata Terms—`http://dublincore.org/documents/dcmi-terms/`

Descriptions of a Resource's Content. This first group of metadata terms comprises 11 elements describing a resource with regards to its content. First of all, the *title*, an *alternative* title, and the *subject* are covered by correspondent metadata terms. The subject can be stated more precisely by adding the *type* attribute to give the nature or genre of a resource or one of the *coverage* attributes that allow to specify the *spatial* or *temporal* topic of the resource. More information can be appended by determining a *description*, an *abstract*, or even a *table of contents*. Last but not least the *language* can also be assigned.

People and Institutions responsible for the Resource. The second group of terms allows to specify different entities that can be either a person, an organisation, or a service being related to the resource such as a *contributor*, a *creator* or a *publisher*.

Formal Information on the Resource. In addition there is also the need to provide capabilities for including a completely different kind of information about the resource: formal information. Therefore, this group comprises 17 elements allowing to provide formal issues. Aside from expected aspects like the *format* or *extent*—which is the size or duration of a resource—the *medium* of a resource is covered by correspondent terms. Of course, an *identifier* and a *bibliographic citation* in order to clearly identify a particular resource can be provided. Moreover, a large group of terms is dedicated to assigning various *date*s. Besides the common dates when the resource was *created* and *modified* at, the date that the resource was *copyrighted* can be stored. Also, a subgroup is allocated for storing dates related to a publication process such as the date a resource has been *submitted*, *accepted*, and *issued*. In addition, the date or typically a date range where the resource is *available* and *valid* can be given. Finally, some technical information concerning the addition of items to the collection like the *accrual method*, the *accrual policy*, and the *accrual periodicity* can be included.

Relation(s) to other Resources. To keep the value of a resource, another form of information concerning the relations to other resources needs to be retained. Basic information are the *source* a resource is derived from and the *relation* to this resource. However, more precisely, relations can be distinguished by using six different types of relations—*has format*, *has part*, *references*, *has version*, *replaces*, and *requires*. Since relations can also be specified as bidirectional every possible relation has its counterpart and *is format of*, *is part of*, *is referenced by*, *is version of*, *is replaced by*, as well as *is required by* can also be used to formalise relations. Moreover, standards that the resource *conforms to* can also be referred to.

Information on Legal and Educational Aspects for Reusing the Resource. In order to be able to actually reuse the resource, legal aspects on the resource are of interest. Therefore, *rights* associated with the resource and also the *rights holder* should be stored to be available if necessary. To be concrete, the *license* and exact *access rights* as well as the *provenance*—by means of recording changes in ownership or similar—can be specified.

Educational Information on Reusing the Resource. Besides legal aspects, information on the educational purpose the resource has been designed for is needed for an efficient reuse. Hence, the *audience* the resource is intended for and the required *education level* or a *mediator* can be specified. Ultimately, the *instructional method* can be included into metadata information.

Researching the area of metadata standards, it soon becomes obvious that Dublin Core influenced and still influences the development and progress of many standards. Therefore, Dublin Core can without hesitation be named as the most important standard to be considered.

However, it has to be noted that the previous and following descriptions only comprise a selection of metadata standards that has been made based on the perceived prevalence and importance of those standards. There are a considerable number of other metadata standards—such as XOBIS[34] or (X)MetaDiss[35]—that offer reasonable subsets and, very often, have been influenced by Dublin Core, too.

[34] XOBIS—`http://xobis.stanford.edu/`
[35] MetaDiss—`http://deposit.ddb.de/metadiss.htm`, XMetaDiss—`http://deposit.ddb.de/xmetadiss.htm`

8.2.2 Learning Specific Metadata Standards

Examining standards within the scope of this work, it seems reasonable to take into account the learning context next. Looking for organisations addressing metadata within a learning context, the most important organisations are named as suggested by Helmut Niegemann et al. [NHD+04, pp.270f]:

- ▷ AICC[36]—the Aviation Industry Computer Based Training Committee
- ▷ ADL[38]—the Advanced Distributed Learning Initiative
- ▷ ARIADNE[39]—the Alliance of Remote Instructional Authoring and Distribution Networks for Europe
- ▷ OUNL[40]—the Open University of Netherlands
- ▷ IEEE LTSC[41]—the IEEE Learning Technology Standards Committee
- ▷ IMS[42]—the Instructional Management Systems project and the IMS Global Learning Consortium

While only the IEEC LTSC is able to actually release recommendations for standards, all of these organisation contributed to important metadata standards for learning by developing suggestions for standardisation recommendations. To do so, all of these institutions worked together within a cooperation network and, in that way, influence each other. An overview of the most important standards—assigned to the corresponding organisations and accompanied with a short description—is shown in table 8.3. [NHD+04, pp.271f]

[36] AICC[37]–`http://www.aicc.org`
[38] ADL—`http://www.adlnet.org/`
[39] ARIADNE—`http://www.ariadne-eu.org/`
[40] OUNL—`http://www.ou.nl/web/english/home`
[41] IEEE LTSC—`http://www.ieeeltsc.org`
[42] IMS—`http://www.imsglobal.org/`

Organisation	Metadata Standard	Description
AICC	Computer Managed Instruction Systems (CMI)	CMI is a guideline for interoperability that was already released in 1993 and, therefore, originally designed for CD-ROM and locally based operations. The purpose of this standard is a definition of interfaces and rules that allow computer-based training content from a variety of sources to interoperate with computer managed instruction systems. [AIC16] In November 2010, AICC announced the development of a new data exchange standard that will not only supersede CMI *"but will define the way courseware and management systems communicate from here forward"* [AIC10]. So far, this standard has not been released. Even though the importance of CMI is acknowledged here, it will not be further considered within the scope of this work.
ADL	Shareable Content Object Reference Model (SCORM)	SCORM integrates a set of technical standards, specifications, and guidelines. SCORM specifies that content should be packaged in a ZIP file, described in an XML file, communicate using Java Script, and allow sequencing using XML rules. [ADL12][Rus12b] SCORM will, therefore, be examined closer in section 8.2.2.

ARIADNE / IMS Global Learning	Learning Object Metadata (LOM)	LOM allows the description of learning objects with appropriate metadata and, in that way, enables the identification, discovering, and re-use of learning objects. [IMS31][NHD+04, pp.272f] Hence, LOM will be examined closer in section 8.2.2.
OUNL	Educational Modelling Language (EML)	EML is *"a semantically rich information model and binding, describing the content and process within units of learning from a pedagogical perspective in order to support reuse and interoperability"* [KM04, p.537]. To do so, EML allows the modelling of domain knowledge, learning outcomes, a component aggregation, and learning activities. [KM04][NHD+04, p.273] EML sums up a number of previous standards and is, therefore, more complex than previous learning standards [NHD+04, p.273]. Due to this complexity, EML is not considered further within the scope of this work.

Table 8.3: A description of metadata standards by organisations [NHD+04, p.270ff]

The two standards considered to be the most important ones—namely, the *Learning Object Metadata* and the *Sharable Content Object Reference Model*—will now be examined more closely.

Learning Object Metadata

The Learning Object Metadata (LOM) standard is the result of early proposals from ARIADNE and IMS Global Learning to the IEEE LTSC. Since then, the IEEE LTSC established a working group and benefited from additional suggestions by ARIADNE, IMS, and ADL. All of these contributions, finally, resulted in a IEEE standard recommendation: IEEE-SA standard 1484.12.1[43]. [Duv01, p.595]

In very general terms, the LOM standard is a conceptual data scheme that defines the structure of a *metadata instance* for a learning object [IEE13]—where a metadata instance is defined as a description of the relevant characteristics of the learning object. Therefore, a set of metadata elements is defined within LOM. Each metadata element is defined by a number of attributes [IEE15, p.7][Duv01, p.597]:

- A *name* referencing the metadata element,
- an *explanation* for the data element,
- the number of values allowed within this element—referred to as *size*—
- a value labelled *order* specifying whether the ordering of the values is significant,
- and, finally, an *example* further illustrating the metadata element.

For simple data elements, a set of allowed values—the *value space*—for the data element is defined, and the *datatype* indicates if a value is a string, a date or time, a duration, vocabulary, character string, or undefined.

Since the LOM standard in total defines 76 metadata elements, all elements have been grouped into nine categories of metadata elements delivering the LOM standard [IEE15, p.6f]:

[43] IEEE Standard for Learning Object Metadata 1484.12.1-2002—`http://standards.ieee.org/findstds/standard/1484.12.1-2002.html`

General. Unsurprisingly, this category groups the general information describing a learning object as a whole. Attributes assigned to this category are a global *identifier*—jointly expressed by a *catalogue* and an *entry* attribute—as well as *title*, *language*, *description*, *keyword*, *coverage*, *structure*, and an *aggregation level.* [IEE15, pp.6f,10ff]

Lifecycle. Subsequently, the second category groups the features related to the history and current state of this learning object as well as those that have affected the learning object during its evolution. Namely, the attributes are *version*, *status*, and *contribute* whereas the last attribute, in turn, consists of three attributes—*role*, *entity*, and *date*—further describing the contribution. [IEE15, pp.6f,16f]

Meta-Metadata. The next group of metadata elements comprises information about the metadata instance itself—rather than the learning object that is described by the metadata element. Hence, meta-metadata attributes are again an *identifier* and *contribute*—each allowing the subordinated attributes as already introduced above—as well as a *metadata schema* and a *language.* [IEE15, pp.6f,18ff]

Technical. The fourth category covers technical requirements and characteristics of the learning object. Corresponding attributes are the simple attributes *format*, *size*, *location*, *installation remarks*, *other platform requirements* and *duration.* In addition, these categories are also comprised of the more complex attribute *requirement* that is accompanied by a number of sub-elements. [IEE15, pp.6f,20ff]

Educational. This category, finally, connects the learning object to its educational and pedagogic context. Since this is one of the main concerns of the LOM standard, this category comprehends 11 attributes: *interactivity type*, *learning resource type*, *interactivity level*, *semantic density*, *intended end user role*, *context*, *typical age range*, *difficulty*, *typical learning time*, *description*, and *language.* [IEE15, pp.6f,23ff]

Rights. A missing consideration of intellectual property rights and conditions of reusing a learning object is delivered by the rights category. Attributes needed to capture these features are *cost*, *copyright and other restrictions*, and *description*. [IEE15, pp.6f,30f]

Relation. The seventh category goes beyond the scope of a single learning object and determines the relationship between a learning object and other related learning objects by allowing a specification of the *kind* of the relation and the related *resource*. The resource, of course, has to or can be further defined by an, already introduced, *identifier* and a *description*. [IEE15, pp.6f,31ff]

Annotation. Any further comment on the educational use of a learning object can be denoted using the annotation category. Such annotations are defined by an *entity*, a *date*, and a *description*. [IEE15, pp.6f,33]

Classification. Finally, the last category allows the description of the learning object in relation to a particular classification system by using *purpose*, *taxon path*, *description*, and *keyword*—whereas the taxonomy path can be further specified by using *source*, *taxon*, *id*, and *entry* as further level of detail. [IEE15, pp.6f,34ff]

Collectively, these categories—each grouping different metadata elements—form the *LOMv1.0 Base Schema*. The description of these nine complex categories shows that LOM is a very comprehensive standard—that also reveals some obvious connections to the previously described DC standard by reusing metadata elements also provided within this standard.

To make it even more sophisticated, there are different bindings—for general purpose datatypes[44], XML Schema[45], and RDF[46]—a number of different application profiles—such as developed by ARIADNE, IMS, and ADL [Duv01, p.595]—and different extensions—such as the extension defined by the Customised Learning Experience Online (CLEO)[47]—to LOM. Moreover, LOM influenced the development

[44] Standard for ISO/IEC 11404 binding for Learning Object Metadata data model—`http://ltsc.ieee.org/wg12/par1484-12-2.html`

[45] Standard for XML binding for Learning Object Metadata data model—`http://ltsc.ieee.org/wg12/par1484-12-3.html`

[46] Standard for Resource Description Framework (RDF) binding for Learning Object Metadata data model—`http://ltsc.ieee.org/wg12/par1484-12-4.html`

[47] The CLEO Extensions to the IEEE LOM standard—`https://www.oasis-open.org/committees/download.php/20490/CLEO_LOM_Ext_v1d1a.pdf`

of other standards and specifications such as *IMS Metadata*[48] and *SCORM*. In summary, LOM can be considered as a comprehensive, complex, and yet most important metadata standard for the educational domain.

The Sharable Content Object Reference Model

The *Sharable Content Object Reference Model (SCORM)*[49] is the result of ADL's endeavours to bring together previous standardisation efforts[50]. Combining those previous findings, the SCORM specification in particular focuses on the technical foundations of e-learning via standardisation [ADL22, p.1-15] by promoting re-usability and interoperability of learning content across different learning systems [ADL12].

To achieve this goal, SCORM provides several components: 1) a specification or data model for content objects, 2) an API for communicating information about a learner's interaction with those objects, 3) a content packaging specification enabling interoperability of learning content, 4) a standard set of metadata elements to describe learning objects, and 5) a set of sequencing rules to organise learning content. [ADL22, pp.1-14f]

It is important to realise that SCORM does not specify where or how to store the learning content but *how* the content is created. SCORM, therefore, builds on *content components* in different sizes [ADL31, p.3-1]:

- *Assets* are the smallest components supported by SCORM. Basically, assets in SCORM represent any digital object—such as text, images, sounds, HTML pages, and other pieces of data. [ADL31, p.3-2]

- Proceeding, *Sharable Content Objects (SCOs)* are the smallest logical unit of information that can be delivered to a learner.

[48]IMS Learning Resource Meta-data Specification—`http://www.imsglobal.org/metadata/`

[49]By now, the SCORM specification is available in version SCORM 2004, 4th edition—`http://www.adlnet.gov/capabilities/scorm#tab-learn`.

[50]SCORM has been selected from a number of learning object content models due to its perceived prevalence. For those interested in a wider selection of learning object content models the reader is referred to a comparison of six different models that can be found in [VD04].

A SCO unit is composed by an arbitrary number of assets that are combined within a SCO. Technically, a SCO is *“the only piece of information that uses the SCORM API”* [ADL31, p.3-4]. Therefore, a SCO can communicate with a learning system by retrieving and sending information. [ADL31, pp.3-2f]

▷ Continuing to the next level, an *aggregation* is a collection of related content. An aggregation can, hence, contain one or more SCO units as well as other aggregations. However, in contrast to assets and SCOs, an aggregation is not a physical file but a *virtual home* within a SCORM *organisation*. [ADL31, p.3-4]

▷ Moving on, an *organisation* is a part of a *content package* that orders SCOs into a tree structure and allows the application of sequencing rules. [ADL31, p.3-5]

▷ Finally, a *curriculum* or course depicts the biggest unit of organisation that is actually outside the scope of SCORM. SCORM content can, however, be combined with other non-SCORM learning assets and experiences within a course or curriculum. For that reason, this content component is also relevant for SCORM. [ADL31, pp.3-6f]

The comprehensive definition of SCORM is organised and given in so-called *books*. More precisely, the core of SCORM is defined in four different books and supplemented by an additional outline book:

SCORM Overview. The SCORM overview book delivers the addressed outline on SCORM as a whole. This book, therefore, covers the history and objectives of SCORM, specifications and standards on which SCORM builds upon, and a description of how the four other SCORM books relate to each other. [JCA13][ADL22, p.1-28]

SCORM Content Aggregation Model. The SCORM Content Aggregation Model (CAM) describes the whole concept, opportunities, and difficulties of components that can be utilised in a learning experience—that is the production of a SCORM content package. A SCORM content package is defined by a *manifest* file; this description may include the structure of the package and, above all, metadata. [JCA13][ADL22, pp.1-28ff]

SCORM Run-Time Environment. The SCORM Run-Time Environment (RTE) book describes the requirements for managing the deployment and delivery of content packages. That way, the SCORM run-time environment ensures the interoperability of learning systems and SCOs. [JCA13][ADL22, pp.1-30f]

SCORM Sequencing and Navigation. The SCORM Sequencing and Navigation (SN) book specifies all possibilities for the sequencing of activities. This sequencing and navigation can be learner- or system-indicated. However, no matter if triggered by a learner- or system-indicated event, a learning activity identified for delivery always has an associated content object. [JCA13][ADL22, pp.1-31f]

SCORM Conformance Requirements. Finally, the SCORM Conformance Requirements book details those requirements that will be verified by the ADL SCORM conformance test suite. [JCA13]

In summary, the scope of SCORM is many times greater than the scope of a common metadata standard like those discussed in the previous sections. Of course, building such a comprehensive standard is quite reasonable for the educational domain and, in particular, complex pedagogical scenarios. Nevertheless, building such complex scenarios within personal learning seems to be too heavy a commitment due to the additional effort that would be imposed upon an individual learner. SCORM is, therefore, not considered in more depth within the scope of this work.

8.2.3 Subject-Specific Metadata Standards

In addition to the general and learning-specific standards that have just been examined, there are of course a number of metadata standards that have been dedicated to specific subjects. These subject-specific standards particularly adapt the needs and requirements of the underlying disciplines. To signify the variety of those standards, a brief digest grouped by scientific disciplines is provided:

Natural Sciences.

- ▷ Starting with a prominent field of natural sciences—*biology*—the *Darwin Core*[51] metadata specification needs to be named. The Darwin Core standard allows the sharing of biodiversity information—that is, among others, information about biological specimens, their spatio-temporal occurrence, and their supporting evidence [Bio08].
- ▷ Another field of natural sciences is the field of *geography*. This discipline actually provides a number of metadata standards. To name just two, the Federal Geographic Data Committee (FGDC)[52] developed an infrastructure to share geographic data called *National Spatial Data Infrastructure (NSDI)*[53]—that also allows the inclusion of a metadata fact sheet [Fed02]—and the *Content Standard for Digital Geospatial Metadata*[54]—that provides a common set of terminology and definitions for the documentation of digital geospatial data [Fed09]. Moreover, there is even an ISO standard—*ISO 19115:2003*[55]—that defines a schema for describing geographic information and services.

Humanities.

- ▷ One of the most prominent standards in the humanities, is the standard provided by the Text Encoding Initiative (TEI)[56]. The standard—referred to as *TEI Guidelines*—enables the representation of the structural, interpretative, and conceptual features of texts in digital form. [Tex13]
- ▷ Looking at another field within the humanities, the Visual Resources Association provides the *VRA Core standard*[57]. VRA Core is a data standard for the description of works of visual culture as well as the images that document this work. VRA

[51] Darwin Core standard—`http://rs.tdwg.org/dwc/index.htm`
[52] Federal Geographic Data Committee (FGDC)—`http://www.fgdc.gov/`
[53] National Spatial Data Infrastructure—`http://www.fgdc.gov/nsdi/nsdi.html`
[54] Content Standard for Digital Geospatial Metadata—`http://www.fgdc.gov/metadata/csdgm/`
[55] ISO 19115:2003—`http://www.iso.org/iso/catalogue_detail?csnumber=26020`
[56] Text Encoding Initiative (TEI—`http://www.tei-c.org/`
[57] VRA Core—`http://www.vraweb.org/projects/vracore4/`

Core 4 has, for instance, been officially endorsed by the METS Editorial Board (cf. section 8.2.1) in the meantime. [Vis13]

- There are, of course, also metadata standards for the wide area of the *arts*: The *Categories for the Description of Works of Art (CDWA)*[58], for instance, standardises the description of art databases by articulating a conceptual framework for describing and accessing information about works of art, architecture, other material culture, groups, and collections of works, and related images [J. 11]. Naming another standard, the Music Encoding Initiative (MEI)[59] provides *MEI schema*—a set of rules for recording the intellectual and physical characteristics of music notation documents [Mus13].

Social and Economic Sciences.

- Starting with social sciences, the *Data Documentation Initiative (DDI)*[60] is a metadata specification for the social and behavioural sciences allowing the documentation of metadata across the data life cycle. [DDI09]

- Providing an exemplary standard from the discipline of economic sciences, the field of data warehousing can be quoted. The *Common Warehouse Metamodel (CWM)*[61] proposes an XML format to interchange data warehouse metadata in distributed heterogeneous environments based on the CWM metamodel. [Obj02, p.1-1]

It should have become clear that there are a number of subject-specific metadata standards. However, the learners that PLIMS is designed for can learn and move within each of these disciplines. Standards described within this section are, therefore, too specific to be considered within the scope of this work.

[58] Categories for the Description of Works of Art—`http://www.getty.edu/research/publications/electronic_publications/cdwa/`
[59] Music Encoding Initiative—`http://music-encoding.org/`
[60] Data Documentation Initiative—`http://www.ddialliance.org/`
[61] Common Warehouse Metamodel (CWM)—`http://www.omg.org/spec/CWM/1.1/`

In summary, to facilitate the successful implementation of metadata structures for resources, the adoption of existing standards is a recommendation—or actually a "must" [BBF+02, p.20]. There are two standards that can be identified as the most important standards in general terms as well as for the scope of this work:

> *"The most popular metadata schemas [...] are the IEEE Learning Object Metadata [...] and the Dublin Core [...] standards."* [VMD07, p.90]

These two standards—Dublin Core (cf. section 8.2.1) and Learning Object Metadata (cf. section 8.2.2)—are, therefore, in particular reflected in the *index structure* for the storage of learning object metadata within PLIMS that will be described in the next section.

8.3 Deriving an Appropriate Index Structure for Learning Objects

In order to proceed to build a learning object repository, an appropriate index structure has to be derived for a simple reason: a uniformly constructed description that is available for every located resource eases the (re-)finding of (learning) objects and allows a faster proceeding to the actual goal of learning—that is the acquisition or emphasis of knowledge [NHD+04, p.269].

There are a number of projects and endeavours already concerned with building learning object repositories and, therefore, working on architectures and index structures for storing learning objects. To name just a few[62] [CF07, pp.273ff][Kno04, p.223f][McG06b, pp.223ff]:

▷ *Edutella*[63] is a peer-to-peer (P2P) project implementing an RDF-based metadata infrastructure for P2P networks that allows the exchange of *information about* learning objects. It is therefore just *"one piece in an e-learning infrastructure"* [NNP06, p.243]. [CF07, p.273][NNP06]

[62] The projects presented are just a small selection of projects established to develop metadata infrastructures for learning objects, learning object repositories, or infrastructure services. For a wider selection of projects see [CF07, pp.273ff], [Kno04, p.223f], and [McG06b, pp.223ff].

[63] The Edutella project—`http://www.edutella.org/edutella.shtml`

▷ Naming a different project, the *Multimedia Educational Resource for Learning and Online Teaching (MERLOT)* model[64] is a large collection of *links* to learning objects—on the one hand providing access to learning objects, on the other hand allowing the creation of personal collections of (links to) learning objects. [Kes06]

▷ In contrast to the previous projects, *EasyInfo* is an architecture actually based on a collaborative bookmark management system. The extended architecture referred to as EasyInfo builds on ontologies to manage learning objects and assist learners in finding relevant learning objects—also by providing personalised object recommendations. [CF07]

▷ As a more fundamental development in this area, the *Abstract Learning Object Content Model (ALOCoM)*[65] can be quoted. ALOCoM is a general content model differentiating content fragments, content objects, and learning objects [VD04, pp.205f]. These objects are subsequently described and classified with an ontological approach [VKM+04, pp.715ff] that has, for instance, also been implemented to enable the composition and decomposition of slide presentations [VJG+05].

▷ *ARIADNE* developed an infrastructure[66] for managing and storing metadata of learning objects. This infrastructure is realised as a distributed network of repositories that encourage the sharing and reuse of learning objects. The ARIADNE infrastructure, therefore, builds on LOM as centralised metadata standard and provides a federated search engine (and registry) that enables a search across a network of repositories, a finder for searching and publishing, a harvester allowing the collection of metadata from external resources, and a metadata validation service. [TVP+09]

As will be clear from this small selection of different projects, there is a variety of approaches and technologies that can be consulted and

[64] The Multimedia Educational Resource for Learning and Online Teaching (MERLOT) project—`http://www.merlot.org/`

[65] The presented project is actually just a small part of the contributions from this group. Generally a lot of interesting and inspiring work on metadata, learning objects, and learning object repositories can be found in Ariadne research group around Erik Duval—`http://hci.cs.kuleuven.be/`.

[66] The ARIADNE infrastructure—`http://www.ariadne-eu.org/content/services`

utilised to build an appropriate architecture. However the major percentage of those projects is concerned with the general collection of learning objects allowing a common (re-)use and are not focussing on single learners.

Accordingly, the derivation of the PLIMS architecture has to utilise a different foundation. For that reason, the theory that can be depicted as the design principle for PLIMS is introduced next to be able to reasonably explain and justify the derivation of the PLIMS architecture and its index structure.

8.3.1 The Cognitive Flexibility Approach as Design Pattern

The theory that this whole architecture mainly builds on is the *cognitive flexibility theory* in combination with *Random Access Instruction* as proposed by Rand J. Spiro et al. [SFJC92].

This approach is in particular suitable for PLIMS due to the fact that it is based on *constructivism* (cf. chapter 1.1)—which is also true for PLIMS. The cognitive flexibility approach is actually even *"doubly constructive"* [SFJC92, pp.64f]: in addition to the assumption that the comprehension of information requires the construction of an understanding by involving previous knowledge artefacts, this theory is based on the assumption that this previous knowledge is constructed of various sources as well.

Discussing specific details, the cognitive flexibility approach emphasises the real world complexity [SFJC92, p.57] and, at the same time, tries to resolve problems and failures that come with this complexity: conceptual *oversimplification*—also referred to as reductive bias—and the *inability to transfer* this knowledge to other opportunities—that is the adoption of just one and, as a consequence, restricting perspective. Both oversimplification and the inability to transfer knowledge, lead to the missing of important aspects and a loss of variability [SFJC92, p.66].

The cognitive flexibility theory therefore suggests a repeated consideration of content to be able to fully comprise the complexity and understanding of information as well as gain new insights [SFJC92, p.65]:

> *"[...] Revisiting the same material, at different times, in rearranged contexts, for different purposes, and from different conceptual perspectives is essential for attaining the goals of advanced knowledge acquisition."* [SFJC92, p.65]

In other words, the cognitive flexibility approach is in particular concerned with the acquisition of an understanding for important elements of conceptual complexity, the ability to use acquired concepts for reasoning and inference, and the competence to flexibly apply conceptual knowledge to novel situations [SFJC92, p.59].

To achieve this, the cognitive flexibility theory provides a number of recommendations—ranging from multiple organisational schemes for presenting a subject matter to multiple representations of knowledge [SFJC92, p.66]. PLIMS follows this theory by utilising a two-tier index structure—as already introduced in chapter 7.2—and that way, in turn, meets the claim that has been made by Spiro et al. [SFJC92, p.59]: the demand for a flexible learning environment that allows the presentation, utilisation, and learning of knowledge items in different ways and for different purposes. The application of the cognitive flexibility theory to flexible learning environment like PLIMS is referred to as *random access instruction* [SFJC92, p.72].

In summary, it is the demand for flexibility that justifies the two-tier architecture including basic and supplementary information. The combination of these two tiers ensures that a learner can benefit from this flexibility. Even though Spiro et al. suggest that this approach should in particular be applied in more advanced and, therefore, ill-structured[67] knowledge domains and learning scenarios, this index structure is still tenable. For the case of PLIMS, this suggestion or concern only implies a minor usage of the second tier for those more introductory learning objects—which is of course not the desirable scenario but also not a major problem preventing the building of the repository.

[67] According to Spiro et al. [SFJC92, p.60], an ill-structured knowledge domain is one that in which the following two properties hold: 1) each case or example of knowledge application typically involves the simultaneous interactive involvement of multiple, wide-application conceptual structures, each of which is individually complex and 2) the pattern of conceptual incidence and interaction varies substantially across cases nominally of the same type.

8.3.2 The PLIMS Index Structure

Proceeding to the construction of the PLIMS index structure, the appropriate technical realisation has to be chosen first. As already introduced in the previous sections, a basic description of learning objects can be achieved by utilising metadata elements. This is exactly the choice that has been made for PLIMS—as might be reasonably expected due the extensive previous consideration of metadata standards: a simple index structure based on metadata elements as attributes of learning objects builds the foundation of PLIMS architecture.

To be exact, the targeted aim of the PLIMS architecture is to present a well-defined mix of basic and richer metadata elements that allows the provision and utilisation of additional information comprised within those metadata descriptions. However, at the same time, PLIMS aims to overcome the troubles of adding metadata with lots of additional effort—that frankly no one will typically go through in their daily routine. It is for this particular reason that *RDF*—a technique that is most likely to be suggested for information modelling in the days of the expected rise of a Semantic Web [Krc10, pp.78f]—is not chosen as preferred implementation. The utilisation of RDF as designated modelling technique typically implicates an enormous effort—that would in the case of PLIMS have to be carried by one learner alone. Therefore, the simpler implementation of an index structure solely based on metadata descriptions as attributes for learning objects is chosen within the scope this work.

More precisely, the *LOM* standard has been chosen for the selection of metadata elements due to a simple reason: LOM is the one and most prevalent metadata standard in particular designed for learning. However as we have learnt in the corresponding introduction (cf. section 8.2.2), the LOM standard is already very comprehensive and the creation of metadata can be *"prohibitively expensive"* [Wil02, p.12]. For that reason the selection of metadata elements has to reflect a trade-off between the possible benefits of reuse and the expense of cataloguing [Wil02, p.12]. As a consequence, the PLIMS architecture is derived from a greatly reduced subset of the LOM standard.

Recalling the proposal and basic description of the PLIMS architecture in chapter 7.2, the design of the architecture is based on a two tier index structure (cf. figure 7.1, p.189) that will now be introduced.

Tier One: the Basic Index Level

The very basic foundation of the PLIMS architecture is reflected in the first tier of the index structure[68]. This first tier represents the general descriptive metadata on learning objects that is inevitably determined by the characteristics of a learning objects itself. This metadata information will typically be objective and not depend on an individual learner—even though manual contributions and alterations may add a personal touch to this metadata information.

As a consequence, this first index level stores all the *basic information* of a learning object by using basic metadata elements as shown in figure 8.1. More precisely, this level includes *descriptive*, *administrative*, and *structural* metadata elements [Mas06b, p.171]. All of these learning object attributes originate from the LOM standard; the serial numbers of the LOM elements are depicted as further information enclosed in brackets in figure 8.1. Additionally, most of these basic elements can also be found in DC standard. Namely, the elements that have been chosen to basically describe learning objects are the following ones:

- ▷ The *location* of a learning object is the unique identifier of a learning object within PLIMS.
- ▷ Of course, the *title* of a learning object should be extracted as essential characteristic of a learning object.
- ▷ Moving in an international environment, the *language* of a learning object can be stored as further description of an object.
- ▷ A more elaborate *description* of a learning object can be given by the utilisation of a conforming attribute.
- ▷ Trying to accumulate more technical, administrative information, the *format* of a learning object can be expressed accordingly.
- ▷ Finally, *copyright* information that may be able to regulate the possible re-use—for instance in collaboration scenarios (cf. chapter 10.1)—can be stored for every learning object.

[68] Parts of this section have already been published in [SH10b].

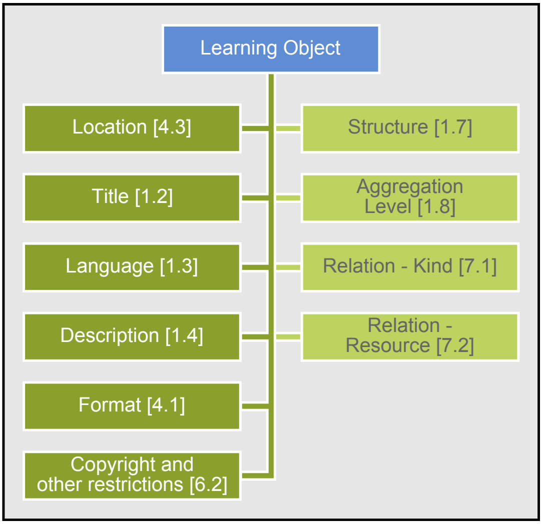

Figure 8.1: Attributes of learning objects stored in the first tier of the PLIMS architecture

Discussing the actual technical implementation, there are of course two more attributes that will be included in a corresponding implementation: the dates of *creation* and the last *modification*. Nevertheless, all of the elements cited in this list are either *administrative* or *descriptive* metadata information.

As suggested above, there is a third kind of metadata information that can be used—*structural* metadata information. Such information can, for instance, be used to facilitate a preservation of learning objects that goes beyond more or less arbitrary file delimitations (cf. chapter 9.2.3). To enable such a future structuring, four more attributes have been designed—but are not yet implemented:

- ▷ The *structure* attribute allows to record the underlying organisational structure of a learning object. As suggested within the LOM standard, this could for instance result in the classification of a learning object as atomic or collection. Furthermore, the *aggregation level* allows to capture the functional granularity of this object—that may be raw media data or a lesson.

▷ On top of this, the design of the PLIMS architecture already plans the intended extraction of relations between different learning objects. Such a relation can be formalised using the two attributes *relation - kind* and *relation - resource*.

Once again recalling the previous description of the PLIMS architecture, this single index level already constitutes the fundamental first tier of the index structure. However as maybe the most essential part of the PLIMS design, a second tier of supplementary metadata information is built upon this first tier to complete the index structure. Put another way, this second tier delivers what has been previously identified as richer metadata information [Duv01, p.591].

Tier Two: the Supplementary Index Levels

Assuming that the basic index level only contains objective, descriptive information, it is this second tier that finally allows the integration of subjective metadata information and, therefore, brings *personalisation* to PLIMS—which is one of the major design issues in building a *personal learning information management system*.

This design objective and the cognitive flexibility approach described above actually already provide a solid foundation for the addition of supplementary information in a second index tier. There are, however, more reasons to choose this design:

1) A general addition of metadata that goes beyond simple descriptive information on learning objects is, for instance, also suggested by Riina Vuorikari et al. [VMD07]. Vuorikari et al. propose the attachment of evaluation metadata—such as annotations, ratings, and other comments regarding the content—to express several quality aspects of the underlying learning object and to provide additional support for the re-use of learning objects [VMD07, p.90].

2) Psychology has revealed that there is a general problem for individuals in categorising items—in terms of deciding which categorisations to use and also in terms of remembering later what label was assigned to that categorisation [Lan88, p.55]. It seems, therefore, reasonable to not force the user into a strict non-

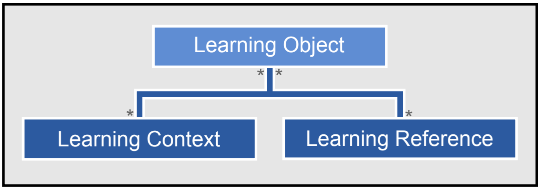

Figure 8.2: The combination of basic and supplementary information with cardinalities

individual classification scheme but to allow a personalisation of those classifications.

3) Finally, the three overarching principles of *personal anticipated information need* introduced in chapter 7.1.3 suggest that a personalisation of this supplementary information is essential because learners have different cognitive and affective responses to information—and, therefore, assimilate and evaluate information in differing ways. Therefore, *keeping activities* as an essential part of personal management activities have to reflect this *multi-faceted nature* of a learner's needs [Jon07, pp.27f].

Added together, all these arguments find expression in the implementation of a second personalised index tier within the PLIMS architecture. As already proposed in chapter 7.2, this second tier is composed of two components or index levels to allow the integration of two different kinds of information: *hierarchical information*—also referred to as learning context—and *non-hierarchical information*—that are learning references.

The connection of the fundamental information—that are the descriptions of learning objects in the first index tier—and these two different kinds of supplementary information draws the overall picture of the PLIMS index structure and is shown in figure 8.2. As depicted by the assigned cardinalities, a learning object can be attributed with any number of learning contexts and learning references. In turn, each learning context and learning reference is allowed to refer to any number of learning objects.

Learning Context as Hierarchical Information. First of all, before presenting reasons for integrating the learning context as hierarchical information, a definition of *contextual information* is needed:

> *"Contextual information is that extra, associated, related, assumed, and perhaps a priori information or knowledge that is required to meaningfully interpret the content of any given information source."* [McC00]

Although this definition comes from an archival or cultural computer science perspective—where a description of the creators of content is sometimes even more important than the actual content [Mas06b, p.173]—this definition is particularly suitable since it emphasis the general importance of *context information*. Jon Mason adds to this definition by specifying that—in addition to descriptive metadata or the *know-what* that is commonly extracted—the contextual information that ought to be considered is *know-how*, *know-when*, *know-where*, and *know-if* [Mas06b, pp.174f].

In addition to this already suggestive definition, there are a number of reasons that recommend the integration of hierarchical information referred to as *learning context* into PLIMS:

- ▷ First of all referring to the previous chapters, we have learnt that learning—even though self-paced and individually structured—is always embedded in a *social context* (cf. chapter 1.1.2). Exactly the same has been revealed for the information seeking process—that cannot be detached from a seeker's social context either (cf. chapter 6.3.1). Additionally, the definition of the personal anticipated information need also revealed that context is cruical (cf. chapter 7.1.3).

- ▷ Proceeding to reason the integration of supplementary information, the additional integration of hierarchical (as well as non-hierarchical) information can, interestingly, be traced back to a human's *semantic memory*[69] and differing theories of its representation. The theory arguing in favour of hierarchical information is the theory of *semantic networks*—that are networks

[69] The semantic memory is the system that is used to store our knowledge of the world. The semantic memory, therefore, depicts a human's knowledge base. [Can13]

representing semantic relations between concepts or nodes of a semantic graph [Sow92].

One of the first models implementing the concept of a semantic network is the *Teachable Language Comprehender (TLC)* that has been proposed by Allan M. Collins and M. Ross Quillian [CQ69][Qui69]. The TLC implements a model of the semantic memory that stores every word as concept in combination with a number of pointers to other concepts or words in the semantic memory [CQ69, p.240] and, that way, results in a *"richly connected network"* [Qui69, p.474]. In other words, TLC constructs a hierarchical representation of knowledge.

▷ More technically speaking and talking about context in general, Edward Cutrell and Zhiwei Guan conducted an eye-tracking study of information usage in web search and learnt that more context information—more precisely, snippets in the framework of web search—improves the search performance for *informational needs* (cf. chapter 6.2). [GC07, p.415]

In all honesty it has to be admitted that more context information actually decreases the performance for navigational information needs (cf. chapter 6.2). Cutrell and Guan, however, justify that this drop can be attributed to the fact that the context snippets distract searchers from the URL due to the structure of the results page [GC07, p.415]. Nevertheless, the findings of Cutrell and Guan are utilised as a general confirmation of the usefulness of context information.

Following the suggestions presented above, a hierarchical dimension for context information has been designed and created within PLIMS. However in contrast to the definition of a learning object and its attributes within the first tier, the reference to the LOM standard is established on the main level: a learning context can comprise the coverage of a learning object (LOM element "1.6")—that is the time, culture, geography, or region to which this learning object applies to—or the principal environment within which the learning and use of this learning object is intended to take place—referred to as context (LOM element "5.6") in the LOM standard [IEE15, pp.13,28].

A learning context itself is simply defined by its *name*, an optional *description*, and some administrative *date* information. Moreover to

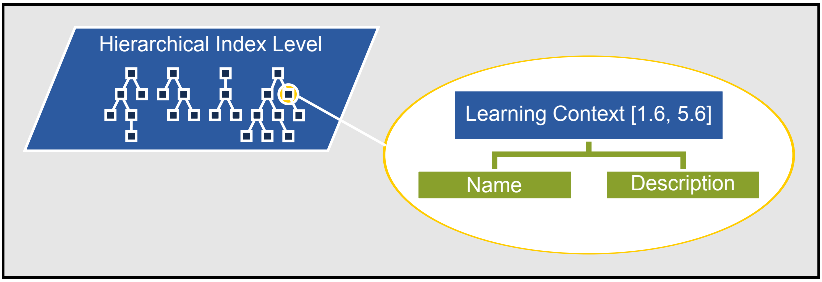

Figure 8.3: Learning context as hierarchical information in PLIMS

actually construct a hierarchy, an optional *parent context* can be assigned to each context. That way, this index level finally results in a simplified version of a semantic network or a simple taxonomy [GL10, p.60] as shown in figure 8.3.

In summary, this first index level of the second index tier actually builds *mono hierarchies* due to the fact that a context can just be assigned with one parent context. Most importantly this index level does not necessarily, however, build just *one* mono hierarchy but a number of parallel mono hierarchies. For that reason, this level also relates to the concept of *facets* and *faceted classifications*[70] [Arn06, pp.159ff].

Learning References or Tags as Non-Hierarchical Information. To complete the description of the PLIMS architecture, the second part of this supplementary tier is now presented: *learning references* also referred to as tags. In contrast to the also suggestive concept of annotations—that are notes made while reading and typically one or more sentences long [Wik13a]—a tag is the more appropriate foundation for learning references in PLIMS:

> *"A tag is a non-hierarchical keyword or term assigned to a piece of information [...]. This kind of metadata helps*

[70] Facets or a faceted classification allow for the description of elements from not just one but a number of different perspectives [Arn06, p.159]. For a further introduction of these concepts and their benefits see [Bro06]; for a further consideration of related concepts such as faceted search see chapter 10.3.1

> *[to] describe an item and allows it to be found again by browsing or searching. Tags are generally chosen informally and personally by the item's creator or by its viewer."* [Wik13j]

In contrast to the creation of hierarchies—such as those built in the first part of this index tier—tagging primarily emphasises the labelling of an information and not the preparation of a systematisation among those labels [Arn06, p.160].

There are, of course, also a number of reasons to facilitate the additional integration of this non-hierarchical information into the PLIMS architecture:

▷ Continuing the investigation of models for representations of a human's *semantic memory* that has been started above, the theory voting in favour of non-hierarchical information are the so-called *feature-based approaches*—where a feature is simply defined as distinctive aspect, quality, or characteristic [Far13b] that can either be essential and defining or accidentally characteristic [SSR74, p.214].

  The most prominent feature-based approach has been proposed by Edward E. Smith et al. [SSR74]. In contrast to semantic networks, this feature model depicts the semantic memory as being composed by a set of elements [SSR74, p.214]. In that way, even though including connections of concepts and attributes, Smith et al. propose a more loose structure of concepts than the one built by TLC.

▷ An interesting contribution to the design of learning references can also be derived from a study conducted by Thomas W. Malone [Mal83] who investigated the organising behaviour of office workers. Malone reasons that there are two different ways to physically organise information: *files* and *piles*. Where files are *"explicitly titled and logically arranged"* [Mal83, p.99] and hence structured, piles are *"very loosely characterised"* [Mal83, p.101] and therefore little structured. This loose characterisation can be achieved with the utilisation of tags.

▷ Examining the phenomenon of tagging as a whole, Gene Smith characterises tags as *"simple, flexible, and extensible"* [Smi08, p.202] and, that way, bridging three different disciplines: information architecture, personal information management, and social software [Smi08, pp.12f]. In conclusion, Smith suggests the inclusion of tags as complementary information to other information structures into the personal information management toolbox [Smi08, pp.193f,202]—among others because the assignment of tags also offers new ways of finding information (cf. chapter 10.3) [Smi08, p.3].

▷ In addition, there are several studies confirming the general usefulness of tags and the support that tags can provide to users in (re-)finding information: Riina Vuorikari et al. [VSPK09], for instance, investigated the usefulness of user-generated tags for the learning resource *metadata ecology*—where the term "metadata ecology" is used to describe the interrelation of conventional metadata and (social) tags as well as their interaction with the environment [VSPK09, p.408]. As a result, Vuorikari et al. revealed that tags can essentially enrich conventional metadata.

Others like Rune Hjelsvold et al. [HFNR10] examined the usefulness of student-generated tags as content-descriptive metadata. Most interestingly, this study also revealed that lecturers—that are experts in their field of teaching—and students—suggested to be new to the particular field of learning—tag differently [HFNR10, pp.75f]. As a consequence an enabling of individual tagging is suggestive.

▷ Finally, recalling the definition of (mashup) personal learning environments (cf. chapter 4.3.2), the integration of learning references into PLIMS follows the suggestion made by Sandra Schaffert and Wolf Hilzensauer: the integration of tagging opportunities with a focus on appropriateness for learning.

In summary, a combination of loose concepts and attributes enabling a less structured classification is transferred to design of the PLIMS architecture by the connection of learning objects and learning references. For that reason the PLIMS index structure is completed by an integration of non-hierarchical learning references. Just as for learning context, the reference to the LOM standard can be established on this main level: a learning reference is most similar to an anno-

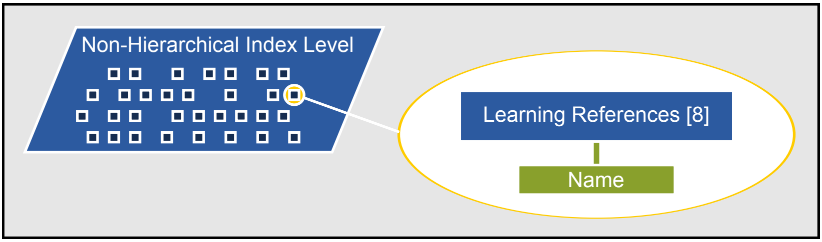

Figure 8.4: Learning references as non-hierarchical information in PLIMS

tation (element "8")—which is an unfortunate coincidence considering the separation of annotations and tags that has just been made above.

In accordance to the simplicity that tags have been designed for, a learning reference is simply defined by its *name*—as shown in figure 8.4—and administrative *dates* as for the previous information assets.

Technical Implementation: Transferring the Index Structure to Zotero

As already reasoned in chapter 7.2, the technical implementation of PLIMS has been realised as an extension of Zotero. Being a reference management system, Zotero already brings some functionality that is required within PLIMS too. The basic existing functionalities as well as the programmed extension forming the two tiers of the index structure are described next.

Building the First Index Tier. Zotero naturally already allows the collection and management of bibliographic items—that way building a learning object repository and the first tier of the index structure including learning objects.

More precisely, Zotero enables the inclusion of the following item types in its publicly available version [Zot13]:

- Classic bibliographic items namely *bill*, *book*, *book section*, *case*, *conference paper*, *dictionary entry*, *encyclopaedia article*, *hearing*, *interview*, *journal article*, *letter*, *magazine article*, *manuscript*, *newspaper article*, *patent*, *presentation*, *report*, *statute*, and *thesis*.

- ▷ Multimedia items such as *artwork*, *audio recording*, *film*, *map*, *radio broadcast*, *tv broadcast*, and *video recording.*
- ▷ New media items like *blog post*, *computer programme*, *e-mail*, *forum post*, *instant message*, *podcast*, and *web page.*

Therefore, as a first extension a *new item type learning object*—comprising the attributes as defined above—has been implemented within Zotero. Although some learning objects will actually be of one of the types presented above, it has been considered important to allow integration of learning objects in general—in particular to be distinguished from general web pages and documents.

Additionally, Zotero already processes text-based learning objects and creates a full text index such that PDF documents as well as web pages added to Zotero can be re-find easily (cf. chapter 10.3.1).

Building the Second Index Tier. Facilitating the organisation of the included bibliographic items, Zotero already features the addition of different types of supplementary information:

- ▷ First of all, every object within Zotero can be enhanced with *notes* that are stored as child nodes of a Zotero item. [Roy11a]
- ▷ Additionally a set of *tags* or keywords can be added to every Zotero item. Just as introduced previously, a tag allows a more detailed and yet brief characterisation of a Zotero item. [Roy06]
- ▷ Finally, Zotero items can be organised in so-called *collections* that allow the creation of groups of items. An item can be integrated into more than one group and groups can be nested. [Roy06]

Therefore as one of the *major contributions* of this work, the hierarchical dimension of *learning context* has been implemented into Zotero to allow the addition of a set of contextual information to Zotero items similar to the addition of tags for items.

As a result, the *extended Zotero* now additionally allows the assignment of one or more learning contexts to every bibliographic item—and also learning objects—within Zotero. The hierarchies of multiple learning contexts can easily be built and resolved applying common drag and drop functionalities. The general management of learning context can be achieved item-specific as well as across the system.

This integration, of course, implicates a number of advanced possibilities to enhance and access the repository of learning objects. At this point it is, however, just referred to chapter 10 in general and chapter 10.3 in particular for a further description of the opportunities that are facilitated by this integration.

To sum up, this chapter derived the architecture of PLIMS and introduced its implementation as a set of three index levels organised in two tiers. Having set this foundation, the question of how to actually build the learning object repository remains. A profound examination of this issue will be the subject of the next chapter.

9 Building the Repository

*"If you know absolutely nothing about a matter you can easily get a simple idea and act accordingly. However once you have started to collect a sprinkling of information, you are jeopardised. You notice how much you still do not know, feel the strong need for more knowledge, collect more information, and even more realise how little you know. [...]
The more you know the better you are aware of what you do not know."*

Dietrich Dörner [Dör03, pp.145f]

The technically supported management of information as achieved within PLIMS is also rephrased as *information processing*. Formally defining information processing—that is information processing in a broader sense—a number of process steps as shown in figure 9.1 can be identified: the provision, storage, and processing of information in a narrow sense [Naj01, p.46].

These phases of information processing can be employed to outline the further description of PLIMS and the structure of this and the

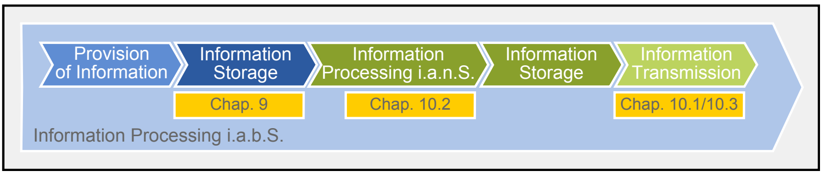

Figure 9.1: Information processing at a glance [Naj01, p.46]

following chapter: This chapter will be concerned with information processing in a broader sense and, thus, deals with the storage of information to build the repository of PLIMS. Subsequently, information processing in the narrower sense comprises the translation of information to a different form as well as transformations of information that connect information with existing information [Krc10, pp.98f]; this kind of information processing is the subject of chapter 10.2. Finally, the transmission of information is examined in chapters 10.1 and 10.3.

Nevertheless, although technically processing information it has to be recognised that ultimately it is the *human information processing* that determines the utilisation of information [GL10, p.76] and, therefore, primarily influences the information provision that leads to the storage of information. In conclusion recalling the personal management activities as defined in chapter 7.1.1 once again, building a learning object repository and, hence, processing information can partly be equated with decisions and actions that have been summarised as *keeping activities* of personal information management: the moment that information is encountered it has to be decided *if* and *how* the information is kept for a later usage, followed by appropriate actions to achieve this keeping. These keeping activities are essential to avoid *prospective memory failures* [Jon07, p.27] and that define the input for personal information collections such as PLIMS.

For that reason, this chapter describes the support of PLIMS in those keeping decisions and, most importantly, after those keeping decisions have been made—in keeping and storing information. To begin with, the *scope of learning objects* that can be integrated into PLIMS are examined—also in terms of validating the architecture that has been proposed in the previous chapter. Following this, *strategies to construct personal collections* as implemented within PLIMS are described.

9.1 The Scope of Learning Objects within PLIMS

First of all, to be able to build the repository and "fill the index structure" that has been described in the previous chapter, the different types of learning objects that are able to be included into PLIMS need to be determined. This section, therefore, specifies the scope of learning objects in more detail than already done in chapter 8.1. At the same time this section validates the design of the architecture and, in particular, the first tier of the index structure by illustrating that the selected metadata elements can be extracted from each of the learning objects that are aimed to be integrated—presupposed that metadata has been specified by the creator of a learning object.

Getting started, there are two different kinds of learning objects that can be integrated into PLIMS[1]: *basic* and *composite learning objects*.

9.1.1 Basic Learning Objects

The first group of learning objects that can be integrated into PLIMS are two different types of fundamental learning objects: *text-based* and *multimedia learning objects*. Referring to the taxonomy of learning objects introduced previously (cf. table 8.2, p.197), basic learning objects are either *b-simple*, *b-passive*, or *b-active* learning objects. The following listing, however, reflects the already signified focus on fundamental and combined-closed learning objects and, therefore, b-simple and b-passive learning objects.

To be able to actually verify the architecture more exactly, it is necessary to briefly consider the different formats of basic learning objects and their format-specific metadata standards.

Text-Based Learning Objects

Building on the distinction of text-based and multimedia learning objects, this section examines the most common text document file formats. Although this consideration is not claimed to be exhaustive, there are at least two prevalent file formats or types of learning objects that should be taken into account:

PDF Documents. One of the most common text-based formats today is the *Portable Document Format (PDF)*. PDF is, by now, an open standard for electronic document exchange that has also been formalised in an ISO standard[2] [Ado13a]. For that reason, PDF documents are most of the time actually the result of

[1] Parts of this section have already been published in [SH10b].
[2] ISO standard 32000-1:2008 —`http://www.iso.org/iso/catalogue_detail.htm?csnumber=51502`

the conversion from any other format to this platform independent format. Referring to the taxonomy of learning objects, PDF documents are either *b-simple* learning objects—if including just text—or *b-passive* learning objects—if the PDF document combines text and other multimedia objects.

Fortunately, basic metadata can simply be integrated as general file information and utilising document properties. Most of the time this metadata is, therefore, already automatically included in PDF documents so that it can be easily extracted. More precisely, the metadata elements already provided with these basic opportunities are *title* and a subject that can be re-used as *description*. As for every other following learning object type, the *location* and the *format* are constitutional. In addition, the document properties are also capable of containing a number of keywords, that could be extracted as *learning references* for the second tier of the index structure.

To capture metadata beyond this basic metadata information, there is a more powerful metadata standard that can be utilised in PDF documents—the *Extensible Metadata Platform (XMP)*[3]. XMP allows the inclusion of almost every desired information as a metadata attribute—for instance by utilising the DC standard—however by including it manually. In conclusion, XMP is the standard that needs to be employed for the direct integration of the missing first tier index level attributes *language* and *copyright*. [Ado13b]

Office Documents. Microsoft Office[4] is also one of the formats to be considered. Just like PDF documents, office documents might actually include other basic learning objects like images or videos and are, therefore, *b-simple* or *b-passive* learning objects depending on their composition.

[3] The Extensible Metadata Platform (XMP)is an XML-based format to represent more advanced metadata. For more information see `http://www.adobe.com/products/xmp/`.

[4] Of course, there are other office suites such as Apache OpenOffice—`http://www.openoffice.org/`. However due to their perceived prevalence office documents are examined using the example of Microsoft Office. Most of the findings can be simply transferred to other office suites, in particular if they utilise XML-based formats too.

> With the appearance of Office 2007[5], Microsoft switched from binary to XML-based file formats and started using the *Office Open XML Format* [Mic05]—that has in the meantime been formalised within an ECMA standard[6]. This foundation results in the automatic inclusion of metadata within the XML core, already utilising different metadata standards like the DCMI metadata terms.
>
> For that reason, the basic information selected within the first tier index level can be naturally integrated into Microsoft Office documents so that it too can be easily extracted. In addition to this basic information, keywords can also be provided and re-used as *learning references*.

Strictly speaking, PDF and office documents should perhaps be classified as composite learning objects since they might contain other basis learning objects. However since this composition is only optional and due to the common utilisation of these formats for the direct provision of learning material, both are considered as basic learning objects within PLIMS.

In addition to these two common formats, there are of course various other formats. One of the most important ones that needs to be mentioned is the (X)HTML format and, therefore, web pages. Due to their nature (X)HTML pages are, however, considered as *composite learning objects* within PLIMS and described in the next section. Another format that is in particular commonly used throughout the scientific community is *LaTeX*. Briefly examining this format, LaTeX documents are typically transferred into PDF to be provided to the targeted audience. As a result, LaTeX allows the definition of metadata information within the preamble of a LaTeX document. This metadata is, of course, also transferred to the resulting PDF document and can, therefore, be extracted from there.

In summary, the metadata elements selected for the first tier of the index structure and even some additional information that can be optionally integrated within the second tier of the index structure are

[5] The following explanations reference the newest version, Microsoft Office 2010—`http://office.microsoft.com/`.

[6] Standard ECMA-376—`http://www.ecma-international.org/publications/standards/Ecma-376.htm`

able to be provided within—and, hence, extracted from—text-based learning objects.

Multimedia Learning Objects

In addition to text-based learning objects, multimedia learning objects are obviously desired to be integrated into PLIMS as well. Multimedia objects are the truly basic learning objects and, therefore, *b-simple* learning objects as defined in the previous taxonomy. More specific, there are at least three different media types that need to be taken into account: *images* as well as *audio* and *video files*.

Images. Starting with images and their different formats, PLIMS focuses on *raster graphics*[7]. Trying to select the most common file formats for images, JPEG[8], PNG[9], and TIFF[10] have to be named. While each of this formats is technically specified differently, commonalities can be found when it comes to possibilities of specifying metadata attributes.

There are different metadata formats that can be utilised to integrate metadata information into images. The *International Press Telecommunications Councils (IPTC) Photo Metadata Standards* and the *Information Interchange Model (IIM)*[11] allow the integration of various information on photographs into the image files and the *Japan Electronic Industries Development Association (JEIDA) Exchangeable Image File Format (EXIF)* facilitates the storing of details on shooting the photo. Ultimately, the already introduced XMP standard is the most comprehensive metadata standard that can be utilised for the specification of almost every metadata element within images too. [Met11, p.18ff]

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[7] Raster graphics are images represented by a dot matrix data structure. For more information see `http://en.wikipedia.org/wiki/Raster_graphics`.

[8] The Joint Photographic Experts Group (JPEG) committee and standard—`http://www.jpeg.org/`

[9] The Portable Network Graphics (PNG) standard—`http://www.libpng.org/pub/png/`

[10] The Adobe Tagged Image File Format (TIFF) specification —`http://partners.adobe.com/public/developer/tiff/`

[11] The International Press Telecommunications Councils (IPTC) Photo Metadata Standards—`http://www.iptc.org/site/Photo_Metadata/`

To advance the interoperability of these different metadata standards, the *Metadata Working Group (MWG)*[12] developed a selection of the most important metadata fields—namely keywords, description, a number of date/time elements, orientation, rating, copyright, creator, and different location attributes [Met11, p.35ff]. Reconsidering the basic attributes of learning objects, *location*, *description*, *format*, and *copyright* are covered. The *language* attribute is typically not, or at least less, important for images and to finally fill the *title* attribute, a shortened version of the description may be used as substitute. Moreover, keywords can, again, be utilised as *learning references*.

Audio & Video Files. Proceeding to further important multimedia formats, audio and video files have to be considered as basic learning objects as well.

The *Moving Picture Experts Group (MPEG) formats* and the corresponding standards are surely the most prevalent formats in the world of multimedia formats. Where *MPEG-4*[13] is the current content standard, the standard from within this group that deals with metadata is *MPEG-7*[14]; the combination of both standards to encode metadata according to the MPEG-7 in MPEG-4 videos is referred to as MPEG-47. More precisely, MPEG-7 is a multimedia content description interface that enables the enhancement of different multimedia formats[15] with metadata information. The concept that facilitates the integration of metadata information are the so-called *descriptors* and corresponding *description schemes*. These schemes represent different functional areas—namely basic elements, content description and management, content organisation, navigation and access, and user interaction [MKP02, p.82]. As already obvious by this listing, this standard provides very comprehensive possibil-

[12] The Metadata Working Group (MWG)—`http://metadataworkinggroup.com/`

[13] The MPEG-4 standard—`http://mpeg.chiariglione.org/standards/mpeg-4`—and its formalisation as ISO standard ISO/IEC 14496—`http://www.iso.org/iso/catalogue_detail.htm?csnumber=55688`.

[14] The MPEG-7 standard—`http://mpeg.chiariglione.org/standards/mpeg-7`—and its formalisation as ISO standard ISO/IEC 15938—`http://www.iso.org/iso/catalogue_detail.htm?csnumber=34228`.

[15] Since MPEG-7 is a general standard for the description of audio-visual information, MPEG-7 can actually be applied to image file formats too.

ities that also include the basic possibilities selected within the PLIMS architecture.

To name another standard in this group and refer to different format, audio files using the MPEG-1 or MPEG-2 Audio Layer III[16]—that are commonly referred to as *MP3*—can, for instance, be enriched with metadata using *ID3* tags. ID3[17], short for "identify an MP3", is a defacto standard for providing additional information by including metadata at the beginning or the end of an audio file. Where the first version—ID3v1—only allows for a small number of metadata information, the second version—ID3v2[18]—is more powerful and, for instance, also allows an integration of images.

In summary, there are metadata standards for audio and video files that provide metadata to some extent and, therefore, enable the extraction of basic metadata. ID3 is, for instance, able to fill all the attributes that are classified as basic information in PLIMS—*location*, *title*, *description*, *format*, *language*, and *copyright*. Nevertheless, most of the time not all or only little metadata information is expected to be available for audio and video files.

This is, of course, just a very small selection of existing formats. Wikipedia[19] lists more than 1100 existing file formats. Nevertheless, the selection is supposed to cover the most common and most important file formats which are, for that reason, also most likely to be used for the provision of learning content.

In what follows, the scope of learning objects within PLIMS is expanded by the consideration of *composite learning objects*.

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[16] MPEG-1 or MPEG-2 Audio Layer III—`http://mpeg.chiariglione.org/standards/mpeg-2`—and the corresponding ISO standards ISO/IEC 11172-3—`http://www.iso.org/iso/catalogue_detail.htm?csnumber=22412`—and ISO/IEC 13818-3—`http://www.iso.org/iso/catalogue_detail.htm?csnumber=26797`

[17] ID3—`http://id3.org/`

[18] The current version of ID3v2 is ID3v2.4. The ID3v2.4 specification of native frames can be found at `http://id3.org/id3v2.4.0-frames`.

[19] List of file formats on Wikipedia—`http://en.wikipedia.org/wiki/List_of_file_formats`

9.1.2 Composite Learning Objects

In addition to basic learning objects, there are of course more complex learning objects that are build as a combination of basic learning objects. These learning objects are referred to as *composite learning objects*.

Strictly speaking, the text-based learning objects introduced above were already perceived as being able to integrate other basic learning objects like images. Those text-based learning objects are however always provided as single learning objects that are by nature not designed for an extraction of included basic learning objects or a separation of those different learning objects. As a consequence those text-based learning objects have still been considered as basic learning objects. Moreover, basic learning objects are by nature designed as local data—even though they might certainly also be provided via a network such as the internet.

In contrast, composite learning objects particularly refer to the *utilisation of the internet* as a major resource of information (cf. chapters 6.4.2 and 7.2). The composite learning objects primarily considered within PLIMS are, therefore, *(X)HTML documents* or web pages. Examining web pages as composite learning objects, there are two different kinds of HTML documents that need to be taken care of: 1) web pages representing "true" learning objects that are directly including learning content and 2) HTML documents depicting so-called *learning hubs* that are, therefore, providing of number of different learning objects.

Web Pages as Learning Objects. (X)HTML[20] is a *markup language* to describe the structure of web pages by employing so-called *tags*. The combination of text, markup tags, and other basic learning objects is, for that reason, far more obvious. Again referring to the taxonomy of learning objects, all of the HTML documents within this category can be classified as *b-active* or t* learning objects.

HTML documents generally allow the integration of metadata information within the head section of a document; since HTML5

[20] The, by now, still most prevalent version of HTML that has already formalised as W3C recommendation is XHTML 1.1—`http://www.w3.org/TR/xhtml11/`. The current version of HTML is HTML5—`http://www.w3.org/TR/html5/`—that is, however, only a candidate recommendation so far.

basic metadata elements are explicitly specified within the official recommendation. The standard metadata names include application-name, author, description, generator, and keywords [W3C17].

In addition, extensions to this predefined set of metadata names can be registered in the WHATWG Wiki on the MetaExtensions[21] page; by now more than 160 extensions for metadata elements have been registered. These extensions include a number of DC elements and, therefore, cover all *basic elements* and keywords that can be used as *learning references*. Actually, there even is a coverage attribute that could be re-used as *learning context* if specified. [W3C17][WHA10]

Web Pages as Learning Object Hubs. Furthermore web pages cannot only directly provide learning content and, therefore, be learning objects themselves but also act as *learning object hubs*. Learning object hubs are defined as web pages providing or linking to a number of different learning objects.

Actually a number of systems and, of course, every person interested in doing so is able to prepare a learning object hub. However learning object hubs that are in particular considered within the scope of this work are web pages generated and provided by *learning management systems*—which have also been identified as major information resource for learners (cf. chapter 6.4.2). With reference to the taxonomy of learning objects, these web pages can be classified as *t-active* or *w* learning objects*. In a strict sense, a learning object hub will however not necessarily be classified as learning object within this taxonomy at all since they are actually "just" providing a number of learning objects. Nevertheless, learning object hubs distribute a number of basic or composite learning objects and, therefore, need to be considered separately.

Learning object hubs have the ability to provide assistance in extracting metadata: Beyond metadata embedded within learning objects, course web pages serving as learning object hubs provide possibilities to enhance those learning objects by the extraction

[21] MetaExtensions registered in the WHATWG Wiki—urlhttp://wiki.whatwg.org/wiki/MetaExtensions

of additional metadata. More precisely, there are different opportunities to gain additional metadata from these learning objects hubs:

- ▷ Firstly, metadata that is provided by course web pages can be transferred and re-used as metadata for included learning objects. Unfortunately, course web pages automatically generated by learning management systems rarely, or at least sparsely, provide metadata.
- ▷ Secondly, the question of how learning management systems additionally incorporate metadata for learning objects rises. Just considering the two out of the most important ones—Moodle[22] and Blackboard[23]—a completely different behaviour occurs: where Blackboard allows the enrichment of learning objects with metadata while uploading the existing data into the system and even the customisation and implementation of metadata sets [Bla13], Moodle lacks possibilities for the integration of metadata[24] [Gra17].

All in all, even though opportunities to provide metadata may not be fully exploited, the least that learning object hubs do is to provide a number of different learning objects to be included in the PLIMS repository.

In summary, the different types of learning objects as outlined above set the scope of learning objects PLIMS is designed for. As already mentioned, this does not imply the impossibility of including other types of learning objects beyond this scope. However a learner might have to accept some shortcomings and less support when aiming for such an integration.

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[22] Moodle—`https://moodle.org/`

[23] Blackboard—`http://www.blackboard.com/`

[24] Actually there are considerations of integrating metadata into moodle and the extraction of metadata from Moodle. There is, for instance, a LOM application profile for Moodle courses—`http://docs.moodle.org/dev/Metadata`. However, so far, all of these considerations are just theoretical and not implemented within Moodle.

9.2 Strategies to Construct a Personal Collection of Learning Objects

Literally the next step after having set of the scope of objects to be included, is the actual integration of learning objects into PLIMS and, hence, the construction of the PLIMS repository.

According to William Jones there is a great variation in the methods of keeping and, hence, a variety of keeping activities that are likely to be performed [Jon07, pp.28ff]. As a consequence, PLIMS needs to flexibly support different strategies to construct a personal collection of information. For that reason the design of PLIMS includes three possibilities of integration along a scale of automation to build the repository; these *levels of integration* are described next. This conceptual description is, subsequently, followed by a brief description of the *technical implementation* of those possibilities in PLIMS. Finally, this section concludes with an investigation of opportunities to move *beyond predefined learning object granularities.*

9.2.1 Establishing Different Levels of Integration

On a conceptual stage, PLIMS is designed to allow the integration of learning content on three differing levels of automation—where automation is generally defined as the operation with minimal human intervention [Far13a]. A completely automatic construction and extraction is explicitly rejected due the fact that the subjective information need always requires the *active incorporation* of a learner (cf. chapter 6.1). Moreover, these three different ways with differing degrees of assistance are supposed to provide an ideal mix of *flexibility*, *support*, and still the *freedom of choice* for an individual learner[25]:

Manual Integration. First of all and by default, *learning content* can of course be *manually*—that is without automation—added to the repository of PLIMS. In other words, basic learning objects and simple composite learning objects as specified in the previous section can be added to PLIMS whenever a learners decides to keep a learning object for a later re-use. Certainly, this possibility

[25] Parts of this section have already been published in [SH09].

applies to local data as well as learning content that can be found on the Web.

Furthermore, the manual addition of supplementary information as stored within the second tier of the index structure is desired. *Learning context* as well as *learning references* can be manually added to every learning object within the PLIMS repository at any time while using PLIMS—that is at the point of time when a learning object is added or at any future date.

In addition, PLIMS has been designed to reduce the efforts that every learner has to put up with. Therefore, conceptually, PLIMS includes two different advanced levels of automation.

Active Learning Points. The first level of assistance for learners are the so-called *active learning points*. Apart from explicitly adding single files or web pages to the repository, the user should be allowed to define specific *points of interest* that are similar to a white list of web pages as, for instance, course web pages.

As a first step, those active learning points are recognised by PLIMS and can, therefore, more easily be integrated into PLIMS. That way, PLIMS also follows the suggestion to integrate components from a learning management system to a learner's personal learning environment [Edu09, p.1] and aligns to the identified major information resources. Building on this recognition of known web pages, an automated revisiting of those pages to periodically check on updates is included in the PLIMS design as second part of these active learning points. In addition to the handling of web pages, the same treatment should be possible for local folders.

With the realisation of these two steps, regularly performed learning actions can be employed to automatically collect the content of personal learning within the scope of PLIMS.

Active Learning Mode. Finally, as the highest level of automation, an active learning mode has been designed. This mode is, basically, supposed to inform PLIMS that the current activities of a learner are related to the achievement of a specific learning goal or learning in general and are, therefore, relevant for the integration into the PLIMS repository.

If this mode is enabled, all visited web pages are considered relevant after passing a *filter*. This filter is designed to validate criteria as specified by a learner and, therefore, matching his or her individual learning style. A criterion that should definitely be included is the passing of a certain time threshold that needs to be exceeded before a web page is considered for addition at all. Furthermore it is suggested that a white and black list of web pages is maintained that are either preferred to be added or excluded from addition.

Of course, the utilisation of this active learning mode as well as active learning points also facilitate the automatic extraction of supplementary information.

In conclusion, the design of PLIMS incorporates three different strategies to actually construct a personal information collection. The realisation of (parts of) these strategies within Zotero—that is the technical implementation achieved within the scope of this work—is described in the next section.

9.2.2 Technical Implementation: A Moodle Translator

Starting from the bottom up, the *manual integration* of almost arbitrary content and, in particular, the item types as listed in chapter 8.3.2 is already in place in Zotero. As already reasoned when introducing the index structure, all of the items within the Zotero repository can be enhanced with a number of different supplementary information—in particular learning context and learning references.

Further addressing the integration of learning objects to the extended version of Zotero, any local file can be integrated into the repository by including it directly or attaching it to a predefined item within Zotero. Of course, web content can also be included into Zotero.

For web pages the integration is however more variable. In a nutshell, there a different ways to include web pages into Zotero:

- ▷ The *manual addition* of web pages is easily possible from any connected browser. This one-click integration results in a new item of the type “web page” with a snapshot of the current version of this page attached to this new item. That way, the web page is also accessible for a full text search.

- ▹ In addition, a *semi-automatic addition* of registered and, therefore, recognisable web pages is possible. This integration works by utilising so-called *translators* that are integrated into Zotero. The recognition of a web page is shared with the user by displaying an icon next to the address bar of the browser. By clicking this icon, the user can initiate the transfer of a single item or multiple items recognised at the particular web page to the Zotero repository. If implemented, snapshots of the web pages to be integrated are transferred as attachments of these new items too.

Obviously, translators are a more complex facility to integrate learning content into Zotero and also the model that brings automation—as proposed in the previous section—to Zotero. For that reason, a new translator allowing the integration of course web pages using the example of Moodle has been designed within the scope of this work.

Basically, translators are *HTML scrapers* or, more generally, *screen scrapers*[26]. A number of different studies—such as [JCKQ08] or [VDIC04]—examine advanced ways of scraping information from web pages. However, translators in Zotero have been designed differently and determine a process to be followed when scraping web pages. A Zotero translator collects information from a recognised web page by following these (simplified) steps:

1) To recognise a web page, the implementation of a translator needs to specify the *target* it is aiming for by using a simple URL or an *regular expression*[27] that needs to be matched to the URL of a web page.

2) Once being recognised, the web page is analysed for known blocks or elements by applying *XPath[28] expressions* that have been de-

[26] A screen scraper, in general, is a program that collects data from the display output of another program to present it differently. A HTML scraper, obviously, searches through the code of a website and filters the desired information. [wis13]

[27] Simply defined, a regular expression is a pattern—that is a special text string—describing a certain amount of text [Goy03]. For an elaborate introduction to regular expressions see `http://www.regular-expressions.info/tutorial.html`.

[28] XPath is a syntax that allows to define parts of an XML document—and, therefore, also HTML documents—and to navigate through documents [W3S13]. An introduction to XPath, its principles, and its powerfulness can be found at `http://www.w3schools.com/xpath/`.

fined within each translator. That way, a translator cannot just process one but multiple recognised entities.

The utilisation of XPath expressions also explains why translators are particularly suitable and applicable for course pages. Since course web pages are typically created by a learning management system, those course web pages always follow a predefined structure that can be easily analysed.

3) Now that the web page has been disassembled into its pieces and different entities, the actual scraping starts. All information needed is collected by the *scraper* to be transferred to Zotero. Just to give an example, information that can be extracted from a page are headlines, text blocks, authors, tags, and a number of other information.

4) Finally a *new item* or multiple new items—matching the type of the extracted entities—are created. The attributes of these items are filled with information that has been extracted in the previous steps. Optionally a snapshot of the web page is attached to each item such that a full text search on the content of the web page is possible. In the end, all new items are transferred to Zotero, included into the repository, and with immediate effect available to the learner.

Following the previous decision to use Zotero as the basis of the implementation for PLIMS, the technical realisation of the strategies to build the learning repository as outlined above is characterised by the design of Zotero.

To give an example, one of the most prevalent learning management systems—Moodle—has been chosen to demonstrate the possible implementation of *active learning points*. More precisely, a recognition of Moodle web pages as *active learning points* has been implemented as Moodle translator within Zotero.

Scope of the Moodle Translator

To begin with, as just introduced, a regular expression is needed to be able recognise Moodle web pages. This, unfortunately, results in some restrictions: Moodle web pages can only be recognised if their URL contains the pattern “moodle”[29]. Moreover, to be able to understand the scope and functionality of the Moodle translator, a few facts on the structure of Moodle web pages have to be known: Moodle web pages are organised in sections of topics or weeks and each of these sections can contain an arbitrary number of *resources* and *activities*[30]—where resources can, obviously, be identified as the most important assets when extracting learning content.

The *Moodle translator* developed within the scope of this work fully covers all different types of resources—except from IMS content packages—and allows the extraction of the learning content represented by those resources to be included in the repository. The extraction of Moodle resources is either possible from a resources page—that is when viewing the resource separately—or from the course page where all resources are linked from—such that multiple resources can be transferred to Zotero at once. That way it is, for instance, possible to easily integrate a number of PDF documents that are provided within a Moodle course. In addition to the processing of resources, forum postings are also recognised and can, therefore, easily be transferred to Zotero as learning content. So, first of all, using the Moodle translator, all information needed to fill the attributes depicted as elements within the *first tier* of the index structure can be filled.

Secondly, the Moodle translator also tries to enhance the extracted items with supplementary information as designed within the *second tier* of the index structure. The extraction of supplementary information for course web pages is based on two facts:

1) A number of different studies and projects have shown that the classification of a document is heavily influenced by its intended use or purpose that may also be anticipated [Jon07, p.27].

2) To be able to re-use learning content, the similarity of the initial learning situation with the situation this content is applied to is crucial [SM04, p.55].

[29] This restriction can actually be easily overcome by adjusting the regular expression used to detect a certain Moodle web page. Nevertheless, it has to be admitted that manual effort is needed in order to cover all existing Moodle pages.

[30] The full list of resources—`http://docs.moodle.org/20/en/Resources`—and activities—`http://docs.moodle.org/24/en/Activities`—as well as an illustration each possibility can be found in the Moodle documentation.

For that reason, information found on the particular web page is re-used as supplementary information filling the second index tier of PLIMS:

Extraction of Learning Context. To be able to retain the context of learning resources, the context has to be located on the Moodle course or resource page. Since the translator is designed to be generic, there is not a large range of options to gain context from. For that reason, the basic structure of Moodle pages is used to extract the learning context.

More precisely, the *breadcrumb navigation*[31] provided on every Moodle page—no matter if a course or resource web page—is utilised as context information. In simple terms—and skipping some exceptions that have to be taken care of—the last part of this breadcrumb navigation is a short term of the course description that is supposed to describe the learning context. Additionally, this single learning context is trying to be split into a content-related and temporal context—that is the declaration of a term in the university context.

The learning context transferred to Zotero is, firstly, just plain. A learner can then, however, rearrange the hierarchies of all existing learning contexts using the interface of Zotero. If the same context is transferred again with another item, the hierarchies are recognised, retained, and re-used for the new learning item.

Extraction of Learning References. In addition to the determination of the learning context, the translator also tries to extract more loose information as learning references. There are different examinations of how to automatically extract *tags* or keywords—that are learning references in PLIMS—from the content of resources[32]. The Moodle translator, however, explicitly does not extract learning references from the content of learning objects since the content of those objects is searchable by utilising a full text search. Moreover, learning references—more than any other

[31] A breadcrumb navigation is a navigation allowing users to keep track of their location and the trails through a website or program—for more information see `http://en.wikipedia.org/wiki/Breadcrumb_(navigation)`.

[32] A good overview on services to automatically extract keywords and a comparison of different techniques is provided in [BVD10].

information of the PLIMS architecture—are supposed to bring personalisation to PLIMS and, hence, Zotero.

Therefore, the extraction of learning references is restricted to the extraction of a reference to Moodle as general *source system* and a reference to the specific source system—such as, for instance, "Virtueller Campus" that is the Moodle learning management system of the University of Bamberg[33]—if implemented within and, hence, recognised by the translator.

In summary, the implementation of the Moodle translator as described brings the first stage of *active learning points* to Zotero. Unfortunately, the framework of Zotero did not allow the implementation of the advanced second level as well as the implementation of an active learning mode. The general feasibility of an active learning mode has however been proven in [Sit09]. Nevertheless, the integration of an active learning mode into Zotero as well as the extension of active learning points to the advanced stage need to be subject of future work.

To complete considerations of how to build the repository within PLIMS, possibilities for enhancing the presented opportunities by moving beyond predefined learning object granularities when building the repository are now examined.

9.2.3 Beyond Predefined Learning Object Granularities

So far, all learning objects that have been considered within the scope of PLIMS are utilised as provided—that is by extracting information from the learning objects, relying on information provided in the environment of those learning objects, and using the learning objects in exactly the style and structure that they are offered. Hence, the previous considerations only apply to learning objects whose granularity is simply determined by the given file structure. To improve the quality and value of learning objects this section examines possibilities to move beyond these structures and, that way, also utilise and fill the additional metadata elements—*structure*, *aggregation level*, *relation - kind*, and *relation - resources*—as proposed in chapter 8.3.2.

[33]Virtueller Campus/Virtual Campus of the University of Bamberg—`http://vc.uni-bamberg.de/moodle/`

Trying to consider the structure of learning objects, three different types of structures between learning objects can actually be identified [LGH02, p.5][LHG11, pp.15f]:

- *Structural relations* reflecting the document structure,
- *relations of content* that are based on semantic interdependencies of learning objects,
- and *ordinal relations* resulting from a placement along a continuum such as a time scale.

Approaching the representation of those relations within PLIMS, some are actually already covered by the previous descriptions of functionalities within PLIMS or, respectively, Zotero. Starting bottom up, *ordinal* relations can be recorded using a corresponding dimension of learning context such as the dimension including all university terms of a student. In addition, the learning context as well as learning references can be used to emphasise relations that are traced back the *content* of learning objects. In conclusion, these two different kinds of relations are already covered within PLIMS and have been described previously. For that reason, the relations left to be examined that this section primarily deals with are *structural* relations.

Structural relations, in particular, apply to modularised learning content that is inherently structured in parts, chapters, or sections. An awareness or, even better, explicit depiction of these structures will also improve the results of information retrieval processes (cf. chapter 10.3) [LGH02, pp.5f]. More precisely, the structural relations between learning objects can be examined from two different angles:

Disassembling Learning Objects. One way of trying to express structural relations is the partition of learning objects or a drilling down of complex units. Learning objects provided in a higher granularity such as a course or a learning unit (cf. granularities of SCORM content components, chapter 8.2.2) can be broken up into a number of learning components or fundamental information objects [LGH02, pp.3f].

This basic disassembling of learning objects is achieved within Zotero—as technical implementation of PLIMS—by the utilisation of translators that are able to extract multiple items. That way a course is broken up into its essentials—the learning objects provided within a course. At the same time, the initial structure is retained by the application and retaining of the extracted learning context. In doing so—and in addition to the descriptions above—learning context can also be used to depict structural relations.

To accomplish an advanced disassembling, fundamental learning objects can be further divided by trying to extract logical parts of these learning objects or documents. To give an example, textual learning objects can, for instance, be dismantled using provided headings, an abstract, or chapters, and subsections as already proposed by Maristella Agosti et al. [ACG91]. To some extent, this fragmentation is also supported by Zotero. The automatic extraction of content from web pages tries to capture an abstract or a description of learning objects. A further automated division is, however, not yet implemented and needs to be the subject of further research and implementation.

Assembling Learning Objects. Examining structural relations from the contrary perspective, fundamental learning objects can of course also be assembled to higher granularities instead of being split. At a first glance, this assembling can be put into practise by the combination of learning objects to form larger units such as learning modules or learning episodes [LGH02, p.4].

Since PLIMS and Zotero classify as tools for personalised learning, a specific construction of larger learning units is explicitly not the targeted objective. However the implicit projection of compound and more complex learning objects [LGH02, p.6] is supported on two different ways: One the one hand this aggregation can, again, be achieved by the utilisation of learning references or tags—already existing within Zotero—and learning context—as described in PLIMS and implemented as enhancement to Zotero. One the other hand, Zotero per se allows a simple connection of related items such as book chapters and their parent volume or a research paper and references cited from [Roy22].

Concluding this examination, it has been shown that Zotero and its extended version PLIMS already provide a number of possibilities to express ordinal and structural relations as well as relations with regards to the content between differing but related learning objects. For that reason, additional metadata elements for structural information are, in particular, needed to depict structural relations from within document—such as chapters and sections. The technical extraction of those internal relations, therefore, needs to be subject of further research.

In summary, this chapter stretches the scope of learning objects that PLIMS has been explicitly designed for, explains strategies of how to actually build the repository by including those learning objects, and depicts the technical implementation of those strategies as extension of Zotero. Altogether this chapter provides a description of information storage as part of information processing in a broader sense within PLIMS and the assistance of PLIMS in keeping decisions of personal information management.

Moving along the pathway of information processing (cf. the beginning of this chapter) and further considering the different types of personal management activities (cf. chapter 7.1.1), the next chapter examines *information processing in a narrow sense* that relates to *m-level* activities in personal information management as well as the *information transmission* and *finding* activities to complete the description and characterisation of PLIMS.

10 Advancing and Accessing the Repository

> *"The utilisation of knowledge is not only another component [...] but rather constitutes the pragmatic purpose of any knowledge management activity that has to be accomplished to ultimately facilitate the management [...] of knowledge."*
>
> Katharina Schnurer, Heinz Mandl
> [SM04, p.54]

This last part of the proposal of PLIMS describes what happens after a learner has successfully built his or her learning repository using PLIMS. In other words, this chapter comprehends what is considered most important for personalised learning: the extensive utilisation—that is the manipulation, making sense, and using [Jon07, p.37]—of a learner's knowledge base. Since this utilisation is essentially unlimited and can be individually determined by each learner, this chapter selects three ways of *advancing* and *accessing* a learner's repository to describe the possible utilisation of the personal information previously collected.

In doing so this chapter brings together a number of disciplines that are connected by the design of PLIMS and also in many current research issues and trends. A field connecting such a number of different disciplines that is, therefore, connected to PLIMS, is the emerging discipline of *social information retrieval*. Social information retrieval incorporates findings from the fields of information retrieval, information filtering, human computer interaction, and the study of information seeking behaviour. Based on the Web as a dependency to fulfil information needs and problems coming with this dependency, social information retrieval steps up to support users with appropriate and effective information management [GF07, p.xiii]:

> *"Social information retrieval refers to a family of techniques that assist users in meeting their information needs by harnessing the collective intelligence of other users—their expert knowledge or search experience. "* [GF07, p.xiii]

Social retrieval systems can be found throughout the Web. They benefit from shareable and reusable evaluations such as for instance provided by reviews or annotations, and include techniques as social tagging, collaborative querying, social network analysis, subjective relevance judgement, and collaborative filtering [VMD07, p.87][GF07, p.xiii].

Since PLIMS has already been classified as an information retrieval system (cf. chapter 7.2.2) and social information retrieval systems are considered to be *"a new generation of information retrieval systems"* [GF07, p.xiii], a classification of PLIMS as social information retrieval system is also desirable. However so far, PLIMS is missing a pretty crucial ingredient to be justifiably characterised as social information retrieval system: the incorporation of communities. For that reason, this chapter brings communities (cf. section 10.1) and collaborative intelligence (cf. section 10.2) to PLIMS. Additionally more advanced ways to explore, utilise, and visualise objects and results of information retrieval systems are examined (cf. section 10.3).

More technically, this chapter deals with *information processing in a narrow sense* as well as the *transmission of information* that are implemented and seized in *finding* and *m-level* activities of personal information management. To derive the focus of this chapter and the three different ways of utilising knowledge further examined within this chapter, the dimensions of finding and re-finding information as proposed by William Jones [Jon07, p.23] and shown in table 10.1 can be employed: The first part of this chapter deals with *collaboration* in learning and, hence, information items from a public store that may or may not have been seen before (*B* and *D* in table 10.1). Subsequently, the *recommendation* of information items from within a learner's repository that seem to be new to a learner—at least in the context recommended—is approached (*C* in table 10.1). Finally, the last section of this chapter

An **Information Item** is...	from a **Personal Store**	from a **Public Store**
seen before	A	B
new	C	D

Table 10.1: Dimensions of finding and re-finding information [Jon07, p.23]

examines ways to *explore* known items in a learner's repository (*A* in table 10.1).

10.1 The Power of Communities: Collaboration in PLIMS

Collaboration[1] and social involvement are natural companions of learning. Collaboration is pervasive [Tat12]—it comes in many forms and ways and is, very often, implemented and performed unconsciously. It is, therefore, suggestive to try to benefit from these companions or aspects of learning in personal learning and personal information management too. This utilisation of collaboration in personal learning turns *personal information management* into *social information management* [Smi08, p.27].

To approach this transformation, this section first of all examines the *foundation* that has to be established to allow collaboration at all, followed by a more tangible discussion of the *art* to actually implement collaboration.

10.1.1 Establishing a Foundation for Collaboration

The foundation of every collaboration is the grouping of any number of people—of course at least two individuals—interested in and commit-

[1] Collaboration is closely related to computer supported cooperative or collaborative work (CSCW), communities of practice, and learning communities [ARLZ09, p.193]. For that reason numerous projects describing the implementation and realisation of collaboration in various scenarios and settings exist. Within the scope of this work, the examination of possible collaboration scenarios is, therefore, limited to the description of possibilities that can be supported by PLIMS in an advanced stage.

ted to doing something together. Obviously, this commitment to work together to create knowledge connects collaboration to the pedagogic concept of *constructivism* also shaping the design of PLIMS. Adding to this, *social constructivism* stresses that the shared representations resulting from the joint construction of knowledge within a collaborative educational setting are supposed to outperform what could have been reached by simply summing all individual contributions [SM04, p.60].

Even though this commitment may vary in its intensity and the number of involved people, it is common to refer to such a group as a *community*; the transfer of a real world community to a virtual environment results in a *virtual community*. Each individual within a community may contribute to its purpose either way and also take along whatever he or she finds to be of interest for further keeping and utilisation. In addition to the assumed gaining of new personal insights, participation in communities by sharing interests or contributing to collective efforts brings *social rewards* that can be just as meaningful as accomplished personal rewards [Smi08, p.27].

Building Blocks of Virtual Learning Communities

Further examining the forming of virtual communities in particular dedicated to the support of learning, Naomi Augar et al. [ARLZ09, pp.195ff] identified four critical *building blocks* for the development of *virtual learning communities*—that will, as a consequence, also have to be provided by PLIMS to allow collaboration:

Technology. To even allow the emergence of a virtual learning community, there has to be a *joint technology* available to all community members providing a possible shared space for the community and, most importantly, communication amongst the members of this community. [ARLZ09, pp.195ff]

PLIMS depicts this shared technology and workspace that is supposed to generally allow the development of groups or communities.

Facilitation. Building on this technical foundation, the important process of guiding learners can be named as key aspect of successful virtual learning communities. Augar et al. suggest the facilitation of virtual learning communities by an instructor along Gilly Salmon's five consecutive steps of e-moderating:

1) access and motivation, 2) online socialisation, 3) information exchange, 4) knowledge construction, and 5) development. [ARLZ09, pp.197ff]

Being explicitly designed for personal learning, PLIMS does not rely on the mediation of an instructor. Nevertheless, supporting the active role of a learner, PLIMS also fosters the accomplishment of those steps listed above—in particular the *access* to personal information through PLIMS, the *knowledge construction* that is enabled by using PLIMS, and the personal *development* of individual learners. In addition, *information exchange* is what is facilitated by a future implementation of collaboration within PLIMS.

Social Context. The identity and behaviour of members of a virtual learning community as well as rules shaping this behaviour form the social context and the identity of a community. This social context, therefore, allows the development of social bonds and trust that are both essential for collaboration. [ARLZ09, p.199]

To successfully enable collaboration, PLIMS has to facilitate the development of such *socials bonds* and the corresponding *trust* that both build the foundation of every virtual learning community by supporting communication between learners.

Shared Learning Goal. Finally, collaboration and, hence, communities need a shared goal be able to develop at all. At best, this goal is clear and apparent to all community members. [ARLZ09, pp.199f]

As a consequence, PLIMS has to allow the building of groups of learners centred around differing interests.

In summary, it is the design of PLIMS—based on the theoretical foundation (cf. part I) centred around learners actively constructing and managing knowledge—and its provision throughout the community of learners that represent the technology to allow and, hence, facilitate collaboration. However to successfully enable collaboration, PLIMS in particular has to allow the communication of groups of learners centred around differing interests.

Systems for Collaboration: Social Software

Since PLIMS has, so far, only been designed to be used locally by one individual at a time, the implementation of collaboration requires steps to transfer PLIMS to an *ubiquitous environment*[2] that cannot only be accessed by an individual but by a number of people as, for instance, a group. The first step[3] towards an ubiquitous environment that is also required to enable collaboration is the transfer of PLIMS from a piece of software that can only be used locally to a software system that can be accessed from multiple devices utilising the internet.

The category of systems enabling such a joint access is commonly referred to as *social software*. In brief, systems classified as social software facilitate human communication and collaboration that typically occurs *self-organised* and bottom-up [Bäc06, p.121]. More precisely, the group of social software systems embraces systems supporting three different kinds of management—information management, identity and networking management, and interaction and communication management [KR09, p.12]. These three categories of management tasks, in turn, result in three crucial aspects describing social software: 1) an active information and knowledge exchange, 2) social networking, and 3) the collaborative construction and processing of content [Dre08, p.7]. More narrow definitions of social software emphasise the connection of people that is facilitated by social software—in contrast to programs simply connecting data [Bau06]. That way, the advent of Web 2.0 and the rise of social software rekindle what has been previously examined as *collaborative software* or *groupware* [RK07, pp.1,8ff][KR09, pp.12f].

Discussing common functionalities of social software systems, Michael Koch and Alexander Richter suggest the re-use and transfer of the acronym *SLATES*—defined by Andrew McAfee [McA06] and previously introduced to describe the phenomenon of *enterprise 2.0* (cf. chapter 3.2.3, p.96). According to this definition, social software

[2]The term “ubiquitous” refers to something that occurs in many settings and scenarios and is therefore perceived to be omnipresent [Far13d]. *Ubiquitous computing* describes the omnipresence of technical devices that, in turn, results in a paradigm shift from the utilisation of technical devices as tools to omnipresent information processing [Sie].

[3]Even though considering first steps, a comprehensive transfer to an ubiquitous environment will not be achieved within the scope of work since this conversion would require the additional consideration of mobile learning scenarios.

systems generally provide one or more of the following functionalities [McA06, pp.23ff][KR09, p.14]:

- *Search*—allowing to easily (re-)find and access information and contributions of users
- *Links*—that is additional information and connections that can be utilised to provide added value
- *Authoring*—describing the facilitation of contributions by users
- *Tags*—allowing the individual categorisation of content and improving find-ability
- *Extensions*—that emphasise the modular design of social software applications
- *Signals*—enabling a notification of users for updates and new content

As a consequence, social software depicts one important foundation of *user-generated content* in communities. Social software is generally freely available for potential users and employs the Web as communication means [Bäc06, p.121]. In concrete terms, social software summarises tools such as forums, wikis, blogs, instant messaging applications, social bookmarking tools, and social networking software [Bäc06, pp.122ff][RK07, pp.11ff].

Obviously, PLIMS and its carefully considered design explicitly support the tasks summarised as *information management* as well as *self-organisation* and *active* learners. More precisely, PLIMS enables *tagging*, the creation of *links* between different content assets, *searching* through acquired content, and, at least partially, the *authoring* of content. The conceptual integration of collaboration, therefore, transfers PLIMS into a social software system.

More precisely, the type of application from within the wide area of social software systems that PLIMS relates to most are *social bookmarking* tools[4]. Social bookmarking, generally speaking, allows the

[4] The maybe most familiar social bookmarking websites are BibSonomy (`http://www.bibsonomy.org/`), Delicious (`https://delicious.com/`), and Mister Wong (`http://www.mister-wong.com/`). Nevertheless, there is a considerably larger number of existing social bookmarking tools.

gathering, categorisation, and sharing of links that may be of interest for an individual or a group of people. In addition, social bookmarking websites are supposed to support the tagging and annotation of bookmarks collected as well as the connecting to other users of the social bookmarking system [Bäc06, p.123]. As already obvious by this short description, analogue or very similar functionalities are provided by PLIMS. Most importantly, PLIMS adds to these functions by actually gathering not just links but the content that can be found within those learning objects collected and providing a full text search (cf. section 10.3.1).

10.1.2 The Art of Collaboration

A number of models to differentiate and classify the various types of collaboration have been proposed. In particular leaning on the area of collaborative information seeking and retrieval, different forms of collaboration can be distinguished by the *intent*—that can be either implicit or explicit [GPB09, p.1]—the *concurrency*—precisely, synchronous or asynchronous collaboration [Rod91, p.320]—the *location* of collaboration—that may be co-located or distributed [Rod91, p.320]—as well as the *means of interaction*—that can either be document-related or human-centred [HJ05, pp.1110ff]—or the *depth of mediation*—that my occur on a user interface level or be reflected in underlying algorithms [GPB09, p.2]—when collaborating [Tat12].

The *three circles of collaboration* proposed by Tyler Tate [Tat12] and shown in figure 10.1 incorporate and combine all of these dimensions. Again, this model actually describes collaboration in search. Since PLIMS is a system fostering information management—which explicitly includes the seeking and search for information—it is however felt that this model appropriately depicts collaboration within PLIMS. Further elaborating this model, collaboration can take place in three differing circles—the *inner circle*, *intermediate social circles*, and the *outer circle*:

A list of social bookmarking tools can, for instance, be found at http://en.wikipedia.org/wiki/List_of_social_bookmarking_websites or http://www.searchenginejournal.com/125-social-bookmarking-sites-importance-of-user-generated-tags-votes-and-links/6066/

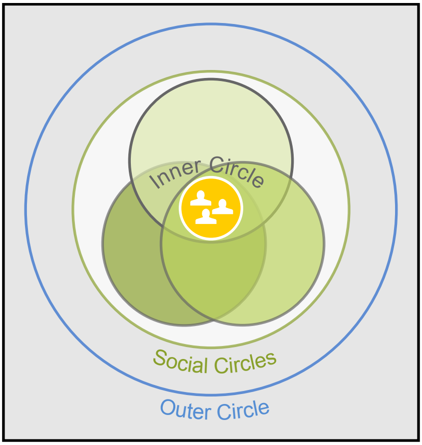

Figure 10.1: Circles of collaboration [Tat12]

The Inner Circle depicts the *nucleus of collaboration* and groups one or more participants, users, or learners sharing a *task*, *organisational*, or *personal goal*. It is this common ground that motivates the establishment of such a circle of collaboration. However even though sharing a goal, the *information needs* of people within this inner circle are not necessarily identical.

To actually implement collaboration within this inner circle, three different strategies can be pursued [Tat12]:

- Collaboration can be achieved adopting a *divide-and-conqueror strategy*—that is a distribution of subtasks among all participants and a reporting of the result back to the collaboration group.
- As an alternative a *brute-force approach* where each collaborator acts individually can be implemented. To actually work together, all participants share their individually collected findings subsequently to these individual explorations.
- Finally, working together can also be performed choosing a *back-seat driver method*. Doing this, all members of a col-

laboration group physically gather around a single display and directly work together.

Each of these approaches, of course, has its peculiarities. Where a brute-force approach is likely to lead to duplicated efforts, the back-seat driver method easily results in frustration due to the need to compromise on the direction and pace of efforts. For that reason, no strategy can be generally preferred over another but the choice has to be left to each collaborative group. [Tat12]

Intermediate Social Circles are surrounding the inner circle of collaboration and describe the next level of collaboration. An intermediate social circle usually groups around a *shared interest*. That way, intermediate social circles form a social source of information that might be consulted from within the inner circle. More precisely, different studies have revealed that people turn to their intermediate social circles for a number of reasons: answers to questions, references to other sources of information, a rephrasing of the problem, validations of a developed plan, and the legitimation from a “respected person” [CS04, p.449]. [Tat12]

The Outer Circle finally includes all collaboration that occurs outside the two previously introduced types of circles and, therefore, primarily describes *unintentional* and *implicit* collaboration between strangers. In fact, collaboration in this outer circle is broad, widespread, and can be very vaguely. Tate even considers the utilisation of *behavioural clues*—such as query reformulation, ratings, or recommendations (cf. section 10.2)—to be classified as collaboration within this outer circle. [Tat12]

In addition to this basic implementation, the model also includes a number of permutations: The inner circle of collaboration can, for instance, also just contain a single individual or learner—a fact that particularly recommends the utilisation of this collaboration model for PLIMS. Moreover, techniques actually located in the outer circle may be applied to intermediate social circles to allow the provision of personalised search results. [Tat12]

In summary, these three circles can be utilised to describe the range of possible collaboration scenarios. The design of PLIMS, in particular, facilitates the first and most direct kind of collaboration—that is collaboration occurring in the *inner circle* of this model. The description of collaboration within this inner circle is, therefore, the subject of the next section, whereas the second section gives an outlook on collaboration scenarios rather located within intermediate social circles.

The Nature of Basic Collaboration in PLIMS

As we have just learnt, the foundation of collaboration and, hence, every social software system is a shared workspace, the successful forming of *groups*—the seeds of communities [Smi08, p.27]—and, subsequently, collaborative efforts to achieve either quite similar goals of cooperating individuals or a shared (learning) goal.

For that reason, PLIMS has to facilitate the forming of groups that can share a workspace, learning goals or interests, and, most importantly, communicate with each other.

The Forming of Groups for Collaboration. To actually implement collaboration, two different *strategies for collaboration* can be employed: the *active participation* in groups or a more *passive involvement* that does not explicitly imply the active engagement with other learners [Smi08, p.27]. As a consequence, these two opposed strategies or natures of collaboration have to be taken into account when forming groups and developing collaboration scenarios.

Active Social Participation. First of all, an *active social participation* requires an active construction of groups. In other words, groups for collaboration form as a result of learners' actions. These actions are typically based on a previously established connection or some kind of relationship between learners. Being precise, there are three different kinds of connections that can be utilised to *form groups* and seed communities:

- ▷ To begin with, groups can develop based on *real world relationships.* Learners knowing each other—due to the joint pursuing of an educational degree, some shared learning goal, or by any other private or professional relationship—transfer this real world connection to another level by creating a virtual learning group and commit to helping each other in any way.
- ▷ Moreover, groups can obviously form based on connections of learners that have been established in the *virtual world*

but do not exist in the real world—due to geographical distance or other reasons. Just as learners are able to meet in the real world, likewise connections can be constituted in the virtual world. To cite an example, learners can meet in forums that have been set up to support formal virtual learning programs or when searching for specific topics and opportunities to exchange and interact with fellow learners on these topics.

- ▷ Finally, groups of users or learners can be connected by the underlying social software system due to characteristics, commonalities, or similarities known by the system. Considering the case of PLIMS, connections to other learners can be formed based on each asset within a learner's repository. Given that a learner stores his or her learning objects, learning reference, and learning context within a global workspace, PLIMS—or any other social software—may suggest the creation of learning groups based on joint information assets. PLIMS can, for instance, suggest the forming of a group to learners sharing a certain number of learning objects, learning references, or learning contexts—just as social bookmarking systems connect users sharing the same bookmarks [Bäc06, p.123][RK07, p.23].

  Even though this third option for the creation of groups is not pro-actively triggered by learners it leads to active social participation. Groups explicitly form and collaboration subsequently occurs within these groups. The system-supported connection of users is for that reason introduced as additional option for the creation of groups.

Of course, connections cited above are not mutually exclusive and groups can also form based on more than one connection.

Passive Social Involvement. In contrast to this proactive engagement of learners in collaboration, *passive social involvement* explores wider possibilities for cooperation among learners. In addition to an active engagement with fellow users or learners, social software, social bookmarking systems—and as a consequence PLIMS—also offer more indirect opportunities for collaboration and the implicit creation of groups of learners.

- ▷ Just as it is accomplished as third option of grouping for an active social participation, learners can be implicitly grouped using the joint information assets within a global workspace accessible by the underlying social software system. In contrast to the active participation, those connections can also be used unconsciously without a learner noticing.

  If used that way, the system employs the connections for individual *recommendations* to a learner (cf. section 10.2). Further elaborating, different kinds of recommendations are conceivable: PLIMS can, for instance, suggest learning references or learning context that have been assigned to a certain learning object by other learners but not by the learner him- or herself. In addition, PLIMS can also suggest new learning objects that are not part of a learner's repository but of the repositories of fellow learners and have been assigned with learning references or learning context within a learner's repository.

This passive involvement results in what Gene Smith [Smi08] defines as *object-centred sociality*—that is the focus on media or learning objects in a repository or a network of repositories in contrast to a focus on individuals such as emphasised in social networking websites. Learners are able to have a social experience without consciously knowing and interacting with each other but due to a shared interest recognised by a system like PLIMS. [Smi08, pp.182f]

Once these groups have been formed, learners can actively or implicitly work together, exchange information, and interact with each other to mutually contribute to the achievement of learning goals within these learning groups. To elaborate the actual support that learners can provide amongst themselves, the different kinds of information collected in PLIMS are employed.

Sharing Learning Objects. Within a defined group, learners can of course simply work together and share learning objects that each of them acquired. To actively share learning objects, learners may simply add learning objects to a shared group workspace or explicitly suggest learning objects to individual group members—as, for instance, also supported by the social bookmarking system Delicious [RK07, p.25]. A more passive collaboration can be achieved as already described as passive involvement above—that is by utilising underlying connections and, for instance, the suggestion of new learning objects for a learner by PLIMS due to a shared learning reference with a fellow learner.

Additionally learning from functionalities provided by social bookmarking system [RK07, p.25][Bau06], PLIMS can display fellow learners sharing a learning object when viewing a certain resources within a learner's repository and allow the navigation through the repositories of these fellow learners based on this connection to combine passive and active engagement.

At this point, a brief consideration of the important *privacy* and *security issues* is indicated. In particular in personal information management, the control of access to information as well as a guided distribution of information is essential [Jon07, p.38]. However instead of applying complicated systems—such as the *digital rights management (DRM)* technology that has, for instance, been transferred to the context of educational resources by Shujuan Wang and Qingtang Lui [WL08]—PLIMS aims to adopt a more simple strategy to allow an individual access control as well as guided sharing and passing on of information.

To adapt PLIMS for collaboration, the *Creative Commons (CC)*[5] licences are utilised. The CC organisation provides a set of free and easy-to-use copyright licenses allowing a controlled sharing, utilising, and composing of copyrighted work [Cre13a] that are used widespread throughout the internet in various domains; the existing licenses are listed in table 10.2. With PLIMS understanding these licenses, learners may simply use the intended field "copyright and other other restrictions" already provided in the PLIMS architecture (cf. figure 8.1, p.226) to specify the desired clearance level of learning objects and, that way, approve or reject the sharing of their learning objects. To fully cover the range of possible releases to fellow learners, an additional option preventing the sharing of a learning object needs to be included.

In this manner, PLIMS is able to provide a simple but flexible access control for original and imported learning objects without requiring the derivation of a complicated system by every single learner or group

[5] Creative Commons—`http://creativecommons.org/`

Token	Characteristics	Description
CC BY	Attribution	This license allows the redistribution, remixing, tweaking, as well as the building of own commercial and non-commercial work based upon the object shared under this license—as long the original creation is credited.
CC BY-NC	Attribution, Non-Commercial	This license enable a remix, tweak, and building upon the work licensed for non-commercial purpose—again, as long as the original work is acknowledged.
CC BY-ND	Attribution, No Derivations	This license permits the utilisation of objects commercial and non-commercial redistribution but require the passing on of the original object unchanged, in whole, and with credit to the creator.
CC BY-SA	Attribution, Share Alike	This license is similar to the *CC BY-NC* license but also allows the utilisation of the licensed work for commercial purposes as long as the new creation is licensed under identical terms.
CC BY-NC-SA	Attribution, Non-Commercial, Share Alike	This license is, basically, similar to *CC BY-SA* but only allows the utilisation for non-commercial purposes.
CC BY-NC-ND	Attribution, Non-Commercial, No Derivations	This license is the most restrictive one. It only allows the downloading, basic using, and sharing of the licensed work when crediting the original creator. Neither changes nor commercial use are permitted.

Table 10.2: The CC licenses [Cre13b]

of learners—in turn leading to the requirement for sophisticated algorithms or manual efforts matching these clearance levels. Since CC licenses are also used throughout the educational domain, learners using PLIMS may also easily rely on free educational content complementing their repository.

Social Tagging and the Social Development of Context Hierarchies. Continuing the examination of collaboration, one of the benefits of the index structure proposed as foundation of PLIMS becomes apparent and can be exploited to enable collaboration.

Starting more general, the maybe most familiar opportunity for collaboration is the so-called collaborative or *social tagging*. Social tagging *"describes the process by which many users add metadata in the form of keywords to shared content"* [GH06, p.198]. Rune Hjelsvold et al. have revealed that learners in general consider it useful to be able to see and explore tags of fellow students [HFNR10, p.77]. Moreover, this sharing of tags assigned to resources, in turn, facilitates the joint exploiting of an information pool as well as the discovery of new objects and perspectives [RK07, p.23]. As a consequence, *social tagging systems* are systems supporting the assignment of tags as well as the utilisation of these tags for navigation or search (cf. section 10.3.1) [Heu08, p.13]. In consideration of the overall design, PLIMS can also be described as a social tagging system. The process of social tagging can, for that reason, be utilised and adopted for the social development of learning references and learning context.

In more detail, the network of terms resulting from social tagging is referred to as *folksonomy*[6] [VK09, pp.1f]. Put simply, a folksonomy has two essential characteristics [Smi08, p.82]:

1) As maybe its most crucial aspect, the tagging leading to the folksonomy has to be performed independently and allow users to freely assign tags just as desired. [Smi08, p.82]

2) To actually create the folksonomy all tags are subsequently aggregated and relationships between tags are inferred whereas the application of any inference method is valid. [Smi08, pp.82f]

[6] The term "folksonomy" is actually a linguistic game mixing the two terms "folk" and "taxonomy" [Bäc06, p.123].

Folksonomies, that way, represent triples consisting of a user, the resource or learning object tagged, and the tag or learning reference itself [VK09, p.2]. The aggregation of this information by creating a folksonomy from the publicly available information in a system can obviously provide valuable information and the potential of *"more sophisticated avenues for resource discovery across contexts"* [VK09, p.12] to each individual user or learner. Basically, the same procedure can also be applied to learning contexts that are similar to hierarchical tags[7].

More precisely, learners can employ learning references or the learning context of other learners presented within a folksonomy to be of assistance in various cases:

Recommendation for Annotations. The individual annotations—that are learning references and learning context—of a learning object can be improved based on the information within such an implicit or explicit folksonomy. This improvement, in turn, influences the quality of the aggregated information within the system. [Smi08, p.27][Bäc06, p.123]

Actively working together in groups, learners may suggest learning references and learning context for shared learning objects—that way improving each learner's repository of learning objects. The same can, of course, be achieved through a passive social involvement when additional learning references or context are suggested by PLIMS—based on what PLIMS knows about learning objects through other learners.

Navigational Aid. Learning reference and learning context can be used as *navigational aids* (cf. section 10.3.1) to the discovery of new learning resources [VK09, p.3]. That way, learning reference and context help to further explore topics already covered in a learning repository or a learning group [Smi08, p.27].

More precisely, based on learning references and contexts used by a learner, PLIMS may suggest additional learning objects tagged or annotated with the same learning reference or context by other learners. This suggestion can, of course, also be provided proactively by a fellow learner from within a collaboration group.

[7] A hierarchy of tags referred to as hierarchical tags has, for instance, been described by Gene Smith [Smi08, pp.198f]

Social tagging does, of course, also have its pitfalls. A simple matching of tags to create a folksonomy quickly reaches its limits due to differing spellings, divergent numbers, the utilisation of different languages, synonyms, or varying compositions of groups of words [RK07, p.24][Heu08, p.15]. The same problems become apparent when utilising tags—or learning references and learning context—for navigation and search purposes [Heu08, p.15].

Nevertheless, social tagging and its variations are one of the most important starting points for collaboration in PLIMS. In addition, there are already several examinations and proposals to cope with these problems—such as [EACV09]—that could be taken into account for a future technical implementation of advanced support for collaboration in PLIMS.

Technical Implementation: Collaboration in Zotero By nature, Zotero already provides a shared workspace that allows collaboration in pro-actively formed groups. More precisely, Zotero supports the creation of groups of three different types: 1) private groups allowing collaboration without *"creating a public face"*, 2) public groups with a closed membership that only allows authorised access to the group environment, and 3) public groups with an open membership where everyone interested can simply join. Within these groups collaboration can take place and group members can interact with each other building the group collection of information assets and additional information. All of these actions can either be performed directly on the shared workspace or using the locally installed program. [Roy28]

For that reason, the integration and facilitation of collaboration into PLIMS—building on the technical foundation of Zotero—is generally feasible. Within the scope of this work collaboration scenarios have however not been implemented—among others, due to the reason that the new improved data structures are not available within the shared workspace and could not be transferred within the available space of time. The implementation of collaboration within PLIMS has to be subject of future work.

In summary, basic collaboration as outlined above is an important and valuable aspect in personal information management for learning. Collaboration is in particular connected to the thoughts of *construc-*

tivism and therefore emphasises the importance of actually constructing one's own knowledge—also with the help of fellow learners accompanying an individual learner along the way. In this manner, collaboration is also able to deliver *social proof*—that is the determination of what is right or appropriate based on what others think [Smi08, p.28].

However most of all, collaboration occurring within the inner circle of collaboration—represented and enabled in basic scenarios and by simple means such as social tagging like just introduced—is supposed to lower the barriers to participation and enhances the overall find-ability of objects of interest [Smi08, pp.32f]. Nevertheless, collaboration is not limited to such restricted groups but can also occur in more complex *learning networks.*

Advanced Collaboration in Learning Networks—an Outlook

Examining less restricted and more flexible ways for collaboration that reach out to more people, collaboration can also occur within the various *intermediate social circles* that a learner is engaged in. This kind of collaboration is described and comprised by the concept of *learning networks*[8].

Learning networks, in very general terms, are *"online learning environments that help participants to develop their competences by sharing information and collaborating"* [SB11, p.56]. More precisely, learning networks can be defined as a combination of different nodes:

> *"[A learning network is] an ensemble of actors, institutions, and learning resources which are mutually connected through and supported by information and communication technologies in such a way that the network self-organises and thus gives rise to effective lifelong learning."* [KRS05]

Working in learning networks, learners may exchange their experiences, work collaboratively in groups, and give any desired support to each other [SB11, p.56]. As will be clear from this definition, learning networks bear a close resemblance to *connectivism* as proposed by George Siemens and Stephen Downes (cf. chapter 1.1). Even though

[8] This section offers a brief outlook on learning networks. For a more detailed consideration see [SB11].

actually built to enrich non-formal environments [SB11, p.56], outlining scenarios that such learning networks are built in or naturally form, two fundamentally different scenarios can be distinguished: learning and collaboration in formal *or* informal learning settings (cf. chapter 1.1.1).

Formal Learning Networks. Learning networks created in a formal environment basically connect institutions—and as a consequence, of course, people working and learning in these institutions—with learning resources. For that reason, those learning networks are built top-down just like most of all institutional programs and build with lots of effort that can only be put up by institutions and not individual learners seeking for collaboration.

An example of such a formal network is, for instance, presented by Christoph Rensing and Doreen Böhnstedt [RB09] who built an e-learning community platform based on semantic networks and ontologies.

Learning Networks for Informal Learning. In an explicit contrast to learning networks built in a formal environment, informal learning networks are learner-centred and, therefore, *"emerge from the bottom-up through the participation of learners"* [Dra09, pp.18,29]. Informal learning networks try to create or foster a *"balance in the use of formal and informal learning offers by providing technology that specifically supports informal learning"* [Dra09, p.29] that is in the need to evolve—in particular in the context of lifelong learning.

Within such an informal learning network, learners are able to adopt different roles—teacher, learner, or knowledge provider—and contribute in any way—by publishing, sharing, rating, or adjusting learning activities in cooperation with fellow learners. As already clear from this description, informal learning networks are closely related to Web2.0 services and their utilisation by learners. [Dra09, p.29]

An example of an informal learning network has, for instance, been proposed by Hendrik Drachsler et al. [DPA+09b]. The sys-

> tem building the informal learning network—Re-Mashed[9].—is based on a mash-up personal learning environment (cf. chapter 4.3.2) and *"offers advice to find most suitable learning content for individual competence development of lifelong learners"* [DPA$^+$09b, p.1].

Expanding PLIMS such that it is actually able to be used for the communication within intermediate social circles as well, PLIMS is required to support the building of more complex learning networks. More precisely, the setting that is PLIMS would be able to facilitate are *informal learning network*—due the fact that PLIMS has been explicitly designed for the assistance of individual learners on their journey through lifelong learning.

To summarise, since there is no doubting the benefits of collaboration even for individual learners, the previous section examined the foundations of collaboration as well as collaboration occurring within two of the three circles of collaboration—namely, the *inner circle* of collaboration and *intermediate social circles*—and their possible coverage and implementation in PLIMS.

As already described when introducing the three circles of collaboration, the missing *outer circle* of collaboration is very vague and, for instance, also includes the utilisation of *clues*—that may also have been delivered by others—for searching. For that reason, the last section of this chapter (cf. section 10.3.1) partially follows the ideas of this circle when examining the various access possibilities to a learner's repository. However prior to that, the next section considers possibilities for a more extensive utilisation of existing information within a learner's repository for personalised *recommendations* to a learner.

10.2 On the Way Towards Personalised Recommendations for Learners

In general, a recommendation is commonly defined as an act of *recommending* that presents an item, a person, or "something" as worthy of

[9]Re-Mashed actually works in formal and informal settings [DPA$^+$09b, p.1] but was initially designed for informal settings and, hence, focuses on informal learning networks [Dra09, p.13]

acceptance [MW13b][MW13a]. A recommendation, therefore, always requires some sort of experience from which such a suggestion can be derived.

For that reason, a recommendation is, at a first glance, something passed on from one human being to another. On second thoughts, recommendations can however also be based on a technical collection of data—representing a system's "experience"—and, hence, be derived and proposed by a technical system. Being aware of this background it can be noted that the derivation and passing on of recommendations actually facilitate the re-use and utilisation of previously collected data—an objective that is for sure desirable for personal learning and within PLIMS too.

In conclusion, this section examines possibilities to derive meaningful recommendations from the learning repository that has been built within PLIMS so far. The first part of this section, therefore, considers different techniques to facilitate *basic recommendations* from within a learner's repository. Subsequently, *recommender systems* and their application in learning and for PLIMS are explored as an advanced outlook.

10.2.1 Basic Recommendations from a Learner's Repository

A technically supported recommendation is always based on information within a system existing in a structured manner that allows a utilisation to compute the recommendation. It is for this reason that recommendation—just like collaboration—also particularly relates to *connectivism* as introduced previously (cf. chapter 1.1).

Simple Recommendations Using Basic Connections

The simplest form of recommendation is, therefore, constituted by the utilisation of an existing structure without a further computation. Actually this kind of utilisation is more appropriately referred to as *navigation* within a learner's repository and will, therefore, be covered in the next section of this chapter (cf. section 10.3). Nevertheless, to give a complete prospect of possible recommendations this alternative for recommendations is briefly examined.

Considering the case of PLIMS, these very basic recommendations can be given to learners who are using PLIMS by utilising the index structure these learners construct when building their learning repository. More precisely, when viewing a learning object other learning objects can be recommended as relevant based on a shared learning reference or learning context.

For that reason, what has actually been proposed as a basic collaboration scenario within PLIMS also depicts a basic recommendation: the additional utilisation of knowledge about other learners and their repositories to recommend learning objects such as already outlined. If displaying additional information—such as the learner whose repository the recommend learning object has been derived from—these special recommendations have the *"the potential to strengthen the social cohesion of the network"* [SB11, p.57].

Taking a step further, the utilisation of these index structures to calculate basic recommendations can be achieved by employing *spreading activation techniques.*

Recommendation through Spreading Activation

Spreading activation is based on a model of the human memory and human memory processing operations[10] [Cre97, p.459]. For that reason processing information within the *Teachable Language Comprehender*—as described in chapter 8.3.2—is also a form of spreading activation [CQ72] (as cited in [Wik13i]). Even though spreading activation has originally only been applied to semantic networks, *"associative retrieval has paved the way for applications in information retrieval"* [BBK+09, p.1915]. For that reason, spreading activation is also closely connected to *associative retrieval*. Associative information retrieval examines the possibilities of retrieving relevant information by utilising associations between different information assets or concepts. More precisely, associative retrieval can actually be based on either static or dynamic associations. [Cre97, pp.453f][BBK+09, p.1915]

Obviously, PLIMS presents those static connections that can be used for an associative retrieval of information assets within a learner's repository. Moreover, associative retrieval is typically performed in small

[10] For a more elaborate introduction to semantic memory and the theory of spreading activation within semantic memory see [CL75] and [And83].

document collections where associations were set up manually or semi-automatically [Cre97, p.454]—a prerequisite that is also most likely to be satisfied in information management for personal learning and, therefore, PLIMS.

Pure Spreading Activation. The *basic model* of spreading activation techniques—that is also referred to as pure spreading activation—is a simple processing of an existing structure. As a consequence, pure spreading activation can be described based on two components:

The Network Data Structure needed to be able to apply spreading activation techniques can be constituted by a semantic network or a more generic associative network. The underlying network, therefore, just consists of a number of *nodes* and *connections* between these nodes. Nodes basically represent real world objects or features, whereas connections can be not further specified, labelled, and/or weighted. [Cre97, p.460]

The Processing Technique describes the actual spreading activation process. Basically, this process consists of a sequence of iterations that is either determined manually or by the completion of a termination condition such as fixed number of iterations completed. Within an iteration activation *"spreads across adjacent edges to adjacent nodes and activates these nodes as well"* [BBK+09, p.1916]. More exactly, an iteration is comprised of one or more pulses and the check of the exit condition where a pulse itself consists of three phases: a pre-adjustment, the spreading, and a post-adjustment. [Cre97, pp.460ff][BBK+09, p.1916]

Obviously, the main processing is represented by the spreading that activates a number of nodes within the network. To compute this activation, three different calculation functions are employed: an input function that is used to aggregate the incoming activation of a node, an activation function determining the actual level of activation resulting from the input, and finally an output function that determines the outgoing activation. So during the process of spreading activation every node visited is assigned with a calculated weight and all nodes above a certain threshold are delivered as results of the spreading activation process. [BBK+09, pp.1915f]

> In addition, the optional pre- and post-adjustment phases can be used to implement *"a loss of interest"* and a decay of activation. [Cre97, pp.460ff]

Put simply, spreading activation basically depicts the navigation through a network to detect or activate nodes connected to each other.

More Advanced Models of Spreading Activation. On top of this basic model there are a number of advanced models working with additional assumptions and constraints. Actually Michael R. Berthold et al. [BBK+09, p.1915] even argue that all spreading activation models use some kind of constraint to determine the spreading since the result of spreading activation would otherwise just be a query-independent state that is delivered to a user anyhow.

Constrained models of spreading activation set out to overcome the drawbacks of pure spreading activation such as an uncontrolled spreading across the network [Cre97, p.463]. It is therefore common to implement the processing technique with rules restricting the spreading. The number of constraints is innumerable but can be divided into different classes [Cre97, pp.463f][BBK+09, p.1916]:

Distance Constraints are based on the heuristic rule that the strength of relations decreases along with the semantic distance. For that reason, distance constraints arrange for a decreasing of activation with an increasing distance from those nodes initially activated. Ultimately, the termination of activation is triggered at a certain distance.

Fan-Out Constraints restrict the spreading of activation for nodes with a high connectivity. That way, these constraints try to avoid a broad spreading due to nodes with a literally broad semantic meaning that are connected to many other nodes.

Path Constraints try to guide the spreading along certain paths that have been determined by specific inference rules.

Activation Constraints basically prevent a full spreading across the whole network by employing a threshold function and requiring a certain degree of input to allow the activation of a node at all. To allow a dynamic evolving of the network, thresholds can for instance be adapted based in relation to the total level of activation within the network.

Where the first three types of constraints are supposed to be applied in the pre-adjustment phase, the last one is more likely to be used during the post-adjustment phase [Cre97, p.465].

Spreading Activation as Information Retrieval Technique. Generally applying spreading activation for information retrieval, nodes in a network to be walked through with spreading activation are terms, documents, subjects, or any other classification available. Basically, a node can represent anything. Links represent the association of one node with another—which can be based on a term occurrence, the assignment of a document classification, or any other relation. [Cre97, p.465]

To implement the retrieval process based on this predetermined structure, the spreading activation process is started by transferring the *query*—that can be either formulated by a user or derived from the system—to the corresponding nodes. Based on this transfer, the actual activation first reaches those nodes directly connected to these initially activated nodes and spreads out through the network from there. Depending on the specific retrieval model, different adjustment can be made. The transfer of the query to corresponding nodes can, for instance, be corrected by a user's relevance feedback. Most of the IR systems using spreading activation techniques will employ distance constraints to stop the traversing of the network and different methods to control the activation level of nodes. [Cre97, pp.466f]

The Utilisation of Spreading Activation in PLIMS. It is this scenario as just described that can be transferred to PLIMS to integrate the application of spreading activation techniques.

More precisely, the proposed future integration of spreading activation in PLIMS relates to *associative information retrieval*—as, for instance, described by Haruo Kimoto and Toshiaki Iwadera [KI90]—where the user's current interest is determined from a sample of documents [Cre97, p.474]:

- ▷ Transferring this idea to PLIMS, the system has to automatically extract the information needs of a learner based on the learning object or the collection of learning objects the learner is currently working with. These objects represent the corresponding nodes in the learning objects layer offering the starting point of the spreading of activation as described above.

- Having determined these starting nodes, PLIMS can traverse through a learner's repository and utilise the three index levels grouped in two index tiers for the derivation of recommendations as shown in figure 10.2. That way recommendations can build on and be derived from more complex connections than direct ones already used for simple recommendations.

  A new learning object can, for instance, be recommended to a learner because this object has been assigned with the children's child or a parent of a learning context assigned to the initially viewed learning objects. This scenario is shown on the right side of figure 10.2. In addition, an advanced spreading can also recommend a learning object based on a co-assignment of a learning references across more than one learning object—as shown in the left side of figure 10.2.

- Obviously, a certain distance criteria determining the spreading has to be formed as well. Since PLIMS is designed to adjust to the needs of an individual learner, it is suggestive to use a predetermined distance but allow the adjustment of this distance by a learner.

- In a even more advanced scenario this technique can, of course, also be additionally employed for searching a learner's repository. A learner can explicitly form a query that is subsequently transferred to the corresponding nodes in the learner's repository. Based on this transfer, an advanced search would also be able to deliver recommendations beyond the more or less exact results of a traditional search.

In summary, recommendations that can be derived by employing spreading activation techniques can provide additional benefits for learners in the mastery of their personal learning. This statement is also supported by the work of André Wiesner [Wie10] who utilised a similar but metadata independent technique derived from SCORM—

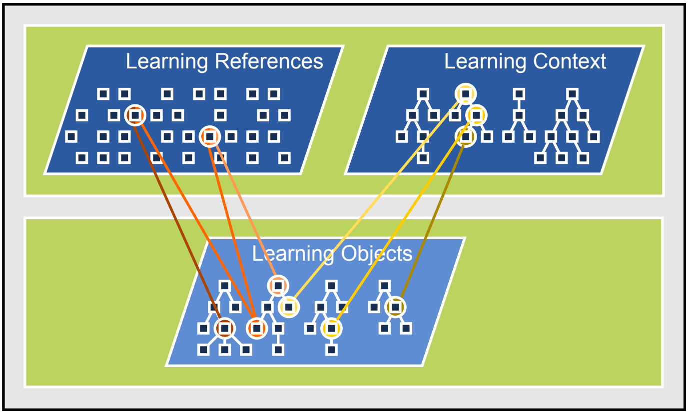

Figure 10.2: The utilisation of spreading activation techniques for the recommendation of learning object in PLIMS

so-called *Activity Trees* and *Activity Tree Harvesting*[11]—to develop, analyse, and utilise SCORM compliant learning objects. More precisely, Wiesner collects learning objects from different repositories and, subsequently, offers search and recommendation services based on an activity tree harvesting [Wie10, p.XI][WS05, p.113].

The technical realisation of this utilisation of spreading activation techniques within PLIMS is however yet to be implemented and has to be subject of further research. Nevertheless, the derivation of simple recommendations and the application of spreading activation techniques in PLIMS also connect PLIMS to *hypertext information retrieval* that enables a retrieval of relevant information by browsing the repository [Cre97, p.477]. This kind of retrieval will be discussed in section 10.3.1 in more detail.

Firstly, an outlook on possibilities for the advanced recommendation of learning objects by the utilisation of complex recommender systems is given in the next section.

[11]In SCORM sequencing an activity equals any item in a SCORM manifest and can, therefore, be an SCO or assets (cf. chapter 8.2.2). As a consequence, the set of all activities and their parent-child relationships can be represented by an *activity tree* depicting the organisation of the SCORM manifest [Rus12a]. Finally, the collection and subsequent utilisation of these structures is what is described as *activity tree harvesting* [Wie10, pp.4,119].

10.2.2 Recommender Systems for Advanced Recommendations in Learning

Moving beyond these basic recommendations, there is a group of systems able to derive even more complex recommendations: *recommendation systems* or *recommender systems*.

For that reason recommender systems are briefly introduced next, followed by an examination of previous efforts to employ recommender systems in technology enhanced learning. Ultimately, an outlook on the possible application of recommender systems in PLIMS is given.

Introduction to Recommender Systems

Accomplishing a simple definition, recommender systems are described as *"software tools and techniques providing suggestions for items to be of use to a user"* [RRS11, p.1]. Recommender systems are dedicated to the pre-selection of information that might be of interest for a user or learner [Dra09, p.17] by trying to *"predict a user's affinity for items or information"* [HKR00, p.241]. On this account, a recommender system requires a set of *items* or learning objects to be recommended and a set of *users* known by the system.

Getting into detail, three constituting parts of recommendation systems—or three general steps to a recommendation—can be identified [Bur02, p.332]:

- ▷ To be able to derive recommendations at all, a recommender system requires a certain amount of information—the so-called *background data*.
- ▷ In addition to these information, a user needs to communicate with the system to finally allow the derivation of recommendations. In other words, a user has to deliver *input data*.
- ▷ Finally, the actual recommendation results from the combination of these background data and the input data using a particular recommendation *algorithm*.

How Recommender Systems Work. There are a number of *recommendation techniques* that can be used to actually derive recommendations. Very general, all recommendation techniques try to create a kind of "neighbourhood" [Dra09, p.7].

Each recommendation technique is either model- or memory-based. *Model-based techniques* periodically analyse a large data corpus to cluster items within in this corpus and estimate recommendations, whereas *memory-based techniques* continuously analyse existing data to calculate recommendation. Since model-based techniques require data sets with more than 10,000 items, recommendation in personal learning, personal information management, and PLIMS should be based on memory-based recommendation techniques. [Dra09, pp.53f]

Further examining memory-based recommendation techniques, two contrary basic approaches can be employed for the derivation of recommendations:

Content-Based Filtering. Content-based[12] approaches—also referred to as *information-based recommendation*—rely on the utilisation of *features* to define the items or objects of interests. Recommender systems using a content-based recommendation technique try to recommend items either similar to those items previously rated or liked by a user—that is *case-based* [Smy07]—or by matching a user's attributes to the attributes of items from within the data set—that is *attribute-based.* [Bur02, p.334][Dra09, pp.57ff]

Collaborative Filtering. In contrast, collaborative-filtering[13] techniques—also referred to as *social-based* approaches—exploit the *collective behaviour* of all users or learners to deduce recommendations. Collaborative recommender systems aggregate ratings and correlate either users—utilising so-called *user-based* techniques—or items—in so-called *item-based techniques*—to generate new recommendations.

The greatest advantage of collaborative techniques over content-based approaches is their complete independence from machine-readable representations of objects to be recommended. [Bur02, pp.332f][Dra09, p.55]

[12] A more detailed examination of current trends and the state of the art in content-based recommender systems throughout different application domains can be found in [LGS11] and [PB07].

[13] An in-depth consideration of memory-based collaborative filtering techniques—also referred to as *neighbourhood-based* recommendation techniques—can be found in [DK11] and [SFHS07]. A consideration of more recent approaches is the subject of [KB11].

In addition to these two basic types, a number of refinements—for instance demographic filtering or utility- and knowledge-based recommender systems [Bur02, pp.333f]—and a number of *hybrid recommender systems*[14] combining different recommendation techniques exist. These advanced approaches in particular try to avoid common problems of recommendation systems such as the so-called "cold-start" problem for new users or new items[15] [Dra09, pp.57ff].

What Recommender Systems Do. Pursuing the description of recommender systems, a number of common *recommender tasks* categorising user tasks or goals of users to be supported by recommender systems have been defined. These tasks enable an evaluation of recommender systems and, most importantly, allow the selection or design of appropriate recommender systems [HKTR04, pp.7,9ff]:

Annotation in Context describes the provision of recommendations while a user is still working on other tasks. These recommendations are, therefore, expected to help users in distinguishing between desired and undesired content while working on a task—for instance by predicting the relevance of different links on a web page. [HKTR04, p.9][MDV$^+$11, p.390]

Find Good Items is the *core recommendation task* that can basically be depicted as the suggestion of specific items—such as a list of web pages to be visited—to a user. Typically, a user will be provided with a ranked list of items that also indicates the assumed relevance or liking of every recommended item. [HKTR04, p.9][MDV$^+$11, p.390]

Find All Good Items is, in contrast to the previous task, explicitly dedicated to the recommendation of *all* relevant items with a false negative rate as low as possible. As a consequence,

[14] Hybrid recommender systems, in general, use a combination of two or more recommendation techniques. The combination of these techniques can be implemented using different hybridisation methods such as a *weighted* combination of recommendation scores or the *mixed* presentation of results from different recommender systems [Bur02, pp.339f]. For a more elaborate consideration of hybrid recommender systems see [Bur02, pp.339ff] and [Bur07].

[15] For a comparison of different recommendation techniques in particular considering problems of recommender systems see [Bur02, pp.335ff].

coverage is particularly important in this task. [HKTR04, pp.9f][MDV+11, p.390]

Recommend Sequence describes the challenge of recommending a sequence of items to the user of system that is *"pleasing as a whole"* [HKTR04, p.10]—such as, for instance, the recommendation of a sequence of songs. [HKTR04, p.10][MDV+11, p.390]

Just Browsing addresses users that are simply following recommendations for the pleasure of doing so—without any particular motive. For that reason, this recommendation task especially focusses on the interface or the provision of recommendations and the ease of using these recommendations instead of concentrating on the accuracy of algorithms calculating the recommendations. [HKTR04, p.10]

Find Credible Recommender finally characterises the exploration of the trustworthiness of recommender systems by a user—for instance by changing the own user profile and the observation of the changes in personal recommendations thereafter. [HKTR04, p.10]

Summarising this brief introduction, a number of different recommendation techniques—as introduced above in excerpts—can be employed to solve the identified typical tasks for users and, hence, recommender systems.

The Use of Recommender Systems in Technology Enhanced Learning

Examining the utilisation and transfer of recommender systems to the field of technology enhanced learning, Nikos Manouselis et al. [MDV+11] show that the previously identified *tasks for recommender systems* can be transferred to corresponding scenarios and, therefore, apply in learning as well[16].

Recommendations in learning have however some particularities that, among others, result from the richness of pedagogical theories and models shaping learning. In addition to the utilisation of learning

[16] For an in-depth consideration and derivation of this finding see [MDV+11] and [VMO+12].

objects and profiles of learners, recommender systems in technology enhanced learning may use

- ▷ the *knowledge level* of a learner—that can be determined by an already achieved academic grade or previously visited courses—
- ▷ the *learning style*,
- ▷ or additional metadata on the learning objects—such as the difficulty level, interactivity level, or technical characteristics.

Not all of these characteristics are automatically met by general purpose recommendation approaches. For that reason, recommender systems in TEL require a more careful consideration of the learning context [KU06, p.2]. [VMO$^+$12, pp.320f]

Most of all, requirements for recommender systems in technology enhanced learning are coined by the general setting for learning they are employed in: formal or informal learning. Where recommendation in *formal learning scenarios* is allowed to be derived in a very structured manner employing techniques of *adaptive sequencing*[17] and a top-down approach, *informal learning* scenarios require a more flexible treatment and, therefore, a bottom-up approach such as a hierarchical clustering[18]. [DM30, pp.8ff]

Recommendation Techniques for Learning. As already outlined above, recommendation techniques are always either model- or memory-based. Within learning in general, both techniques may be employed. In personal learning no large corpora are expected, which is why *memory-based recommendation techniques* are suggestive [DHK08, p.412].

Working with memory-based recommendation techniques, Hendrik Drachsler et al. [DHK08] examine the existing different techniques, their advantages and disadvantages, as well the usefulness of every technique in technology enhanced learning and in particular learning

[17] Adaptive sequencing in a learning context generally describes the generation of the learning paths adapted to a learner's needs [KS05, p.129]. For a more elaborate consideration see, for instance, [KS05].

[18] Hierarchical clustering in very general terms describes a method to build a hierarchy of clusters of items—`http://en.wikipedia.org/wiki/Hierarchical_clustering`.

networks[19]. Drachsler et al. conclude that *"hybrid memory-based recommendation techniques could provide the most accurate recommendations by compensating for the disadvantages of single techniques in a recommendation strategy"* [DHK08, p.420].

Recommender Tasks in for Learning. All recommender tasks introduced above can be followed for recommendations in technology enhanced learning, too. However in addition to these general recommender tasks, Manouselis et al. also suggest the consideration of three additional recommender tasks that are supposed to be of particular importance in technology enhanced learning [MDV+11, p.390]:

Find Novel Resources describes the specific recommendation of new resources—that are, for instance, the latest additions to a repository or new resources on recently covered topics. [MDV+11, p.390]

Find Peers characterises the task of recommending other people with interests that are supposed to be of interest for a user—such as the suggestion of peer students. [MDV+11, p.390]

Find Good Pathways finally depicts the tasks of recommending pathways through a repository of learning objects that may also be an alternative to a path just taken. [MDV+11, p.390]

Recommender Systems in Technology Enhanced Learning. This being said, there are of course a number of projects, researches, and experiments transferring and applying recommender system to support technology enhanced learning[20].

Since there are a wealth of projects, the one that is maybe most closely related to PLIMS is cited: Hendrik Drachsler [Dra09] examines the possible application of recommender systems *"to offer personalised navigation support to learners in informal learning networks"* [Dra09, p.7] (cf. section 10.1.2) and proposes a comprehensive model of a recommender system for informal learning networks that implements and

[19] Due to reasons of scope it is simply referred to [DHK08, pp.412ff] for an extensive consideration.

[20] Extensive lists and descriptions of recommender systems in technology enhanced learning as well as a comparative evaluation of such systems can be found in [Wie10, pp.61ff], [MDV+11, pp.399ff] and [VMO+12, p.320].

combines pedagogical characteristics with collaborative filtering algorithms.

More precisely, the system called *ReMashed* is a mash-up environment allowing the personalisation of information in an online community with a recommender system [Dra17, p.9]. On this account, ReMashed provides a recommender system for mash-up learning environments, offers an environment to test new approaches to recommendation, and creates informal user-generated-content data for the evaluation of new recommendation algorithms. A prominent implementation of ReMashed in a different domain is the MovieLens project [DPA+09a, p.790].

The Possible Application of Techniques for Recommendation in PLIMS

Proceeding with the case of PLIMS, the particular consideration and application of recommender systems in *personal learning* and *personal information management* in general is suggestive for three particular reasons:

- First of all, recommender systems arise from the field of *information retrieval* and are, therefore, still closely connected to information retrieval systems and, in particular, web search engines [KU06, p.1]. Since PLIMS has been classified as an information retrieval system (cf. chapter 7.2.2), the application of advanced techniques to improve retrieval results is also suggestive.

- Moreover, as for instance accomplished and shown in the e-commerce market, recommender systems are able to facilitate and implement *personalisation* [Dra09, p.17]. Obviously, personalisation can be identified as *the* major goal in personalised learning, personal information management, and therefore also for PLIMS.

- Finally, recommender systems are targeted at individuals *"who lack sufficient personal experience or competence to evaluate the potentially overwhelming number of alternative items"* [RRS11, p.1f]. A goal that has been identified as one of the major problems in personalised learning.

In summary, it is the concentration on *individuals* and the feasible *personalisation* of data that classifies recommender systems for personal learning and personal information management. Once more recalling the problems of personal learning identified as issues to be approached within the scope of this work and with PLIMS—*keeping learning at a glance* and, in particular, *finding the needle in the haystack* (cf. chapter 4.1)—recommender systems are assumed to be able to contribute to the mastery of these problems within PLIMS.

Nevertheless, advanced recommendation as enabled by the utilisation of recommender systems will be most effectively used in advanced collaboration scenarios such as learning networks (cf. section 10.1.2).

Recommendation Techniques for PLIMS. By building a learner's repository as designed, PLIMS already fosters the one claim that has been made above: the additional consideration of the context of learning. This context is delivered by the second index tier.

Determining the appropriate recommendation technique for the utilisation in PLIMS, the suggestion of Drachsler et al. is followed and a *hybrid recommendation approach* is supposed to be chosen for the application in PLIMS. The appropriate combination of techniques will have to be the subject of further research. It is, however, suggestive to examine a combination of user-based collaborative filtering and attribute-based techniques.

Recommender Tasks for PLIMS. The recommendation tasks that can be identified as the most important ones in PLIMS are *find good items* and *find all good items* for explicit search or recommendation tasks a learner might actively initiate as well as the *annotation in context* for learners working through their learning repository.

In addition considering advanced collaboration scenarios as outlined in section 10.1.2, the learning specific recommender task to *find peers* will be of interest to support learners and the building of virtual learning groups.

The Technical Implementation. Just like the integration of basic recommendation techniques, the actual technical implementation of advanced recommendations and the addition of recommender systems-like recommendation techniques needs to be subject of further research.

There are existing systems like the Duine framework[21]—which has also been used in some of the implementations cited above—that can be used to put this implementation into practice.

In summary, recommendation describes a meaningful approach to support the re-use of information within a learner's repository. Since recommendations build on existing knowledge or information, recommendations can actually already be described as some kind of (re-)finding information. Finding itself is, however, more comprehensive and not only describes the detecting of information by recommendation. As a consequence, the more elaborate consideration of finding by *exploring* a learner's repository is the subject of the last section of this chapter.

10.3 Exploring the Learning Repository from a Learner's Perspective

Concluding the description of PLIMS and its design, this section focuses on the way that learners experience PLIMS. As already mentioned several times, a basic access to information is the concern of information retrieval—which is why information retrieval has also been depicted as a *basis technology* of learning (cf. chapter 1.4.1). More precisely, the study and assistance of users in accessing information and dealing with retrieval systems is the concern of *interactive information retrieval*[22] [Rut08, p.44].

In other words, this chapter describes the possibilities of learners to explore their individual learning repository by utilising the provided *user interface* or *search user interface*—that is *"the window through which search systems are seen"* [Hea11, p.21]. A search user interface

[21] The Duine Framework—`http://www.duineframework.org/`

[22] More accurately, interactive information retrieval comprises research on information and search behaviour as well as research on the development of new ways of interacting with electronic resources [Rut08, p.44]. The design of information retrieval systems as being the concern of interactive information retrieval is actually related to a number of disciplines and areas of research. An extensive considering of those disciplines as source of materials on interactive information retrieval and also a comprehensive overview on state of the art can be found in [Rut08, p.46].

generally should be designed to help users or learners in understanding and expressing their information needs, formulate corresponding queries, select the appropriate sources of information, and comprehend the results of search [Hea11, p.21]. As a consequence, this is what has to be kept in mind to be able to design an appropriate search user interface—in general and for the case of PLIMS.

A carefully designed (search) user interface for PLIMS allows to achieve an *integration through search* [Jon07, p.45] as cure for *information fragmentation*. This integration, in turn, facilitates the different *dimensions of integration* in personal information management as outlined previously: integration across physical locations, in the means of access and organisation, by grouping and inter-relating of items, and with the current context, an integrative view on information, as well as integrative facilities of data manipulation (cf. chapter 7.1, p.178). Finally, the search user interface has to provide access meeting the demands of the differing *information needs* including informational, navigational, and transactional information needs (cf. chapter 6.2). As reasoned in the exemplary scenario for the utilisation of PLIMS (cf. chapter 7.2.1), the system in particular deals with *informational* and *navigational information needs*.

For that reason this section, at first, examines the *(re)-finding of information through search and navigation* to fulfil these two different information needs in focus. Subsequently, the second part of this section moves beyond these classical ways of access and examines possible visualisation of a learner's repository to additionally foster the mastery of personal learning—*keeping learning at a glance* and *finding the needle in the haystack*.

10.3.1 (Re-)Finding Information through Search and Navigation

Recalling the previously phrased definition (cf. chapter 7.1.1), finding and re-finding help in satisfying an existing information need by seeking, searching, browsing, or scanning. All information that has been consciously put in a learner's repository is somehow already known. The process of discovering this information is, therefore, an act of *re-finding*. It can, however, not necessarily be assumed that this is true for every piece of information. Learning objects and additional information that have been added automatically have not necessarily been processed by a learner before. As a consequence, the act of revealing this information is an act of *finding*. [Jon07, p.24]

Either way, this finding and re-finding of information located in a learner's individual repository is also referred to as *personal search*:

> *"Personal Search refers to the process of searching within one's personal space of digital information."* [EKK11]

Thus, a personal search actually comprehends the search in terms of all the information that is sometimes also informally referred to as "stuff an individual has seen" [KKE11, p.81]. As we have learnt previously (cf. chapter 7.1.2), this personal space of information is in contrast to personal information collections unique and only exits once for every individual. Nevertheless, each personal information collection—such as the collection or learning repository that can be formed by the utilisation of PLIMS—is a subset of an individual's space of information. For that reason, personal search also refers to the search within personal information collections and PLIMS. To get around to performing a personal search and, hence, (re-)find information, several steps are required in addition to the existing information need: the learner has to remember to look for the information, must find a way back to the information, and recognise that the detected information is what he or she was looking for [Jon07, p.25].

Technological support for this information seeking by information retrieval systems can be achieved in two different ways: *query-based* or *browse-based*. Where query-based systems *"force searchers to pull information out of the stored resource by expressing a request"*, browse-based systems help searchers to navigate their information space [Rut08, p.45]. As a consequence, the actual process of (re-)finding of information can also be achieved with two different strategies: by directly *searching* for the desired information to get immediate access or by *navigating* through a repository to find the information.

The Basics of Searching for Information

This being said, the different search tasks a learner may conducted have to be considered. These search tasks generally range from simple to very complex tasks [Hea11, p.21]. Nevertheless, in *query-based systems* the primary starting point for a search is the formulation of a query by entering words describing the information need behind this query into a search box. This kind of search is typically referred to as a *keyword search*.

Keyword Search. The standard user interface for a textual query is a search box entry form [Hea11, p.27]. A search box depicts the most simple dialogue that may be offered to user to allow searching the repository that is also commonly used in web search nowadays [Hea11, p.22].

More precisely, different studies (cf. [SWJS01], [Tat24], [Ged10], or [TPS+12]) have shown that short queries consisting of a small number of words[23] depict the standard scenario. In a next step these queries are likely to be reformulated if the presented results do not look relevant. Otherwise the user will most likely go through the results, find the most relevant-looking website, and navigate there to satisfy his or her information need. [Hea11, p.26]

Technical Implementation: Basic Search in PLIMS. As a consequence, PLIMS has to offer this primary search opportunity to its users. This basic search functionality is supposed to cover the search through all information included in a learner's repository—that are learning objects, learning references, and learning context.

Zotero already provides such basic search functionalities to find information located within a learner's repository. A basic keyword search—the so-called *quick search*—provides a search box that can be used to either search just the most important fields of learning objects, all fields and tags, or everything that is included in the repository. Most importantly, this last option for search also covers the full content of learning objects able to be processed by the indexer—that are the saved snapshots of HTML pages and PDF documents at the moment. Moreover,

[23] Even though previous studies in 2001 have shown that the average number of terms in query is only 2.4 words [SWJS01], recent studies have revealed that the number of terms per query actually increases above 3 words per query [TPS+12] and more than 54,5% of all queries submitted to Google are greater than 3 words [Ged10]. Nevertheless it can be concluded that Web queries are typically short compared to natural language [Hea11, p.26].

Zotero allows the advancement of this basic search by selecting specific fields or any combination of specific fields to be searched and allows the the utilisation of wild cards to broaden possible search results. [Roy11b]

In other words, the basic search for learning objects and learning references has already been in place in Zotero previously. Of course enriching Zotero with learning context as described previously (cf. chapter 8.3.2, p.235) to become PLIMS, this basic search as well as its advancement have also been extended to comprise searching all learning context and any combination with learning context.

In summary, a simple keyword search actually already allows the access of all kinds of information that has been gathered in a learner's repository and the utilisation of all these information as clues for a search. Nevertheless and in particular in a personalised environment, a simple standard keyword search has be assigned with limited effectiveness [Car09, p.2]. Moreover, a keyword search is very likely to be able to fulfil an *informational need* but supposed to be less successful for a *navigational need*. For that reason, more advanced and exploratory ways of finding those assets meeting existing information needs have to be examined.

An Exploratory Approach to Information

Studies have shown that searchers often prefer browsing over searching if the information is structured to allow a comfortable browsing [Hea11, p.22]. By utilising the existing structures in a learner's repository as formed within PLIMS, a learner can move beyond the direct access of information via a keyword search to a more vague approach allowing the development and progressive specification of information needs.

This section covers those searches not starting *"with typing a keyword query in a search box"* [Hea11, p.24]. In contrast to a directed search, a *navigational approach* encourages *"the orthogonal visit of available learning resources by exploiting associations the user would not have thought of"* [DA07, p.222]. More precisely, the exploratory search for information may be constituted by following existing information paths, the finding of new paths traversing the information repository, or the finding of information by chance—that is the uncovering of one piece of information when actually looking for another one [Rut08, p.44].

This advanced utilisation of existing structures for the pro-active navigation of a learner through his or her repository, in particular relates this searching in PLIMS to two different areas of information retrieval: *hypertext information retrieval* and *faceted search.*

Hypertext Information Retrieval. As already reasoned when introducing the architecture of PLIMS (cf. chapter 7.2.2, p.188), building the structure of a learning repository in PLIMS and utilising this structure connects PLIMS to *hypertext information retrieval*[24]:

> *"IR hypertext is a document base that allows access to documents mainly by navigation and browsing. An IR hypertext is composed of nodes, stores of information, and links; connections between nodes. The user navigates from node to node using links."* [ACM96, p.459]

As a consequence, hypertext information retrieval presents the user with the possibility of actively browsing through the indexing structure. This idea or concept can easily be combined with *spreading activation techniques* [Cre97, pp.477ff] or even be depicted as a manual implementation of spreading activation. Nevertheless, in that way, a user is supposed to be able to acquire an in-depth understanding of semantic contexts preserved in this index structure by navigating through the information to gain access. [ACG91, pp.316f,321]

Maristella Agosti et al. [ACG91] proposed a model—EXPLICIT[25]—that is based on a two-level architecture and its experimental prototype HyperLaw as an implementation of hypertext information retrieval.

Due to its architecture, PLIMS is obviously a system bearing a close resemblance to hypertext IR and, as a consequence, pre-

[24] For a more elaborate consideration of hypertext information retrieval and the proposal of corresponding systems see [ACG91], [AGM92], and [ACM96]

[25] The hypertext IR model EXPLICIT builds a two-level architecture from the collection of documents and all indexing terms. The index terms are additionally represented by an auxiliary schema of concepts that can be utilised by users to browse the repository as well as for the (re)-formulation of queries. The prototype HyperLaw employs this concept for the management of a collection of legal documents. [ACG91, pp.316f]

destined to allow this kind of navigating access to its learning repository.

Faceted Classification and Search. *Facets* are *categories* used to characterise items in a collection; each facet is assigned with a name and can be flat or hierarchical [Hea06, p.26]. In contrast to a mono-hierarchy, a faceted classification enables the assignment of more than one of those facets to an information item [Arn06, p.159] and as a consequence the (re-)finding of information items via multiple paths [Smi08, p.76].

A system allowing the utilisation of facets for the purpose of search is a *faceted search system*[26]. As proposed by Marti A. Hearst [Hea06], these systems are supposed to best match the following criteria and tasks: the support of a flexible navigation within the collection, a seamless integration with the direct (keyword) search, the opportunity to flexibly switch between refining and expanding the query, the prevention of empty results sets, and finally the retention of control and understanding for a user at all times. As a consequence, a search user interface suitable for a faceted search has to provide this extended possibilities for an interactive navigation through a repository. [Eck11, p.18]

Actually, the utilisation of learning references and learning context in PLIMS has to be differentiated from the utilisation of facets. Neither explicitly find their expression in named facets [Wik13d]. Nevertheless, the concept of faceted search is clearly connected to how a learning repository can be explored.

In summary, all of these implementations of search in *browse-based systems* rely on a *information scent* that can be followed as meaningful clue the desired result of search [Hea11, p.24]. It is this scent that also leads the exploratory approach to search in PLIMS.

Examining the possible utilisation of these concepts for the navigational exploration of a learner's repository two typical applications can be derived:

Navigation as Query Refinement. Building on what has been previously introduced as basic keyword search, the structure of a

[26] For a more elaborate definition as well as a short review of corresponding literature see [Eck11, pp.18ff].

learner's repository may be utilised for the comfortable refinement of the initial textual query. To use navigation for the purpose of query refinement, a learner would still start by formulating a textual query to the system and will be presented with corresponding results. However instead of scanning through the presented results to discover the most relevant (learning) object, a learner will utilise the additionally displayed information to refine his or her query.

For the case of PLIMS such a refinement can be achieved by the utilisation of learning references and learning context. The learning references and learning contexts meeting the initial query are displayed and can, subsequently, be used for the reformulation of this initial query—for instance by adding one or more learning context and learning references as supplementary condition for the search.

Browsing as Initial Starting Point. In contrast with the textual search pattern, a user may also solely rely on browsing and navigation through a learning repository to find the information meeting the current information need. Navigating through a repository, every information asset included in the repository can be utilised for the description of an information need and, hence, be employed as "scent" or trail to the desired information.

In the case of PLIMS, it is in particular the information collected in the second tier of the index structure that is suitable to be utilised for the navigation through the learning repository. More precisely, all learning references and learning context existing in a learner's repository are displayed at the beginning. Starting the navigation through his or her repository, a learner may select a learning reference or learning context that seems to be most appropriate for the current situation. Moving from there, this initial query—even though not formulated textual—can be refined just as described above.

Technical Implementation: Navigation in PLIMS. Already including the utilisation of tags, Zotero allows browsing the repository by selecting tags as well as the refinement of initially phrased queries.

The same behaviour has been implemented for learning context such that learning references as well as learning context can now be used for the refinement of a query or an arbitrary browsing through the learning repository. Of course, this browsing is following common guidelines for the ease of use. As suggested by Marti A. Hearst [Hea11, p.22] selections can easily be reverted, refined, or restarted at any point in time during the browsing process.

What becomes apparent when examining the browsing process is that *"the human perceptual system is highly attuned to images, and visual representations can communicate some kinds of information more rapidly and effectively than text"* [Hea09a]. An appropriate visualisation of information is, therefore, able to considerably improve the browsing experience and, as a consequence, provide additional insights on the information within the learning repository [Hea09a].

For that reason an outlook on advanced visualisation that may be implemented into PLIMS in the future is presented next.

10.3.2 An Outlook on the Visualisation of a Learner's Repository

In general, visualisation or illustration is a different form of knowledge representation [SM04, p.55] that—as Keith Stenning and Jon Oberlander reason [SO95, p.98]—limits the abstraction necessary and, therefore, aids the processability of complex information:

> *"The goal of information visualisation is to translate abstract information into a visual form that provides new insight about that information."* [Hea09a]

The application of visualisation in information retrieval can benefit the retrieval process in different ways—by utilising the human perceptual ability, reducing cognitive workload, and enhancing the retrieval effectiveness [Zha08, p.13]. For that reason, the field of information visualisation is a particularly vibrant one with *"hundreds of innovative ideas burgeoning on the Web"* [Hea09a]. Giving a comprehensive overview on information visualisation or even visualisation in information retrieval is therefore not feasible within the scope of this work[27]. What will, however, be discussed in this section are visualisations that may be applicable in learning and in particular for the case of PLIMS and a future implementation.

One of the inevitable prerequisites to work with PLIMS at all, is the basic visualisation of the all the information included in a learner's repository. So far, the implementation of PLIMS—that is the extended Zotero—displays the content of a learner's repository in a quite simple manner as shown in figure 10.3. Due to the substantiation on Zotero, the interface is, by now, quite simple and smoothly blends into the existing user interface of Zotero.

However further evolving PLIMS, a more advanced visualisation of the different kinds of information in a learning repository are feasible. As a consequence, the visualisations discussed in this section may be suitable for the display of information and the navigation through a learner's repository whereas the specific display of search results as a response to a textual query—such a lists of retrieved items enhances with snapshot, snippets or similar [Hea11, pp.30ff]—is not discussed.

Starting to examine visualisation, there is no way around Ben Shneiderman's famous *information seeking mantra*:

> *"Overview first, zoom and filter, then details-on-demand."* [Shn96, p.337]

Basically, this mantra summarises what Shneiderman depicts as the basic principle of every good visualisation: the delivering of an *overview* of the collection, the allowance of a *zoom in* on items of interest that includes the *filtering* of uninteresting items, and the display of *details on demand* for an item selected. Moreover the relations of items in a collection should be displayed, a history of performed actions should be kept to allow an reverting of these actions, and an extraction of sub-collections should be possible. [Shn96, p.337]

A more advanced visualisation of the information within a learner's repository employing this information seeking mantra is meaningful—not only for the benefit of a more comfortable browsing but also for

[27] For those interested in digging deeper into the subject of information visualisation, a reading of principles of information visualisation—such as for instance the *Gestalt* principles—discussed in [Hea09a] is suggested along with the coverage of information visualisation from an information retrieval perspective in [Hea11, pp.24ff] and [Zha08].

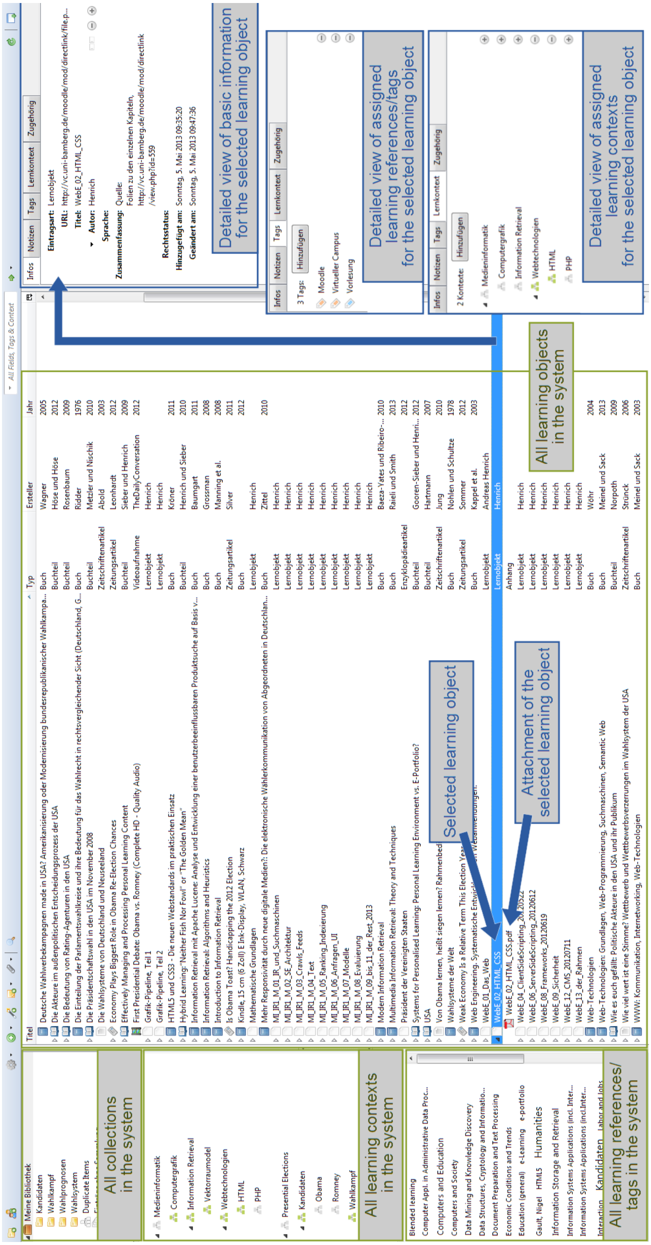

Figure 10.3: The PLIMS interface displaying all learning objects, detailed information on a currently selected learning object, as well as all learning references and learning context

added value—such as the gaining of new access paths to content—that these visualisations are able to create for learning [Wed07].

Working with a learning repository featuring three different kinds of information—learning objects, learning reference, and learning context–the examination of possible visualisation has to consider these differently characterised information:

Visualising a Collection of Learning Objects. An improved visualisation of a number of files, documents, or learning objects is actually hard to find—in particular when examining a visualisation separated from any context information. Today's operating systems have created a familiarity with lists of documents or objects that leads to users being capable of coping with lists as metaphor for the organisation of a large number of items. For that reason, the display of a list of learning objects is how a learner's repository is visualised by now.

A possible advancement can be derived from the suggestion of David J. Harper and Diane Kelly [HK06] who propose the utilisation of a *pile metaphor* for the organisation of search results. Using this metaphor, learners could be allowed to even personalise the display of their repository. However, in summary, it is considered to be more useful to utilise the existing additional information for the visualisation of the underlying collection of learning objects for the case of PLIMS.

Visualising Non-Hierarchical Information. The most common visualisation of non-hierarchical information are so-called *tag clouds*. A simple tag cloud that has been created from section 10.1 of this work is shown in figure 10.4.

Basically, a tag cloud[29] consists of a number of terms that are arranged in a cloud-like formation independent from any possibly existing connections among those terms. The words actually displayed in a tag cloud may be a collection of tags or, for instance, the terms of a document visualised in a tag cloud. Tag clouds

[28] Wordle—`http://www.wordle.net/`

[29] For a more extensive consideration of possibilities and options for the creation of tag clouds see [Smi08, pp.95ff].

Figure 10.4: A simple tag cloud of section 10.1 created using Wordle[28]

can, among others, also be used to visualise search results[30]. Usually the size of a term is an indicator for its frequency in the collection or document that the tag cloud has been derived from—even though this correlation is not strictly transferred to the scaling of tags in a tag cloud [Smi08, p.97].

However, most importantly, tag clouds are usually not just a visualisation but a *"thin layer of navigation on top of other content"* [Smi08, p.102] that can be used to explore an underlying repository such as the collection a learner has formed using PLIMS.

Additionally, Christian Glahn et al. [GSK08] have shown that tag clouds are able to serve as a personal tool for individual learners and support the reflection process in learning. For that reason, the integration of tag clouds for an advanced visualisation into PLIMS is suggestive—even though, technically speaking, a tag cloud is not only a separated visualisation of non-hierarchical information but already a combination of learning references and learning objects.

[30] Citing an example, Search Cloudlet—`https://addons.mozilla.org/en-US/firefox/addon/search-cloudlet-for-google-yah/`—is a Firefox add-on visualising search results as tag clouds and allowing a cloud-based navigation.

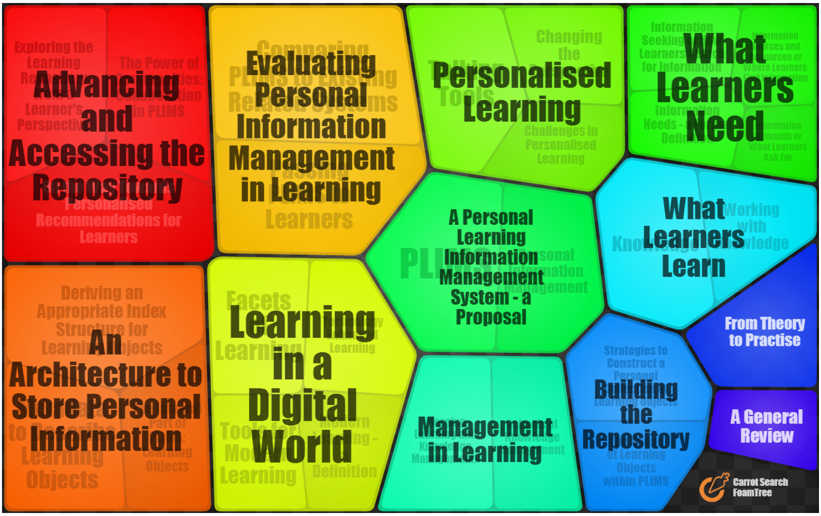

Figure 10.5: A treemap visualising the structure of this work created using FoamTree[31]

Visualising Hierarchical Information. There are a number of visualisations that have been examined and proposed in particular for the visualisation of hierarchical information. An interesting visualisation amongst those is the concept of *treemaps* that has been initially proposed by Brian Johnson and Ben Shneiderman [JS91]. A treemap utilises all of the existing display space and maps the hierarchical information to a two-dimensional rectangle [Eck11, p.37][JS91]. An example of a treemap visualising the structure of this work is shown in figure 10.5. The visualisation shows the chapter headings as top level hierarchy as well as the section headings as secondary hierarchy. Even though this example just visualises two levels of a hierarchy, treemaps are generally not limited to such relatively flat hierarchies.

However just as for tag clouds, treemaps are meant to be more than just a visualisation. In addition to a novel view on a hierarchy, a treemap also enables navigation. First of all the structure

[31] FoamTree—`http://carrotsearch.com/foamtree-overview`

itself can be navigated. Using the example shown in figure 10.5, a click on a chapter opens the view on the sections below and may results in the additional display of subsections within these sections. Secondly, this navigation is of course supposed to lead to the information that the visualised hierarchy is actually structuring [JS91, p.284]. For the case of PLIMS this would, for instance, intend that a learning context from within an arbitrary hierarchy of learning contexts leads to a number of learning objects assigned with this context.

A visualisation like this seems to be particularly useful for the integration into PLIMS, since it is able to display a number of parallel hierarchies that may vary in depth and do not necessarily share a common root node. For that reason a future integration into PLIMS is suggestive. Again, technically speaking, a treemap is not a strictly separated visualisation of hierarchical information but a combination of learning references and learning objects.

As already obvious by these attempts to examine the visualisation of different kinds of information separately, the real value of visualisations can only be unleashed if all of the existing information is visualised jointly.

When trying to move beyond this more or less separated visualisation of these different kinds of information for a future implementation, visualisations of *multi-layered networks* should be considered as well. Nevertheless even though aiming an advanced visualisation, we have to remember that visualisations still have to meet their purpose and not be implemented for their own sake. Visualisations in PLIMS have to be designed to *facilitate* an effective and easy-to-handle management and utilisation of personal information.

Wrapping up...

This being said, the proposal and description of the concept, design, and implementation of PLIMS is completed.

PLIMS has been designed to...

- ▷ ... support modern learners and foster modern learning.
- ▷ ... manage modern learning.
- ▷ ... face the challenges of personal learning.
- ▷ ... be able to satisfy a learner's needs.
- ▷ ... allow the building of a personal information collection.

To achieve this and to particularly assist *individual learners* in facing the *challenges of personalised learning*, PLIMS provides a comprehensive support of *personal information management activities*—namely keeping, (re-)finding and m-level activities.

Ultimately, PLIMS supports an integration of personal information across five out of the six dimensions[32] curing *information fragmentation* (cf. chapter 7.1.3, p.178):

- ▷ An *integration across physical locations* is achieved by the different possibilities to integrate learning objects and additional information into PLIMS (cf. chapter 9).
- ▷ The *integration in the means of access and organisation* is accomplished by the provision of basic and advanced facilities to explore the learning repository previously created (cf. chapter 10.3).
- ▷ An *integration by grouping and inter-relating of items* is facilitated by the organisation of learning objects utilising hierarchical and non-hierarchical information provided in a supplementary index tier of the PLIMS architecture (cf. chapter 8.3.2).
- ▷ This promoted integration of hierarchical information additionally fosters an *integration with the current context.*
- ▷ An *integrative view on information* is delivered (cf. chapter 10.3.2).

[32] The support of *integrative facilities for data manipulation* can, at most, be described as partial. A direct manipulation of integrated information is only possible for the additional information used to organise information, however not an information item itself.

In summary, PLIMS constitutes a learning technology (cf. chapter 1.4.2) to be used for the purposes of personal learning and personal information management. Incorporating future enhancements—such as the integration of possibilities for collaboration and recommendation—PLIMS can even be depicted as a *social learning system* and, hence, belongs to the category of systems that has been previously identified as possible future direction for tools in modern learning.

The Finish Line

Recalling where we started—the point of departure (cf. chapter 7.2.1)—we have now reached the *finish line*: Being presented with an revisited information need, our learner is now able to satisfy his or her navigational information needs. Depending on the individual organisation of the learning repository, our learner may utilise the information of the supplementary index tier to narrow down the search and navigate to the desired information. Alternatively, a full text search may also be able to provide assistance in re-finding the desired information.

Assuming that all the advanced possibilities have been technically implemented as well, our learner will also easily be able to share the information just re-found with the group of fellow learners he or she is working with. If no group for collaboration has been formed so far, all of the learners gathered can actively choose to additionally collaborate in sharing their resources and form a new group of learners.

Part III

Evaluating Personal Information Management in Learning

11 PLIMS—an Evaluation

"Optimism is good for overcoming obstacles that are part of daily life, but over-optimism can blind us to adversities that need addressing."

Michael Shermer [She22]

The proposal of PLIMS itself has been completed in the last part of this work. However to establish a well-founded and complete picture of PLIMS, an important part is missing so far: the evaluation of what has been proposed.

Being a system supporting personalised learning, personal information management, and personal search, PLIMS unfortunately inherits the problems from these areas: the validation of its results. The area of personal information management evidently suffers from a lack of *ground truth*—that is a quality metrics to be used for an evaluation [Gon11, p.3]. Similar problems are reported from the area of personal search—where *"everyone has a unique collection of personal documents, which makes it difficult to compare the performance of one user against another"* [EL11, p.1].

As a consequence, the evaluation of PLIMS had to be specially designed and could not rely on existing schemes. To be able to deliver an evaluation result as comprehensive as possible, the approach followed within the scope of this work is split into two components:

- ▷ At first, PLIMS is compared to *existing related systems* to emphasise the distinctive features of PLIMS and its position in relation to what has been previously done.

- ▷ In contrast, the second part of the evaluation accomplished is implemented as a classical *user study* incorporating those people that PLIMS has been designed for—the learners.

11.1 Comparing PLIMS to Existing Related Systems

As tempting as it sounds to be a pioneer, the question that has to be answered first is: *"Hasn't it already been done before?"* And the obvious answer is: *"Of course."*—there are different approaches, projects, and systems targeting the solution of the same or at least problems very similar to those that this work has been dedicated to.

For that reason[1], an overview of the array of existing systems will be presented. Subsequently, a selection of related projects and systems will be introduced in more depth to be finally contrasted to PLIMS using three different approaches for the comparison.

11.1.1 The Array of Existing Systems for Personalised Learning, (Personal) Information Management, and Information Retrieval

Considering the wide area of different fields that this work spans across, there is literally a huge array of systems dealing with similar approaches that can, therefore, be claimed to be related to PLIMS and the overall scenario. To provide at least a brief, basic overview on existing systems, a short description based on four different groups systems is employed:

(Commercial) Search Appliances. The first group of systems summarises the area of *retrieval-focused* systems that enable the collection of data from different data sources—most of the time within an organisation—and assure the availability of these data in a desired scope. Starting with a commercial focus, the most general available search appliances are the Google Search Appliance[2] or systems like Inforce[3]. Moving from a commercial or organisational environment to an individual approach to search, desktop search systems such as, for instance, the Copernic Desktop Search[4] have to be mentioned.

[1] Parts of this section have already been published in [GSH12].
[2] Google Search Appliance—`http://www.google.com/intl/en/enterprise/search/`
[3] Inforce—`http://www.inforce.de/`
[4] Copernic Desktop Search—`http://www.copernic.com/en/products/desktop-search/`

Infrastructure Projects. The second group of systems covers comprehensive infrastructure projects that are settled in the widespread field from managing information and improving *information processes* to the guiding and supporting of *learning processes* and the management of *learning resources*. For that reason only some important infrastructure project are exemplary cited:

- ▷ On the one hand there are very general projects such as the MATURE project[5] or APOSDLE[6]. Where MATURE establishes a foundation for an improved process performance of knowledge workers and the organisations these workers contribute to [MAT09], APOSDLE is trying to find, support, and foster new ways to work, learn, and collaborate in order to support knowledge workers in taking on different roles performing their work tasks: worker, learner, and expert.
- ▷ On the other hand, more specific infrastructure projects have contributed to the sharing and re-using of learning resources. The Learning Resource Exchange (LRE)[7], for instance, provides an infrastructure service federating different systems that provide learning resources and, subsequently, offers a seamless access to these resources [Eur] [Mas09].

  Naming another important representative, ROLE[8]—actually a project pursuing a radical approach of adaptivity and personalisation for learning and, therefore, belonging to the fourth group of systems—also provides a comprehensive infrastructure and generic framework facilitating the interoperability across software systems and technologies [ROL13] which is why it can be cited within this group of systems too.

Systems for (Personal) Information Management. Moving from retrieval-focused systems to systems concerned with the compre-

[5]The MATURE project—`http://mature-ip.eu`
[6]APOSDLE—`http://www.aposdle.org`
[7]The Learning Resource Exchange (LRE) project—`http://lreforschools.eun.org`
[8]The ROLE project—`http://www.role-project.eu`

hensive objective of information management, organisational—and most of the time commercial—systems such as IBM Impliance[9], Cimple[10] from Yahoo! Research, or Microsoft's Stuff I've Seen[11] have to be named first. In addition there are general frameworks such as SMILA[12] enabling a unified information access[13].

Bridging the way towards *personalisation* but still allowing more than "just" personal information management, two different projects can be cited:

- ▷ NEPOMUK[14]—the Networked Environment for Personalised, Ontology-based Management of Unified Knowledge—provides an extension of the personal desktop that allows personal information management as well as a sharing of information. [NEP]
- ▷ The TENCompetence project[15] fosters the personal competence development throughout the journey of lifelong learning by providing a suite of software—the personal competence manager (PCM)—to support networks of individuals, teams, and organisations as well as LearnWeb2.0—a web application giving access to a number of Web2.0 tools [TEN09].

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[9] IBM Impliance is a next generation information management system enabling the storage, analysing, and search of all data within an enterprise among others to find trends and exceptions [Bha07].

[10] Cimple, a community information management platform project [DBR+07]—`http://pages.cs.wisc.edu/~anhai/projects/cimple/`

[11] Stuff I've Seen (SIS) is a system for personal information retrieval and reuse that provides a unified index of information across different information sources—such as emails, Web pages, documents, or appointments. Subsequently, these rich information can be used as contextual cues in the search interface. [DCC+03]

[12] The SMILA framework is a unified information access architecture that allows the building of databases from unstructured information and the implementation of a search solution to process and access this information subsequently [Ecl07].—`http://www.eclipse.org/smila/`

[13] A good and more comprehensive examination of personal information management tools can, for instance, be found in [KD10].

[14] The NEPOMUK project—`http://nepomuk.semanticdesktop.org/`

[15] The TENCompetence project—`http://www.tencompetence.org/`

Finally moving to software enabling an individual information management, existing systems are, again, providing a wide range of support: There are specialised commercial systems such as Citavi[16]—facilitating a comprehensive literature management—or freely available services like Evernote[17], Papers[18], or Instapaper[19] that allow a device- and location-independent collection of information for single users. In addition, social bookmarking tools as already cited in chapter 10.1.1 can also be assigned to this category of tools and systems.

Systems for Personalised Learning. The last group of systems that needs to be considered incorporating the scope of this work, are systems enabling and facilitating personalised learning. Very different approaches have been followed to provide this personalisation. As a consequence, different systems enabling this personalisation are available.

Starting with a more general approach to personalisation, CourseRank[20]—a social system, initially developed by the Stanford University InfoLab, that enables a course planning based on social recommendation as well as the monitoring of the individual progress [Staa]—can be named. Citing a completely different approach, GRAPPLE[21]—a generic responsive adaptive personalised learning environment—allows the integration of adaptive learning environments into prevalent learning environments such as learning management systems [GRA11].

Concluding the description of systems for personalised learning, there are of course the two different kinds of systems that have already been introduced as tools in personal learning (cf. chapter 4.3)—personal learning environments and e-portfolio systems:

- Examining explicit implementations of personal learning environments, a number of different tools can be found.

[16] Citavi—`http://www.citavi.com/`
[17] Evernote—`http://www.evernote.com/`
[18] Papers—`http://www.papersapp.com/papers/`
[19] Instapaper—`http://www.instapaper.com`
[20] CourseRank—`https://www.courserank.com`
[21] GRAPPLE—`http://www.grapple-project.org`

Naming just a few, PebblePad[22] or SymbalooEDU[23] are commercial systems that may also be used individually. Additionally there are proprietary systems that have, for instance, been developed by universities such as the PLE TU Graz[24] or myPaed[25] developed by the University of Darmstadt.

Moreover, systems like ROLE or the PCM—previously introduced as infrastructure projects or systems fostering the management of information throughout the journey of lifelong learning—can also be depicted as personal learning environments [Wik13g][Kew07, p.4].

▷ Proceeding to consider e-portfolio systems, there is a number of different existing systems[26] too. A system that has already been referenced as personal learning environment is PebblePad. PebblePad is, however, explicitly classified as personal learning space *and* e-portfolio system [Peb13]. Citing another example, Mahara[27] has to be named. Indeed, Mahara is the e-portfolio system that seems to be most prevalent—in particular due to its close resemblance to the learning management system Moodle. Mahara has, for instance, also been utilised in the project dikopost[28] at the University of Darmstadt.

11.1.2 A Selection of Related and Similar Systems

To be able to contrast PLIMS to existing systems more concretely, a selection of systems to be introduced in more detail needs to be derived from the array of systems presented above. For that reason, one or two representatives are selected from each group of systems just described with one exception: Even though contributing to the overall picture,

[22] PebblePad—`http://www.pebblepad.co.uk/`
[23] SymbalooEDU—`http://www.symbalooedu.com/`
[24] PLE TU Graz—`http://ple.tugraz.at/`
[25] myPaed—`http://www.mypaed.tu-darmstadt.de/`
[26] A more comprehensive list of e-portfolio systems can be found at `http://en.wikipedia.org/wiki/E-portfolio`.
[27] Mahara—`https://mahara.org/`
[28] projekt dikopost—`http://www.zfl.tu-darmstadt.de/dikopost_projekt/`

the group of general search appliance is not further considered due to its generality and the non-existent consideration of a learning context.

Starting with the group of *infrastructure projects*, *APOSDLE* is chosen as a more general representative due to its consideration of knowledge workers—that have been depicted as more general learners within the scope of this work (cf. chapter 2.2.2)—and based on its currentness. Additionally, *ROLE* is selected for a further investigation due to its dedication to learning and the fact that it has also been depicted as implementation of a personal learning environment.

The selection from the group of *(personal) information management systems* includes *LearnWeb2.0* as proposed within the TENCompetence project because 1) it is one of most comprehensive projects of the last years in this area and 2) due its unarguable connection to learning.

Finally, this selection is completed by two *systems for personalised learning*—an e-portfolio and a personal learning environment. More precisely, the *PLE TU Graz* is chosen to represent the category of personal learning environment due to its clear mission statement and the non-commercial setting this tool was built in. *Mahara* is appointed to represent e-portfolio systems due to its perceived prevalence.

To examine just one—but the maybe most conspicuous—non-selection, literature management systems and social bookmarking tools from the area of information management systems have explicitly been *not* chosen for a simple reason: each of these systems only manages references to information but not the information itself. A comparison to PLIMS would, therefore, just reveal the obvious missing but essential parts—that is the completely lacking consideration of (learning) content at all.

All in all, this derivation results in a selection of three flagship EU projects in the area of technology enhanced learning since 2005 and two exemplary systems for personalised learning that will now be examined in more depth depicted in chronological order regarding the project start.

The Personal Competence Manager & LearnWeb2.0

The Personal Compentence Manager and LearnWeb2.0 originated within the *European network for lifelong competence development*

(TENCompetence)[29]. TENCompentence was funded by the European Community under the Information Society Technologies (IST) priority of the 6th framework programme (FP6) for Research & Development[30] and ran from December 2005 to November 2009. By now, the TENCompetence foundation is coordinating the preservation and evolution of all project results.

Generally, TENCompetence targeted networked individuals and their lifelong competency development with a focus on on occupational certification [ML06, p.9]. The overall project result is the so-called *Personal Competence Manager (PCM)*[31] *"a web-based system designed to support individuals in developing their competences in order to achieve their personal goals"* [TEN09]. PCM is an integrative portal environment providing a flexible solution catalogue that is applicable at all levels of participation—for individual learners, teams, and organisations within various settings of learning [TEN09]. To provide this support, PCM integrates concepts from the fields of e-learning, human resource, and knowledge management. More precisely, PCM includes the following components [TEN09]:

Server Software. The technical foundation of PCM is Liferay—an enterprise Open Source portal and collaboration platform[32]. To be extremely adaptable Liferay uses the concept of *portlets*[33] and is already delivered with a number of out-of-the-box tools to customise a work environment. Supplementary PCM portlets provided by TENCompetence services—ensuring the desired functionality for the suite of portlets—and TENCompetence Learning Design services–engines, players, and servers for the Learning Design portlets—enable further customisation.

Portlets. As just mentioned, the integration of PCM with Liferay is achieved using customised portlets supporting the lifelong competence development. These portlets can be divided into two

[29] The European Network for lifelong Competence development (TENCompentence)—`http://www.tencompetence.org`

[30] Information Society Technology (IST) priority in framework programme 6 — `http://cordis.europa.eu/ist/`

[31] A demonstrator for the Personal Competence Manager is available at `http://pcm.tencompetence.org/web/guest`.

[32] Liferay—`http://www.liferay.com`

[33] Portlets are small software components that can be arbitrary plugged into a combined interface and displayed in a Web portal [Wik13h].

categories: 1) portlets supporting users in orientation, planning, execution, and the monitoring of tasks and 2) portlets enabling the creation and management of competence development networks and services.

Standalone Software. Ultimately, PCM is enhanced with three software packages that can either be used as standalone software or be integrated within the overall Liferay solution:

- ▷ The *ReCourse Learning Design Editor*—an editor allowing the development of IMS Learning Design[34] and IMS Question & Test Interoperability[35] learning units.
- ▷ *TENTube*—a web-based video tool fostering the creation of connections among community members and content.
- ▷ *LearnWeb2.0*—a web application allowing access to Web2.0 tools and information stored on institutional servers, centralised repositories, and community sharing systems.

LearnWeb2.0 is the application that relates to what is trying to be achieved with PLIMS. For that reason, LearnWeb2.0 will now be discussed in more detail.

A deeper look into LearnWeb2.0. LearnWeb2.0 is an application for the sharing, discovering, and managing of learning resources [AMNZ09b, p.154]. Roughly spoken, LearnWeb2.0 is a *meta Web 2.0 application* that integrates a number of other existing Web 2.0 applications. Being more precise, ten popular Web 2.0 services as shown in table 11.1 are integrated by LearnWeb2.0. Technically, these features are combined based on a Web2.0 service adapter as well an authorisation component. The main features of LearnWeb2.0 can be described using three core modules as introduced by Fabian Abel et al. [AMNZ09b, pp.156ff]:

Search and Exploration. By integrating all those different learning resources, LearnWeb2.0 provides a search interface allowing the resource discovery across all services; an advanced search enables

[34] IMS Learning Design Specification—`http://www.imsglobal.org/learningdesign/`

[35] IMS Question & Test Interoperability Specification—`http://www.imsglobal.org/question/`

Web 2.0 tools	Learning Objects	URL
blogger	blogs	http://www.blogger.com
delicious	bookmarks & links	http://delicious.com/
facebook	friends	http://www.facebook.com
flickr	images, videos	http://www.flickr.com/
groupMe!	groups	http://groupme.org/
ipernity	images, videos, word documents, audio files	http://www.ipernity.com/
last.fm	music, audio files	http://www.lastfm.de/
slideshare	presentations	http://www.slideshare.net/
vimeo	videos	http://www.vimeo.com/
youtube	videos	http://www.youtube.com/

Table 11.1: Web 2.0 tools integrated in LearnWeb2.0 [Zer][AMNZ09b]

the selection of resources based on additional information such as tags, file types, or timestamps.

Technically, a user's query is split into queries to all specific services on the server side whereas the result of these queries are, in turn, combined and presented jointly. Additionally, queries can be used as so-called *standing queries*. In that case, the query terms are used as initiation for an RSS feed that notifies the user if new matching resources are available.

Annotation and Aggregation. If a user adds a new resource to his individual repository, a reference to this resource is added. Resources can, therefore, efficiently be added to different learning contexts. Metadata can be manually appended using the Dublin Core standard (cf. chapter 8.2.1). All resources can be bookmarked, tagged, rated, and commented by all other users who are allowed to access this particular resource.

Besides, resources can also be aggregated by building on the GroupMe! functionality. In other words, users can individually bundle their resources to groups of learning resources. On top of this individual grouping, users can however also work in groups and collaboratively aggregate and contribute resources to a specific topic. RSS feeds for groups are also available to support these collaborations.

Upload and Sharing. Finally, arbitrary resources from the Web as well as local resources can be integrated or uploaded and shared using drag and drop features [AMNZ09a, p.1].

In summary these capabilities provide a seamless view of all individual learning resources—which is why LearnWeb2.0 can also be referred to as *personal Web 2.0 learning space*.

Advanced Process-Oriented Self-Directed Learning Environment

Particularly targeting lifelong learning, the EU project *Advanced Process-Oriented Self-Directed Learning Environment (APOSDLE)*[36] developed an environment to support learning while working—that is *"within the context of your immediate work and within your current work environment"* [APO06]. The project was also partially supported by the European Community under the IST priority of the 6th framework programme for Research & Development and ran from March 2006 to February 2010. A demonstrator[37] as well as an Open Source version[38] containing the APOSDLE platform, the APOSDLE client, and two exemplary domains have been released in the meantime.

Essentially, APOSDLE is trying to find, support, and foster new ways to work, learn, and collaborate to support the different roles knowledge workers take on performing their work tasks (cf. chapter 2.2): worker, learner, and expert. For that reason APOSDLE supports knowledge workers in learning during the execution of a specific work task, in learning collaboratively, and in learning from resources existing within the knowledge workers' organisation.

To achieve this six work packages have been defined—work processes, self-directed learning, contextualised collaboration, integrated

[36] The Advanced Process-Oriented Self-Directed Learning Environment (APOSDLE) project—`http://www.aposdle.org`

[37] Login and instructions for the APOSDLE demonstrator can be found at `http://aposdle-sda.know-center.tugraz.at/demo/`

[38] APOSDLE Open Source package, lisenced under GPL v3, is available for download at `http://www.aposdle.tugraz.at/results/downloads/opensource_packages`

knowledge structure, semantic spaces, and requirements, application, and evaluation—that result in two main contributions: 1) a *conceptual framework* for *work-integrated learning* based on two empirical studies and 2) a proof-of-concept *software framework* realising the findings and considerations of the conceptual work.

APOSDLE—a Close-Up. The *"integrated support for the learner, knowledgeable person and worker, and that it assists with learning activities within work and learning processes"* [LMPK10, p.2] is what distinguishes APOSDLE from other systems. To achieve this assistance, different services have been implemented:

Base: Semantic Models. APOSDLE is founded on a knowledge base formed by three interrelated semantic models as well as annotated documents from the organisation's repositories. This knowledge base represents the "intelligence" of APOSDLE [LMPK10, p.5]. As a consequence, APOSDLE needs to be customised to the particular learning domain at first by creating semantic models for work tasks, required knowledge, and learning topics using specific modelling tools [LKL^{+}06, pp.151ff].

Context Detection Services. Each user is characterised by a user profile. Building on the semantic models, this profile is automatically built by interpreting a user's interactions as knowledge-indicating events that support conclusions on a user's prior knowledge respectively a user's competencies. APOSDLE is now able to detect a user's context by analysing a user's current work task, prior knowledge, and the user's interaction within the system and with other users. [LMPK10, pp.2,4]

Recommender Services. Being aware of a user's context, APOSDLE subsequently reasons a user's needs and is able to recommend various artefacts relevant to the user. Artefacts are any documents from within the knowledge base or knowledgeable people—that are people with similar or more advanced skills. Users are, therefore, allowed to access artefacts from different knowledge sources without having to change the environment. [LMPK10, p.2]

Collaboration Services. As a next step, APOSDLE provides scripted support for collaborations between knowledge seekers and knowledgeable persons whereas transcriptions of these collaborations can later be shared with other and fed back into the system to enhance the existing knowledge base. [LMPK10, pp.2f]

Learning Guidance Services. Everything that has been described above can also be summarised as learning guidance services—that is the support of APOSDLE users in taking on their different roles as learners, workers, and knowledgeable people. Three steps—altogether fostering self-directed learning—deliver this guidance service: 1) informal learning support by suggesting knowledgeable artefacts, 2) an unobtrusive information delivery raising the awareness for knowledge resources, and 3) learning in context with resources. [LMPK10, p.3]

Bringing this description to a conclusion, the final evaluation implicated that APOSDLE works successfully in highly specialised domains whereas it is less effective in broad customer-driven domains [LMPK10, p.7].

Responsive Open Learning Environment

The *Responsive Open Learning Environment (ROLE)*[39] is supported by the European Commission within the FP7 Information and Communication Technologies (ICT) programme[40]. ROLE ran from February 2009 to January 2013. The ROLE project aims to *"empower learners for lifelong and personalised learning within a responsive open learning environment"* [MC] by providing 1) a user-centric approach to learning environments with a focus on end-user development to design and control a personal learning environment, 2) contemporary pedagogical models for personalisation in learning networks, self- regulated learning, and collaboration in networked communities, 3) contemporary engineering frameworks for designing, integrating, orchestrating,

[39]The Responsive Open Learning Environment (ROLE)—`http://www.role-project.eu`

[40]FP7 Information and Communication Technologies (ICT) programme, subprogramme "Digital libraries and technology-enhanced learning" (ICT-2007.4.3)—`http://cordis.europa.eu/fp7/dc/index.cfm`

and evaluating learning services, tools, and content, and 4) frameworks for evaluating learners interactions in learning networks [MC].

The most important foundation of ROLE is a radical approach of adaptivity and, therefore, personalisation: personalisation in terms of content, navigation, and the entire learning environment and its functionalities [ROL09]. As a consequence, ROLE aims to create a *"truly learner-centred personal learning environment"* [ROL09] or—quoting Martin Wolpers [Cen09], the main coordinator of ROLE—to finally proceed from rather just personalised learning to *individualised learning.*

A showcase platform[41] reports the current state of development and allows insights on software created. This platform also helps to describe the overall picture from a user's perspective [ROL]:

ROLE Tools are the software applications actually building the infrastructure. These tools in particular include applications similar or related to (personalised) learning management systems: 1) the ROLE Personal Learning Management System: a learning management system—CLIX[42]—enhanced with a personalised panel including learning widgets, 2) MUPPLE II: a mash-up personal learning environment helping a learner to trace and replay usage strategies on the web, and 3) OpenSocial[43] plug-ins for Moodle: a plug-in for Moodle allowing the integration of OpenSocial gadgets into Moodle and usage within the system. Further applications available are collaboration environments—such as Graaasp[44] or Confolio[45]—and several monitoring tools—for instance the Student Activity Monitor[46] or PAcMan[47].

[41] ROLE showcase platform—`http://role-showcase.eu/`

[42] Learning management system CLIX—`http://www.im-c.de/global/en/solutions/learning-management/clix-learning-suite/`

[43] OpenSocial is a common API, initially developed for social network applications—`http://code.google.com/intl/de-DE/apis/opensocial/`

[44] Graaasp collaboration environment—`http://role-showcase.eu/role-tool/graaasp-collaboration-environment`

[45] Confolio, a portfolio sharing tool—`http://role-showcase.eu/role-tool/confolio-personal-and-shared-portfolios`

[46] Student Activity Monitor—`http://role-showcase.eu/role-tool/student-activity-monitor`

[47] PAcMan, a personal activity manager—`http://role-showcase.eu/role-tool/pacman`

Widgets (& Widget Bundles) are micro applications—*"small portable Web-enabled application"* [KGP31, p.18f]—performing a dedicated task whereas tasks can be widespread and range from simple to more complex tasks [MC]. Widgets[48] constitute the content-related foundation of ROLE. It are these applications that the user is supposed to put together according to his or her personal learning style. Additionally, the ROLE showcase already provides a number of widget bundles assembling different widgets for a common purpose [MC].

In general, any suitable environment—even a general platform like iGoogle[49]—can be used to individually arrange these ROLE widgets and to build a *personal learning environment* as facilitated by ROLE.

ROLE in more Technical Detail. Two different kinds of underlying models constitute the foundation of the ROLE architecture: *data models of the static objects* and a *model of the learning process*:

- ▷ User, competence, domain, and context are static models. These four models represent the data that can be processed by ROLE services [KGP31, pp.2ff].
- ▷ A *learning process* in ROLE is defined as the *"acquisition of knowledge, skills, and competences by interaction with a learning environment that provides learning resources and appropriate learning context comprising different actors, tools/services, and artefacts"* [KGP31, p.11]. More precisely, the ROLE learning process model is based on *learning activities*[50]. Grouping these activities five learning phases can be identified: plan, prepare, learn, and reflect. Each learning phase is composed of different key activities—that can be grouped as mega-cognitive, cognitive, and enabling activities (cf. chapter 4.2.1) [KGP31, pp.14ff].

[48] Widgets and gadgets are basically used interchangeable within the scope of this work. A gadget acts like a widget and, most of the time, fulfils the same purpose, but it is proprietary and therefore only works within a particular environment [Nat]. A Google widget is, for example, called gadget [MC].

[49] iGoogle—`http://www.google.de/ig`

[50] The comprehensive list of learning activities supported and addressed within the ROLE project can be found in [KGP31, pp.36ff].

Being aware of these foundations, three core services or parts of the ROLE architecture—altogether forming a personal learning environment—can be identified:

Widget Service. A repository of widgets and widget bundles is provided within an open widget store[51]. Since there is a number of widgets, a taxonomy of tools delivering a learning-specific classification is also provided [KGP31, pp.41ff].

User Service. Acting on the assumption that learning environments change, the ROLE user service offers a stable place for user data. This service is completely user-centred and stores information such as competences, goals, learning history, learning progress, certificates, and preferences of a user [GD31, p.7]. The user data can either be gained by 1) users setting their profile explicitly or 2) monitoring the user's actions [GD31, p.20]. Subsequently, user data is accessible through resources[52] [KGP31, pp.20f].

Space Service. Finally, the concept of spaces completes the three core concepts. Put in simple, a space is a setting allowing a group of users to perform several activities [KGP31, p.19] and consists of metadata, administrators, participants, space resources, and tools (very likely widgets) [KGP31, p.21].

The core services as depicted above are complemented by a number of enabling service that are used by the widgets in the PLE platform. These enabling services basically provide data to widgets. Services included are a tracking service—monitoring the user's interaction within the system environment—a content service—providing a content storage and metadata management for repositories of artefacts—a concept reference service—for storing and sharing concepts on learning goals and competences—a recommendation service—recommending learning resources to the user—and a search service—retrieving content matching a search term. [KGP31, pp.21ff]

Additionally, these basis components complete the ROLE framework: an authentication component, an authorisation component, a

[51] The ROLE widget store—`http://www.role-widgetstore.eu/`

[52] A resource within the ROLE architecture denotes an identifiable entity that is ideally described with metadata. Most importantly, every resource is either assigned to a user or a space (cf. *Space Service*). [KGP31, p.19]

real-time messaging component, and an inter-widget communication component [KGP31, pp.23ff].

An Exemplary E-Portfolio System: Mahara

Mahara[53] is an Open Source e-portfolio system established in 2006—promoting itself as e-portfolio, blog, resumé builder, and social networking system[54] [mahb]. Interestingly, Mahara—being an e-portfolio system—is characterised as a form of *personal learning environment*, which is sort of contrary to the definitions given in chapter 4. This declaration is based on the one guiding principle leading the development of Mahara: a *learner-centred approach* explicitly contrasting institution-centric systems such as learning management systems. Nevertheless, the architecture of Mahara is *"inspired by the modular, extensible architecture of Moodle"* [mahb]; the core developer even view Mahara as a "sister" application to Moodle—which results in a single-sign on interface to Moodle. [mahb]

Mahara is a standalone web application. Hence, a typical web infrastructure is needed to actually use Mahara—that is a web server, a database server, and PHP. The philosophy of Mahara is constituted by two fundamentals:

1) Mahara is *"designed to leverage Web 2.0 web services and built with interoperability in mind"* [mahb].
2) Mahara is designed to complement a wider virtual learning framework of learners by enhancing it with a learner-centred personal learning environment [mahb].

Discovering Mahara's Core Features. The outstanding feature of Mahara is a flexible structure of artefacts, views, and groups:

Artefacts. Every item or information within Mahara is a so-called *artefact*. Artefacts also include profile information, blog posts, and resumé details. In addition, every information desired to be integrated into a learner's portfolio can be easily uploaded to the file repository. [Kir08]

[53] Mahara—`http://www.mahara.org`

[54] A demonstrator introducing the core features is available at `http://demo.mahara.org`. Mahara is freely downloadable at `https://launchpad.net/mahara/1.4`

Views. Artefacts within Mahara can be reused (and renamed) in different contexts by the utilisation of views that facilitate access control within Mahara. To initially present and share an artefact or a bundle of different artefacts, a view needs to be created. The creation of a view provides the e-portfolio owner with the possibility to 1) receive public or private feedback on a view or shared artefacts and 2) submit a view for assessment. Views themselves can be grouped to collections—granting the same access to a set of views and, respectively, pages. Moreover, a watch list allows one to easily keep track of changing views that have been shared with oneself. [mahb]

Groups. Finally, groups enable portfolio owners to share views or collections not only with single users but groups of users. As a consequence, groups can be used to support learning and social activities [Maha]. Depending on the particular system configuration, users can create groups and add users to groups—where groups can either have an open membership, require the request for membership, or be restricted to membership based on personal invitations. Within a group, views can be shared and open issues can be discussed using forums.

Of course, these three main components are supplemented by advanced features such as a blogging tool—allowing to create Mahara blogs or integrate existing blogs via RSS—a social networking environment—enabling users to build and maintain lists of friends, including messaging—and a resumé builder—facilitating the preparation of a digital curriculum vitae from within the e-portfolio system. Also, capabilities to maintain user profiles and accomplish system administration have been implemented and are provided—including the consideration of aspects like scalability, security, and interoperability. [mahb]

Personal Learning Environments—a Sample: PLE TU Graz

Being convinced that PLEs are *"the next generation environments which help to improve the learning and teaching behaviour"* [TETM09, p.997], the Graz University of Technology (TU Graz)[55] developed a

[55] Graz University of Technology—`http://www.tugraz.at/`

personal learning environment to be used throughout the university. The platform is in productive service since October 2010 [56] [Ebn10].

Put simply, the PLE TU Graz enables aggregation. Naturally this aggregation incorporates different services from distributed (learning) portals within the university. However in addition public applications from the Web can be included as well [EST^{+}11, pp.29f]. The metaphor this PLE employs is those of a *personal desktop* build within a web browser [Ebn10]. More precisely, this personal desktop is composed using two different components—*spaces* and *widgets*:

Spaces. The personal desktop is composed of different spaces (or walls) that can be individually filled with widgets from a widget store[57]. The number of spaces can be individually managed. Notifications from the widget can be displayed on spaces.

Widgets. Confirming the previous definition, widgets comprise a number of various tools. Widgets can be learning tools—such as a Chinese vocabulary trainer or a matrix calculator—, TU Graz services—like a search widget for the library or an integration of TeachCenter[58], the TU Graz course management system—, communication tools—integrating various mail services or social networking tools as Facebook or Twitter—, or even games. There is also a category called "miscellaneous" including everything that cannot be categorised but is useful in particular cases—such as a number of different dictionaries, Google services, a LaTeX formula converter, an integration of Slideshare or Scribd, etc.

Technically, the PLE is based on the *model-view-controller (MVC)* pattern[59] and uses common web technologies like HTML and JavaScript [Ebn10]. An interesting—however, so far future—aspect are the plans on extending the PLE by using recommender technologies. Different usages scenarios have been (theoretically) outlined so far: 1)

[56] The PLE TU Graz—`http://ple.tugraz.at/index.php/users/index?ref=extern`. A guest account for anyone interested is provided—login: gast, password: gastgast

[57] To date (2013-04-02) 78 widgets are available.

[58] TU Graz TeachCenter—`http://tugtc.tugraz.at/`

[59] The Model-View-Controller (MVC) pattern is an architectural design pattern describing 1) a separation of concerns between, domain, application logic, and presentation and 2) an interaction pattern. For more information on MVC see [LR09].

a study path recommender, 2) a widget recommender, 3) a peer student recommender, and 4) a hybrid recommending system combining aspects of the previous three recommending systems. [EST+11, pp.33f]

11.1.3 Contrasting the Scope of Systems

By contrasting what has been proposed within in the scope of this work with a selection of existing systems, a validation of this proposal can be achieved. Having set the task of comparing different systems, requirements and reference criteria have to be defined. Within the scope of this work, a validation of PLIMS will be achieved by a gradual approach of the application domain in three steps:

1) Hereinafter all systems within this comparison are tried to be classified and categorised as e-portfolio systems according to the definitions that have been previously given in chapter 4.3.1.

2) Moving from a well-defined tool to the less accurately defined concept of a personal learning environment, one of the definitions already given as description of personal learning environments in chapter 4.3.2 is employed in order to qualify the considered systems as personal learning environments.

3) Finally, a functional distinction based on operational characteristics of the proposed system is used to underline special features of PLIMS and ultimately contrast the systems selected for this comparison.

Different Kinds of E-Portfolios?

Explicitly aiming at personalised learning within the scope of this work, it is reasonable to start this comparison with an attempt to classify the selection of systems—including PLIMS—as those tools that have been identified as suitable for personalised learning: e-portfolios and personal learning environments.

This section starts with the validation of a all system as e-portfolios. Even though almost none of the selected systems is initially classified as an e-portfolio, this section will show that all of the systems can yet be classified as e-portfolios and, as a consequence, support portfolio work and personalised learning. This validation will be achieved using two different verifications:

- ▷ At first, the dimensions of working with an e-portfolio will be used to determine the extent of support that each of these systems is able to provide for portfolio work.
- ▷ Subsequently, the taxonomy of e-portfolio systems is employed to detect the specific type of e-portfolio depicted by each system.

Dimensions of Working with an E-Portfolio. As introduced previously (cf. chapter 4.3.1), the ideal support provided by an e-portfolio implementation can be described using the dimension of working with an e-portfolio. Whereas the first of these dimensions—the determination of the purpose and context of an e-portfolio—is omitted in this evaluation for obvious reasons, the following four dimensions can be employed for a characterisation [HHP06, pp.5ff]:

1) The collection, selection, and attachment of artefacts to educational objectives,
2) the facilitation of reflection and regulation in a learning process,
3) an enabling of an appropriate presentation and sharing of artefacts, and
4) the assessment and evaluation of the developed competencies

The resulting validation matrix is shown in table 11.2. Briefly reasoning the classification for PLIMS, it can be easily verified that PLIMS provides a comprehensive support for the collection of artefacts as well as a number of different possibilities to present the artefacts to a learner. However, capabilities for the sharing of artefacts—that is collaboration—have been conceptually considered in PLIMS but not put into practice—which is why a comprehensive support for the presentation and sharing of artefacts could not be assigned. Reflection and a subsequent regulation of the learning process is targeted at by the design of PLIMS; a proven support can however not be assigned too. Completing the classification, assessment and evaluation have not been implemented in PLIMS due to the fact that it has not been considered relevant for individual learners.

	PLIMS	LW2.0	APOSDLE	ROLE	Mahara	PLE Graz
Collection	✓✓	✓✓	✓	✓✓	✓✓	✓
Reflection/ Regulation	○	○	✓[(1)]	✓[(2)]	✓✓	✓[(1)]
Presenting/ Sharing	✓	✓✓	✓	✓✓	✓✓	✓
Assessment/ Evaluation	×	✓	○	✓	✓✓	×

✓✓ comprehensive support

✓ partial assistance; ✓[(1)] reflection on work tasks; ✓[(2)] regulation by changing integrated tools

× no implementation

○ not applicable/no given evidence

Table 11.2: Dimensions of working with an e-portfolio as validated for selected systems

Obviously, Mahara—being an e-portfolio system—implements all desired features and provides the most comprehensive support for portfolio work. Nevertheless, this evaluation reveals that all of the selected systems—including PLIMS—can be used for several dimensions of portfolio work. More precisely, the actual collection of artefacts as well as presentation and collaboration are supported particularly fine throughout all systems, whereas activities concerning learning as a process are supported less consistently.

A Categorisation. Having confirmed that a labelling of the selected systems as e-portfolio is actually feasible, a categorisation of all systems to determine the specific type of e-portfolio within the taxonomy of e-portfolios as previously defined (cf. chapter 4.3.1) is now realised.

Recalling the taxonomy as proposed by Peter Baumgartner et al. [Bau12], three *basic types*—reflection, development, and presentation portfolios—were identified at first, followed by the addition of *ownership*—personal or institutional—and the *orientation*—product or process. This iterative classification process is now applied to each of the selected systems:

PLIMS. The primary concern can clearly be identified as *reflection* just as the absolute *personal* ownership. The orientation is, however, a little more difficult to determine: Processes are crucial to build and enhance the repository and, therefore, implicate the need to reflect learning processes. Nevertheless, the result of these processes is what matters. Therefore, the decision was taken to assign a *product* orientation.

LearnWeb2.0. Starting to assign a basic type, LearnWeb2.0 also aims to foster *reflection* since it is designed to facilitate personal information management. Ownership is completely *personal* since most of the data is integrated using existing Web2.0 services. The orientation LearnWeb2.0 adopts is summative and, therefore *product*-based.

APOSDLE. Supporting knowledge workers in learning is nothing but assistance in career *development*—induced by a particular company and, hence, *institutional*. Even though learning is supported within the process of accomplishing work tasks, the overall goal is to enhance worker productivity—that is to either arrive at a result faster or to reach a superior result. Therefore, APOSDLE is identified as being *product* oriented.

ROLE. Since ROLE is explicitly targeting a learning environment for lifelong usage, the categorisation as development portfolio could be reasoned. However, the focus is also on learning—obviously, a personal inner process of an individual being—which is why *reflection* is chosen as appropriate basic type within this classification. The ownership is *personal*, even though provided from an institution, since the data integrated is under the control of a learner. Concerning the orientation, ROLE is perceived to be more summative than formative and, hence, *product*- oriented.

Mahara. Being an e-portfolio system, the determination of a basic type is difficult: Mahara can be used to create and present one's resume—that is for presentation—or as a companion exploring and taking advantage of career possibilities—which would correspond to a development portfolio. However, concerning that

	Portfolio Category
PLIMS	learning product portfolio
LearnWeb2.0	learning product portfolio
APOSDLE	job portfolio
ROLE	learning product portfolio
Mahara	learning product portfolio
PLE TU Graz	learning product portfolio

Table 11.3: Determined portfolio categories for each of the selected systems

the support of personalised learning is the probably most prevalent scenario—and even though every other assignment would be reasonable, too—*reflection* is assigned as basic portfolio type. Ownership is, nevertheless, always *personal* due to comprehensive control of granted to a user. The orientation can, again, be formative as well as summative—however, with a slight advantage on latter leading to a *product* orientation.

PLE Graz. The platform PLE TU Graz mainly focuses on supporting learning within a university context which leads to the appropriate basic type *reflection*. Even though the platform itself is a proprietary development, the ownership is—also due to integrated widgets—assigned to be *personal*. Concerning the orientation, the PLE TU Graz adopts a summative perspective on learning and is, therefore, clearly *product*-oriented.

Summarising the classifications accomplished above and transferring all assessments to the overall taxonomy of e-portfolios, the resulting determined portfolio categories are shown in table 11.3. Consulting this categorisation it has to be kept in mind that this classification explicitly tried to assign "just" one manifestation of each criterion. However, very often—in particular in a university environment—distinctions are not always obvious [Bau12, p.47].

Nevertheless, as a result it is revealed that most of the systems are actually targeting the same direction—even though the systems themselves are very different.

Categorising Personal Learning Environments

Proceeding the evaluation of these systems and investigating the usability for the scope of personalised learning, each of the selected systems is now analysed for its fit as personal learning environment. To be able to qualify these systems as personal learning environments, a slight modification of the seven crucial aspects of personal learning environments as introduced previously (cf. chapters 4.3.2) is employed.

More precisely, six out of the seven criteria are based on the previous description of crucial aspects whereas the seventh criterion is added as particular reference to mashup personal learning environments (cf. chapter 4.3.2). All of these criteria have been validated based on a rating a described hereinafter. The results of this validation are shown in table 11.4.

	PLIMS	LW2.0	APOSDLE	ROLE	Mahara	PLE Graz
Role of Learner	✓	✓	×	✓	✓✓	✓
Personalisation	✓	✓	×	✓	✓	✓
Variety of Content	✓✓	✓✓	×	✓	✓✓	✓
Social Involvement	×	✓✓	✓✓	✓	✓	×
Data Exchangeability	×	✓	×	○	✓✓	○
Linkage to Traditional Systems	✓ (2)	✓ (1)	○	✓✓ (1)	✓ (1)	✓ (2)
Mashup Integration	○	✓✓ [3]	○	✓✓ [2,3]	○	✓✓ [3]

✓✓ comprehensive support

✓ partial assistance

(1) integration into traditional LMS; (2) loosely coupled implementation

[1] service integration; [2] provision of a personal dashboard; [3] implementation of a new framework

× no implementation/unavailable

○ not applicable/no given evidence

Table 11.4: Crucial aspects of personal learning environments validated for the selection of system

Role of Learner. A comprehensive support of this criterion is in particular characterised by the opportunity to create own content. Partial assistance is, therefore, attested if content creation is only possible regarding the artefacts actually integrated in the environment—that is the content of the repository. However, in terms of creating new learning content it has to be drawn on content created elsewhere—such an application integrated using a widget.

Extent of Personalisation. By definition the extent of personalisation explicitly includes the design of the look and feel of a personal learning environment. Hence, the absence of this possibility for individual configuration leads to the assignment of partial assistance instead of comprehensive support.

Variety of Content. Being able to include almost every artefact desired to be part of a personal learning environment, depicts a full support of the variety of existing content. In contrast, partial assistance is available if the possible integration of content is determined by existing widgets and, therefore, restricted.

Social Involvement. A comprehensive support of social involvement is constituted of two parts: 1) the possibility for collaboration and 2) the understanding and usage of communities as foundation of a personal learning environment. Where collaboration is fostered but this strong commitment for communities as foundation of the learning environment is missing, assistance is considered to be partial.

Data Exchangeability. A comprehensive support of data exchangeability implies that *all* data stored within the system can be exported and transferred to another context. If at least parts of the data can be reused, partial assistance is assigned.

This criterion is marked as non applicable if—apart from data concerning the design and usage of the personal learning environment—there actually is no data within the system due to the usage of widgets integrating views on data from external sources.

Linkage to Traditional Systems. The intentional consideration of traditional learning systems not limited to a particular system is considered to amount to comprehensive support. The limitation to a particular system is classified as partial assistance.

Additionally, an index is used to denote the nature of integration: (1) reveals an integration of the system into a traditional learning management system whereas (2) indicates a loosely coupled implementation on top of existing learning management systems.

Mashup Integration. As defined in chapter 4.3.2 there are different ways to implement mashup personal learning environments. A comprehensive support of this criterion, therefore, implies the selected system to be a mashup learning environment. This feature is simply not applicable if the selected system is no mashup learning environment.

The index given signifies details on the technical realisation: [1] depicts a service integration of additional features into learning management systems, [2] implies the provision of a personal dashboard, and [3] describes the implementation of a new framework.

Again briefly justifying the classification of PLIMS as just made, it can be determined that PLIMS partially supports the *active role of a learner* as the creator of content since learning content cannot be created directly within PLIMS. The content to be integrated into PLIMS as well as its organisation is, however, completely under the control of an individual learner. The *extent of personalisation* does not include the look and feel of PLIMS which leads to partial support of personalisation. The *variety of content* is, however, comprehensive due to the various possibilities to integrate a number of differing formats and learning objects. Even though *social involvement* has been conceptually discussed and is generally feasible on different levels, collaboration has not been implemented yet. The subject of *data exchangeability* has not been further discussed throughout the scope of this—even though actually possible within Zotero—which is why this feature has been classified as not applicable.

Proceeding to the technical implementation, PLIMS establishes the *linkage to traditional systems* based on loosely coupled connections—the translators as discussed in chapter 9.2.2—but only enables a connection to Moodle so far. For that reason, assistance has been assigned to be partial. Finally it can be stated that PLIMS clearly is not a *mashup* learning environment.

In summary, the foundation of personal learning environments—that is *personalisation*—is supported throughout almost all selected systems, at least to a certain extent. However as far as known none of the selected systems allows for complete personalisation since an individual design concerning the look and feel is not fully supported in any of these systems.

In contrast to the categorisation of the selected systems as e-portfolio systems—where a common course could easily be confirmed—the consideration of all other criteria in this classification reveals very different focus areas of these selected systems. It has also been confirmed, as was clear from the last section, that APOSDLE falls out of alignment due to its very special setting within a working environment and the strong commitment to domain knowledge.

A Functional Differentiation of Selected Systems with PLIMS

Building on the two previous distinctions classifying the selection of systems as e-portfolios and personal learning environments, this section finally derives a distinction of these systems based on a functional differentiation—basically to emphasise the core features of PLIMS.

Designing such a functional comparison, different approaches can be followed—in particular if considering the different areas that this work relates to:

- ▷ The main concern of this work can be clearly identified as *learning*. Searching for guidelines to evaluate the design of learning environments, Allan M. Collins [Col96b] can be cited.

  Even though Collins published his guideline 15 years ago—which seems to be ages away considering the technological evolution since that time—his examination of design issues for learning environments and the trade-offs that have to be made is still considered to be valuable. However where each of these design decisions and trade-offs could easily be reasoned for PLIMS[60],

[60] More precisely, Collins proposes four categories that should be considered in designing a learning environment: *learning goals*, *learning context*, *sequence*, and *teaching methods*—where each of this categories comprises a number of trade-offs that need to be addressed by designers. Citing an example for each category, learning environments can be designed to either target a resulting diverse or uniform expertise of learners, be teacher-controlled or learner-centred, enable

the same decisions cannot be reasoned for every other system in the selection without guessing.

▹ Proceeding the examination of guidelines from related areas, the field of *(personal) knowledge management* can be of assistance. This comparison could, for instance, also build on the components of the Munich Model (cf. chapter 3.2.3 and 4.2.2)—namely knowledge representation, knowledge utilisation, knowledge communication, and knowledge generation in combination with knowledge goals, knowledge evaluation, and stress and failure management—that has been proposed as merge of learning and knowledge management.

Ultimately, it seems however to be more appropriate to utilise a guideline with a technical focus when functionally differentiating technically implemented systems.

For that reason, a general classification of the functionalities of *information systems* as initially described by Otto K. Ferstl and Elmar J. Sinz [FS08, p.1] is adapted as structuring guideline for this functional comparison. The utilisation of this guideline for the purpose of this work can be justified by the work of Anja Lorenz et al. [LSE11] who transferred this abstract definition of requirements for information systems to universal characteristics of information systems for learning (and teaching) and confirmed the validity of these characteristics. Since all systems selected are intended to be of assistance in learning—and are, therefore, information systems for learning—these categories are used to structure the following comparison.

Very basically, information systems for learning—just like any other information system—therefore need to support 1) the acquisition of information, 2) the transmission of information, 3) a subsequent transformation of information, 4) the storage of information, and finally 5) the provision of information [LSE11, p.2].

Eventually before proceeding with this comparison, it is important to signify that this comparison explicitly utilises PLIMS as reference system and is for that reason biased.

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structured or exploratory learning, and focus methods of articulation or reflection. In the case of PLIMS, this would result in a characterisation as a system to gain *diverse* expertise by allowing *exploratory* learning in a *learner-centred* environment fostering *reflection*. [Col96b, pp.349ff]

The Acquisition of Information. The variety of content to be integrated has already been examined in the previous evaluations; the different types of content or information to be collected have however not been considered so far.

Using PLIMS as reference system, three important types of content can be distinguished: learning objects—the artefacts building the foundation of the learning repository—as well as additional hierarchical and non-hierarchical information—learning context and learning references.

Concerning the actual acquisition or collection of information, the basic possibility for the acquisition of information is depicted by a manual addition of content. However in addition, PLIMS also allows a semi-automatic addition of information from recognised *points of learning* and has been designed to integrate an active learning mode in a later stage of implementation (cf. chapter 9.2).

Seeking for these two distinctive features within the systems selected for a comparison, the following situation can be determined:

- All of the selected systems allow an integration of learning objects to actually build a learning repository—even though APOSDLE limits this integration to a certain predefined domain. In addition, all of the selected systems also enable the integration of supplementary non-hierarchical information—most of the time implemented as a tagging functionality.

  However as far as ascertained, none of the selected systems allows for a flexible but still *hierarchical classification* as provided by PLIMS.

- The actual integration of information occurs on a manual basis in LearnWeb2.0, ROLE, Mahara, and within the PLE TU Graz. In addition each of these systems provides some kind of automation due to the fact that the information items can be harvested from other sources—such as Web2.0 tools for LearnWeb2.0. APOSDLE forms an exception since it is based on an preceding analysis of the learning domain.

  Again, as far as known, none of the selected systems implements a mode similar to a, at this point still future, *active learning mode* in PLIMS.

The Transmission of Information. The category of information transmission is applied rather figuratively to describe the re-use of information by exchanging this information with others—that is nothing but *collaboration* (cf. chapter 10.1). Even though not yet implementing collaboration, PLIMS has been designed to enable and facilitate collaboration at a later stage.

An examination of possibilities for the further transmission of information within collaboration scenarios reveals a simple but crucial fact:

▷ Considering the transmission of information in terms of facilitating collaboration, all of the selected systems are actually ahead of PLIMS. Each of these systems already implements collaboration scenarios in various depth.

The Transformation of Information. An acquisition of information is in particular reasonable if there is a suggestive subsequent utilisation of this information. This claim is aimed to be met by PLIMS through the integration of additional assistance services: the integration *recommendation* techniques into PLIMS—where the actual implementation, again, has to be achieved in a future version of PLIMS. Nevertheless, the conceptual design has already been proposed—in particular by the utilisation of spreading activation techniques (cf. chapter 10.2).

A differentiation of the selection of systems based on the implementation of recommendation technique reveals a quite widespread picture:

▷ Considering APOSDLE, recommendation is actually one of the constituting components providing the support to knowledge workers during their daily working routines and processes.

▷ Strongly building on the support of communities in learning, LearnWeb2.0 and ROLE already integrate different recommendation services. LearnWeb2.0 utilises so-called standing queries for the continuous recommendation of information items supposed to be of interest for a learner, whereas ROLE provides profound recommendation services based on advanced recommendation techniques.

▷ As far as determined within this examination, neither Mahara nor the PLE TU Graz offer any recommendation services.

The Information Storage. One of the crucial factors differentiating PLIMS from the selection of other systems is the storage of information. Within PLIMS all of the information gathered is, at first, stored completely locally. This results in a storage location and *ownership of data* thoroughly within the responsibility of a learner. In other words, a learner retains the complete freedom of choice on transmission or sharing of data. As a consequence, a learner is also free to drop his or her sole ownership of data and share parts or the whole content of a learning repository with fellow learners.

An examination of the information storage in the selection of systems to be compared to PLIMS reveals an interesting situation:

▷ Although designed for learners acting on their own, all of the systems selected only provide a certain extent of such personal ownership. LearnWeb2.0, ROLE, and APOSDLE are—in varying extents—based on central repositories and the integration of public and personal data into this central repository of artefacts to be able to provide the information to others. None of the information to be used within one of these systems can be saved locally; information has always to be submitted to the central repository first. Of course, a personal ownership of data can still be put in place if desired.

▷ The e-portfolio system Mahara constitutes the sole exception from within this selection: even though the data is also stored on a central repository, the ownership of data is essential and, therefore, always solely granted to a learner at first.

▷ The PLE TU Graz does not allow the integration of personal content at all—or at least just to a very wide extent as, for instance, the visualisation of data from a Dropbox[61] account within one of the widgets displayed.

The Provision of Information. Concluding this differentiation, the provision of information needs to be discussed. PLIMS ensures the appropriate availability of all the information collected. One of the most distinctive feature is the availability through basic and advanced

[61] Dropbox is a free service offering cloud storage and file synchronisation—`https://www.dropbox.com/`.

search features—that is 1) the utilisation of all the information for the purpose of searching and 2) a facilitation of *exploratory search* by browsing the repository (cf. chapter 10.3.1). Of course, learning objects and supplementary information relevant are visualised at any time.

Investigating the existence of these features within the selection of systems, the results show that visualisation and navigation have been considered important throughout all these systems:

- ▷ All of the systems provide a basic visualisation of the information collected within each system—even though varying in the level of aggregation employed in these visualisations. Moreover, each system allows the utilisation of existing non-hierarchical information—tags—as important clues for searching the information within a system.
- ▷ As a particular reference, ROLE has to be cited. The widgets provided within ROLE included widgets such as, for instance, "knowledge map" that allow an advanced exploration of knowledge.

A Summary. To summarise and complete this comparison, the six dimensions of integration proposed by William Jones [Jon07, pp.41ff] and previously introduced as a solution to the major issue of *information fragmentation* (cf. chapter 7.1, p.178) are employed one last time.

Each of the systems within the selection is characterised regarding the achieved integration of fragmented information along these dimensions. The results of this classification are also shown in table 11.5, where the determination of each dimension of integration has been established as follows:

Integration...	PLIMS	LW2.0	APOSDLE	ROLE	Mahara	PLE Graz
... across physical location	✓✓	✓✓	✓	✓✓	✓✓	✓
... in the means of access/organis.	✓✓	✓✓	✓	✓	✓✓	✓
... by grouping/inter-relating items	✓✓	✓✓	×	✓	✓✓	×
... in views on information	✓✓	✓	✓	✓	✓	✓
... of facilities for data manipulation	✓	✓	✓	✓	✓	×
... with the current context	✓✓	✓	✓✓	✓	✓	×

✓✓ comprehensive support

✓ partial assistance

× no implementation/unavailable

Table 11.5: Dimensions of integration as achieved by the selection of systems

Integration across physical location is attested for those systems allowing the integration of any content—no matter where this information is originally located. For that reason, this kind of integration is actually a modification of one of the criteria for the classification as personal learning environment—the variety of content. As a consequence, if the information to be integrated is restricted to certain sources, partial assistance has been assigned.

Integration in the means of access and organisation unifies the information previously integrated into the system—for instance by the provision of search facilities. If all of the information to be combined can be accessed and organised jointly and if the system provides an appropriate search facility, a comprehensive support is attested. If any of these possibilities is missing, a system can only reach partial assistance of this integration.

Integration by grouping and inter-relating of items moves beyond a simple collection of information and allows an advanced organisation of items by utilising folders, (sub-)collections, or any other grouping of information. If this grouping and inter-relating of items is facilitated throughout the system, a comprehensive support is assigned. The provision of only basic possibilities for organising information results in partial assistance.

Integrative views on information comprise the transfer of the advanced possibilities for organising information to appropriate visualisations. If the information items themselves as well as additional information are displayed altogether, this dimension of integration is comprehensively supported. If this view is somehow restricted, only partial assistance is facilitated by a system.

Integrative facilities of data manipulation complete a thorough personal information management. A comprehensive support is assigned to systems allowing the direct manipulation of integrated information items. A partial assistance of systems is described by the possibility to manipulate more than just one piece of information by adapting additional information used to organise information—however not an information item itself.

Integration with the current context finally describes a preservation of the initial context of information. If systems provide an explicit possibility to keep this context, a comprehensive support of this dimension of integration can be assigned. If this opportunity is not explicitly provided but the context can still be kept utilising other features such as tags, a partial assistance is attested.

Once again briefly reasoning the classification as decided for PLIMS and as already described in the summary of part II completing the proposal of PLIMS, it can be stated that—besides a full support of data manipulation—PLIMS implements a comprehensive support across all dimensions of integrating information and, therefore, assists in curing the fragmentation of information.

In summary, it should be clear that PLIMS is justifiably classified as a system supporting *personalised learning*, *personal information management*, and *personal search.* As far as known, there is no existing system trying to smooth the process of assembling all information related to an individual learning process as well as facilitating new learning insights by providing

- comprehensive support to set up a personal information collection,
- sufficient search and navigation possibilities to efficiently re-find and re-use learning material within this collection,
- and a cure to *information fragmentation* by the utilisation and visualisation of single information pieces and additional information.

The concepts for systems closest to PLIMS are *e-portfolios* and *personal learning environments.* Strictly speaking, however, PLIMS misses these two categories: to be fully classified as an e-portfolio PLIMS would have to explicitly support the reflection and regulation of learning processes and an assessment; to unexceptionally be a personal learning environment, PLIMS is too much of a system and less of an environment allowing the integration of other widgets. Nevertheless, the first two sections of this evaluations have shown that a number of systems can actually be classified as e-portfolio and personal learning environment in a broader sense. So does PLIMS.

One of the crucial distinctive features[62] of PLIMS is the fact that it can be used as part of an *individual initiative* without depending on institutional access or a server-dependent availability. However to be fully competitive with the selection of systems it has been compared to, *collaboration*[63] and *recommendation* as already outlined have to be implemented into PLIMS.

11.2 Passing PLIMS to Learners: a User Study

Completing the evaluation, this section delivers an evaluation of PLIMS by those people that PLIMS has actually been designed for—the *learners*. Considering that PLIMS has been introduced as solution to "what learners in personalised learning need", the question if the design and implementation of PLIMS have successfully created a tool supporting personalised learning cannot be answered without asking those intended to use PLIMS.

To be able to actually assess the real value of PLIMS for learners moving on *individual learning paths* throughout their journey of *lifelong learning*, a study would however have to accompany different learners for a considerably long time in *real world learning scenarios*. Different reference groups—learning and managing their information with and without the support of PLIMS—as well as an appropriate monitoring of these groups would be required. Due to a limited scope of time a comprehensive study like that could not be accomplished within the scope of this work.

As as consequence, other ways and means had to be taken to be able to evaluate PLIMS and its benefit for learners—at least to a certain extent. For that reason, this section describes the design, results, and

[62]Most importantly, it has be to accentuated that this whole comparison did not set out to discredit the systems PLIMS has been compared to but rather to emphasise the specifics of PLIMS and justify its proposal and existence.

[63]The transfer of the learning repository from a local to a web-based store that is still only accessible by a learner, constitutes a first step towards a subsequent sharing. In turn, this transfer of course rescinds the independence and brings at least some sort of dependencies to server-based availabilities.

implications of passing PLIMS[64] to learners within a small but carefully designed user study.

11.2.1 The Design of the Study

Designing a user study to obtain a basic evaluation of PLIMS, it has to be determined what it is exactly that ought to be evaluated. PLIMS is, at first, aimed to be evaluated as a whole. To achieve this, any of the product qualities suitable for an evaluation of the user experience—namely the utility, usability, visual attractiveness, and hedonistic quality [SK10, p.262]—can be selected. For the evaluation achieved within the scope of this work, the most common scenario—that is an evaluation of the general *usability* of PLIMS—has been chosen:

> *"Usability describes the extent to which a product (e.g. tool) can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use."* [SK10, p.262]

Proceeding to implement this user study, there are a actually a number of methods[65] to be chosen from but also two common approaches that can be utilised: a log-file analysis or a laboratory-based user study [EMA09, p.280]. In the present scenario the latter one has been chosen. On this account, the set-up of the user study is described next followed by the introduction of the questionnaire that has been used to gain the users' feedback.

The Set-Up of the User Study

To conduct a laboratory-based user study and to be able to evaluate the utilisation of PLIMS by learners and the resulting (perceived) usability, a number of evaluation sessions have been designed and scheduled—each session was designed to last 90 to 120 minutes. For reasons of

[64]Within these descriptions, the part of PLIMS that has actually been technically implemented and was, therefore, able to be evaluated is either referred to as PLIMS or extended Zotero.

[65]A brief examination of 16 different methods to determine the usability of software can, for instance, be found in [Bes].

consistency and to subsequently ensure the interpretability, each evaluation session was structured identically[66].

At first, a live demonstration introduced the relevant functionalities of PLIMS to all participants of each evaluation season. This demonstration followed a previously defined protocol to ensure its consistency across all sessions and was assumed to last about 25 minutes. As a matter of fact, the actual duration was however depending on the number and intensity of questions the participants were asking during and after this demonstration. Having completed this introduction, the participants started working with PLIMS.

To further structure the evaluation sessions, all participants were presented with a task sheet including instructions to be followed while working with PLIMS (cf. appendix A.1). More precisely, these instructions included two different tasks to be fulfilled during the session:

Getting to know PLIMS. The first task was designed to allow an individual *get to know* of PLIMS by actually utilising the extended Zotero and its functionalities. Since the focus was on an active engagement with PLIMS, no specific subject or learning goal was implemented within this task.

As a consequence, the presented task included instructions to perform actions resulting in 1) the *collection* of information items to be integrated into the repository—based on the different capabilities of PLIMS for collecting items such as the manual addition of local and web-based learning objects as well as the utilisation of *translators*, 2) the *organisation* of the items just collected using *collections*, non-hierarchical *learning references*, and hierarchical *learning context*, and 3) the *search* for objects employing basic and advanced possibilities for searching the repository.

For the sake of completeness it has to be mentioned that this introductory task was complemented by a final sub-task ensuring the cleansing of the system to be able to make a fresh start for the second task.

[66] All the information on these evaluation sessions as well as PLIMS—the extended Zotero—has been presented to the participants of the study using a Moodle course and is, therefore, still available at `http://vc.uni-bamberg.de/moodle/course/view.php?id=2043`

A Learning Task. In contrast to the first exercise, the second task was dedicated to the achievement of a specific learning task—that way simulating a real world learning experience as accurately as possible within a predefined evaluation session.

Since the user study was actually conducted one week ahead of the 57th United States presidential elections in 2012, the participants were requested to research the *presidential elections* on the basis of four given key aspects: 1) the examination of candidates, parties, and the history of presidential elections, 2) a brief investigation of the elective system in the United States, 3) a look at speeches and television duels, and 4) an examination of the so-called "Super Tuesday" and current poll numbers.

As a general directive, students were asked to prepare the information such that they would be able to re-use and extend the information in four years when the next presidential election will take place. Moreover, students were provided with some additional information on the possible variability of sources and an estimated time frame of 10 minutes for each sub-task.

Once each of the participants felt that all of the tasks had been sufficiently completed, every participant was presented with a questionnaire to reflect his or her experiences with PLIMS.

The Questionnaire

As previously reasoned, the overall study targeted an evaluation of the general usability of PLIMS. For that reason the development of the questionnaire used to gain the feedback of the learners participating in the user study strongly followed existing guidelines on the evaluation of usability by utilising standardised questionnaires.

There are a number of standardised usability questionnaires—such as, for instance, the ISONORM 9241/10 questionnaire[67], the IsoMetrics questionnaire[68] provided by the University of Osnabrück, or the

[67] ISONORM 9241/10 questionnaire—`http://www.ergo-online.de/site.aspx?url=html/software/verfahren_zur_beurteilung_der/fragebogen_isonorm_online.htm`

[68] IsoMetrics questionnaire—`http://www.isometrics.uni-osnabrueck.de/qn.htm`

Software Usability Measurement Inventory[69] (SUMI) [Bes09]—to be guided by.

The questionnaire derived within the scope of this work has in particular been based on a short questionnaire[70] provided by the Swiss Federal Institute of Technology of Zurich. This short questionnaire is considered to be especially suitable due to the fact that it has, among others, been derived from a study transferring the *technology acceptance model*[71] to a learning scenario—that is to evaluate the user acceptance for e-learning technology in public unemployment vocational training [HWYK06].

The questionnaire itself (cf. appendix A.2) is composed of six parts:

General Information. The first part of the questionnaire collects some information about the learner conducting the study.

Learning Behaviour. Starting with the actual questioning, the learning behaviour of a learner is determined. The questions on the learning behaviour comprise a capturing of the scope of learning material utilised as well as details on the individual search, organisation, and re-finding behaviour of a learner.

General Usability. The third group of questions, finally, interviews the learner on the general usability of PLIMS. More precisely, this group includes issues such as the perceived ease-of-use, learnability, and complexity of PLIMS as presented to the learners.

A Detailed Consideration. The next block of the items is concerned with some of the important details of Zotero. To be exact, the different kinds of possibilities to organise learning objects—that are *collections*, *learning references*, and *learning context*—as well

[69] The Software Usability Measurement Inventory (SUMI)—`http://sumi.ucc.ie/`

[70] The short questionnaire provided by the Swiss Federal Institute of Technology of Zurich is freely available for download at `http://www.evalguide.ethz.ch/project_evaluation/prov_eval_instr/product_layer/usability/usability_form.doc`.

[71] The technology acceptance model (TAM) is an information systems model describing the utilisation and acceptance of technology by users. More precisely, TAM proposes different factors such as the perceived usefulness or the perceived ease-of-use to explain the decision of user when and how to use a certain technology. For more information see `http://en.wikipedia.org/wiki/Technology_acceptance_model`.

as the options to collect learning objects are assessed for their perceived usefulness.

Concluding Remarks. Finally, learners were able to rate the perceived overall support in organising their learning material using PLIMS—also compared to their current organisation of learning material.

Open Feedback. Concluding the questionnaire, all participants were encouraged to provide an additional open feedback on positive and negative aspects perceived to be of importance as well as any other suggestions crossing a learner's mind.

All questions were provided to users as single- or multiple-choice items or free text boxes. If users were requested to provide an estimation or certain level of agreement with a statement, a five-point Likert[72] item was presented to users.

11.2.2 Results of the Evaluation

The laboratory user study was realised at the University of Bamberg during the winter term in October 2012. The conduction was announced and a call for participation was widely distributed across different university channels and by personally advertising the user study in lectures. The most important results will now be discussed in more detail; the comprehensive evaluation sheet can be found in appendix A.3.

The Participants

In the end, 18 participants[73] undertook the user study during one of the evaluation sessions. All of the participants were experienced learners—even though differing in the depth of experience: about one third of the participants went to school before starting the current course of

[72] The Likert scale is a method to measure personal attitudes in questionnaires. It is the most widely used scale for responses in surveys—`http://en.wikipedia.org/wiki/Likert_scale`.

[73] Considering that the call for participation—also announcing the price draw of gift certificates—reached more than 300 students in different disciplines at varying stages of progression in their studies, the number of students willing to actually participate in the study was unexpectedly small.

studies or studied previously (item 1.1, 37,5% each); half of all participants were in their first or second term, whereas the other half of the users were at least studying in their third semester (item 1.5). Also the participants studied differing disciplines of study paths and could, therefore, be supposed to have a different technological background (item 1.3).

This diverse picture shows that the target to reach a variety of learners could be reached. The overall number of participants is however way to small to be able to make significant statements on the utilisation of PLIMS by user groups differing in educational background or technological expertise.

On the Previous and Current Learning Behaviour

Examining the learning behaviour that learners participating in the user study displayed so far, two different areas have been covered: *sources of information* and the *organisation of learning material.*

Sources of Information. To begin with, learners were asked to mark those sources for learning material they use in addition to officially provided lecture notes and textbooks (item 2.1). Table 11.6 shows the overall results and, most importantly, reveals and confirms the internet as important *information resource* for learning used by the majority of participants. Additionally asked to rate the importance of online information seeking in learning, three out of four students identified seeking information through the Web as significantly important (item 2.2). Further examining the online search, 94.4% of all participants stated that they regularly employed search engines to seek information (item 2.3).

In summary, this first part was able to justify the general setting and, in particular, the information resources that PLIMS is targeting: learners today strongly build on the Web as valuable source in learning and utilise search engines to find the desired information.

The Current Organisation of Learning Material. The second part in this group of items on the learning behaviour covered the current organisation of learning material. Learners were asked to assess the perceived satisfaction with their individual organisation of learning material and

Sources of Material	Util.
Internet	94.4%
Libraries	77.8%
Journals/Newspaper	38.9%
TV/Films	22.2%
Others	16.7%

Table 11.6: Sources for learning material used by learners (item 2.1)

the easiness of keeping an overview and re-finding information. In contrast to the previous items, the results were quite scattered:

- ▷ The *satisfaction* with the individual personal *organisation of learning material* was assessed with a median[74] of 3 and an interquartile range[75] (IQR) of 1 (item 2.4).
- ▷ The rating provided by participants assessing their *perceived easiness* in terms of *keeping an overview* on their learning material (item 2.5, median: 3, IQR: 1.75) and *re-finding learning material* (item 2.6, median: 2.5, IQR: 1.0) confirmed this impression.

In summary, these results uphold the claim made throughout this work, that there is definitely room for improvement in a typical learner's personal information management.

The Perceived General Usability of the Extended Zotero

Finally starting the actual evaluation of PLIMS, a group of questions captured the perceived general usability. To begin with, learners have been asked to rate the accuracy of a number of statements on their experience of getting to know and familiarising with PLIMS:

- ▷ 61.1% of the participants strongly agreed in attesting PLIMS to be *easy to learn* (item 3.2) and 55.6% considered themselves

[74] The median is numerical value separating the higher half of a data sample from the lower half—`http://en.wikipedia.org/wiki/Median`.

[75] The interquartile range (IQR) is the difference the third and first quartile and, therefore, delivers the "middle fifty" of a distribution—`http://en.wikipedia.org/wiki/Interquartile_range`.

to be able to utilise Zotero without further assistance after the introduction at the beginning of an evaluation session (item 3.1).

- ▷ Proceeding to examine the interface providing the services of PLIMS, the students participating in the user study assessed the interface to be generally understandable and easy-to-use but still flexible at the same time (items 3.5 and 3.6, median: 2, IQR: 1).

Overall, the *general usability* (item 3.3), *the perceived ease-of-use* (item 3.4), the *comprehensibility* (item 3.7), and *the mental efforts needed* to be able to utilise PLIMS (item 3.8) were all assessed with a median of 2—that is a general agree to each item. Remarkably, the IQRs for the perceived ease-of-use (IQR: 0) and the mental efforts required (IQR: 0.25) were really low.

Altogether, this group of items confirms and justifies the general design and provision of PLIMS as achieved within the scope of this work—yet no significant insights could be provided as a result.

The Organisation and Collection of Learning Material in PLIMS

Considering the outstanding features of PLIMS in more depth, two different aspects have been further examined: the *organisation* and the *collection* of learning material.

Organising Learning Material. Recalling the possibilities provided to organise learning material—or learning objects—in extended Zotero, three different options are available: *collections*, *learning references*—also referred to as tags—and *learning context*. Learners were able to 1) rate the *appropriateness* of these means for an organisation of learning material and 2) select those means *perceived to be useful* in a multiple-choice item. The overall results of these assessments are shown in table 11.7.

Interestingly, a strong agree to the *appropriateness* of *collections* and *tags* was considerably lower than the rated *perceived usefulness*, whereas it is the other way round for *learning context*. Nevertheless, it could be revealed that learners strongly preferred organising their learning material in folder-like hierarchies over the organisation by utilising non-hierarchical tags or a more flexible implementation of hierarchies.

Organisation	Median	IQR	Approp.ness	Usefulness
Collections	1	0	82.4%	94.4%
Learning References	1	1	70.6%	83.3%
Learning Context	2	2	37.5%	22.2%

Table 11.7: Assessment of means for the organisation of learning objects in PLIMS as well as the perceived usefulness (items 4.1-4.4)

Collecting Learning Objects. The second group of exceptional features comprises the possibilities for the collection of information items—namely the semi-automatic addition utilising the so-called *translators*. Being asked to assess the general usefulness of translators, 16 out of 17 answering participants attested translators a valid support (item 4.6). In particular questioning the support delivered by the translator implemented within the scope of this work—the Moodle translator—participants attested an even higher approval to the particular usefulness: 88.2% of all students (strongly) agreed in describing the Moodle translator to be supportive. Moreover, all of the students (58.8% strongly agree, 41.2% agree) were satisfied with the information transferred to the extended Zotero by the translator.

In summary, this basic evaluation of advanced possibilities for the collection of learning objects was able to confirm the need for more advanced possibilities: learner generally appreciate the options to reduce manual efforts for adding information to a learning repository.

The Overall Feedback

Finally, the overall impression and rating of the extended Zotero was gathered based on four items. The overall results are shown in table 11.8.

An evaluation of these items shows that all of the 17 participants assessing whether extended Zotero supports the organisation of learning material (strongly) agreed on the provided support (item 5.1). Moreover, rating the added value compared to bookmarking tools (item 5.2) and the current organisation (item 5.3) the added valued delivered by PLIMS was generally confirmed. In the end, 77.5% see a possible util-

	++	+	○	–	––
General support by PLIMS	58.8%	41.2%	–	–	–
Added valued c/w bookmark collections	73.3%	26.7%	–	–	–
Added valued c/w current organisation	35.3%	47.1%	11.8%	5.9%	–
Future Utilisation of PLIMS	22.2%	55.6%	22.2%	–	–

Table 11.8: Overall assessment of PLIMS (items 5.1-5.4)

isation of PLIMS for the future organisation of their learning material (item 5.4, median: 2, IQR: 0).

This overall impression was also confirmed by additional comments provided by participants in the open feedback.

Outcomes from the Collected User Data?

In addition to an evaluation of the feedback received from students through the questionnaire, the learning repositories created by each participant have been kept for a further evaluation in the hope to be able to gain further insights into the utilisation of PLIMS. To give an example, it was, for instance, planned to evaluate the utilisation of the differing means—hierarchical versus non-hierarchical—for the organisation of learning material.

Unfortunately, the number of repositories able to be kept was even smaller than the number of participants—only 14 repositories were able to be retained. In addition, the size of repositories varied strongly: The smallest repository included 11 items whereas the most comprehensive repository comprises 79 items. On average, 29 items were collected in a repository during the second part of the evaluation sessions[76]. As a consequence, the data that was able to analysed was simply too sparse to allow for a meaningful calculation. No further implications were able to be drawn from this small-sized data set.

[76]The basic data able to be extracted from the learning repositories retained—namely number of items, tags, learning contexts, and collections as well as the number of items assigned to each of them—can be found in A.4

In summary—even though the conducted user study has its restrictions, some interesting insights that will be valuable for a further development and a more comprehensive evaluation could be gained:

1) Today's learners strongly build on the Web as valuable source of information.

2) Learners appreciate and still need support in their personal information management.

In more detail, the most interesting aspect uncovered is the fact that learners seem to prefer a more *strict hierarchical* organisation for learning content. Collections—almost identical to traditional folders—were attested to be the most valuable means by far for organisation. Collections clearly outrank the more flexible implementation of hierarchies in learning contexts and also the non-hierarchical organisation with tags.

This finding has also been confirmed by William Jones who reports that users were not willing to give up their folders—even if presented with supplementary means for organisation [Jon07, p.35]. Similar observation are described by Gene Smiths who reasons that users rely on folders to represent the understanding of items contained in these folders [Smi08, pp.25f].

12 A General Review

> *"Improvements in our ability to manage personal information should bring improvements, not only in our personal productivity, but also in our personal life."*
>
> William Jones [Jon07, p.56]

This work set out to cope with the recent changes in the nature of learning that have been triggered by the current transition of our society and the associated technological progress. To be exact, this thesis has been dedicated to the comprehensive research of *individual learners* and their mastery of these changes as well as new requirements caused by these changes—which amounts to *personal information management in learning*.

The general research question guiding these examinations has been initially formulated as follows:

> *"How can learners moving on individual learning paths be supported by the utilisation of modern technology for learning?"*

To be able to answer this question, three refined research issue to be dealt with have been identified: the characterisation of individual learners as the foundation of this examination and an improved support for the management and retrieval of a learner's personal information. The results of exploring these three issues will now be briefly summarised.

Individual Learners and Their Personal Information Management. The characterisation of individual learners and, in particular, the personal efforts to manage information has revealed and confirmed that, in general, personal information management research has to face a crucial challenge: an individual's learning and personal information management practises are always unique [Jon07, p.52].

For that reason, the concept of an improved technological support for individual learner's has been designed along two major challenges that every individual learner has to face:

1) Finding the needle in the haystack.
2) Keeping learning at a glance.

Yet acknowledging the uniqueness of individual learning and personal information management practices, a resulting comprehensive *flexibility* for learners has been selected as the overall leading design principle for the development of PLIMS—the solution proposed as a result of this work.

An Improved Support of Personal Information Management.
PLIMS provides an improved support for the management of personal information due to a number of reasons:

- ▷ PLIMS enables the building of a personal information collection that comprises of learning-related information originating from different information sources. Furthermore, an enhanced support for the integration of information is available for those sources of information that have been identified as vitally important for (individual) learners.
- ▷ The learning repository built within PLIMS is formed based on a two-tier architecture that ensures a consistent representation of information and, at the same time, facilitates an advanced organisation of all information within the personal information collection.
- ▷ Most importantly, the two-tier architecture designed for PLIMS allows 1) a consideration of the learning environment and 2) a multifaceted personalised organisation of information by employing hierarchical and non-hierarchical clues that can be assigned to every information asset within the learning repository.

An Improved Support of Personal Information Retrieval.
Accomplishing an improved support for the management

of information, PLIMS is also able to provide an advanced support for the personalised retrieval of information:

- ▷ The find-ability of personal information has been notably improved by creating multiple ways of re-finding the information within a learning repository—that is by the addition of hierarchical and non-hierarchical additional information or, respectively, learning context and learning references.
- ▷ This special combination of hierarchies and flat keywords in retrieving information also facilitates an exploratory search for information within the personal information collection.

Altogether the achieved improved support can, in large parts, be traced back to the theoretical consideration of management theories and the practical incorporation of information retrieval techniques. Above and beyond the focus on *individual learners*, it is this combination of *learning* and *knowledge management* as well as *learning* and *information retrieval* that characterises and distinguishes the endeavours of this work. In that way, PLIMS also explicitly contrasts with approaches that allow a comprehensive management of information but require a tremendous effort to set up the system on the one hand and simple applications like social bookmarking tools that can be instantly used but lack sufficient retrieval possibilities on the other hand.

The prototypical implementation and the user evaluation have shown that the concept and ideas of PLIMS are generally appreciated by learners. A statistically significant validation could however not be accomplished due to an insufficient number of participants in the user study.

In summary, this thesis illustrates possible improvements of personal information management in learning *and* delivers a corresponding concept and system implementing these improvements.

The findings of this work offer sufficient proof that research into personal information management with a particular focus on individual learners is both necessary, contemporary, and able to deliver promising results and improvements—in particular when incorporating current information retrieval techniques. Multiple ways to pursue personal information management research as well as to extend PLIMS have already been introduced throughout the previous chapters.

The full potential and long-term effect of solutions like PLIMS is, however, yet to be validated and exploited. It has to be kept in mind that—no matter how carefully designed—solutions not fitting an individual's personal learning and organisation style *"can still end up further complicating a person's overall information management challenge"* [Jon07, p.7].

Part IV

Appendix

A The PLIMS Usability Study

This appendix includes the components of the PLIMS usability study as conducted in the winter term of 2012/2013 at the University of Bamberg. The following parts are included hereinafter:

- ▷ A.1: instructions presented to the participants of the user study
- ▷ A.2: the questionnaire designed to gain feedback from the participants
- ▷ A.3: the evaluation of the questionnaire results
- ▷ A.4: the user data collected during the user study

For a detailed description of the user study and its evaluation it is referred to chapter 11.2.

A.1 Instructions for Participants

Alle Informationen finden sich auch in einem zugehörigen VC-Kurs:
http://vc.uni-bamberg.de/moodle/course/view.php?id=2043, Zugangsschlüssel: Zotero

Einarbeitung

Machen Sie sich zunächst durch Ausführung folgender Aufgaben mit dem System und seinen Möglichkeiten vertraut.

Hinzufügen von Objekten

- Fügen Sie dem System mindestens **drei beliebige Webseiten** hinzu.
- Fügen Sie dem System mindestens **drei lokale Dateien**, davon mindestens eine PDF-Datei hinzu. Ergänzen Sie diese lokalen Dateien jeweils mit einem **passenden Eintrag** um Zusatzinformationen hinzufügen zu können.
- Wählen Sie einen Ihrer aktuellen **VC-Kurse** und versuchen Sie alle wichtigen Informationen mit Hilfe des erkannten Zotero-**Übersetzers** in Ihre Bibliothek zu übernehmen. Überprüfen Sie welche Informationen Ihrem System hinzugefügt werden. Testen Sie dabei mindestens **drei** aus den folgenden sechs Möglichkeiten.
  - Übernahme von Informationen aus der **Kurswebseite**
  - Übernahme von Dateien aus **Verzeichnissen**
  - Direkte Übernahme von **Arbeitsmaterialien** (eingebettete PDF-Dateien)
  - Direkte Übernahme von **Forenbeiträgen**
  - Direkte Übernahme von **HTML-Seiten**
  - Direkte Übernahme von **Links**
- Nutzen Sie mindestens **fünf** aus den folgenden zehn **Übersetzern** (Translator) für Webseiten um Ihrem System neue Objekte hinzuzufügen. Überprüfen Sie welche Informationen die Übersetzer Ihrem System hinzufügen.
  - Springerlink
  - Zeit Online
  - IEEEXplore
  - Süddeutsche.de

- Wiley Online Library
- Google Scholar
- Amazon
- The New York Times
- Youtube
- Flickr

Organisation von Objekten

- Erstellen Sie eine neue **Sammlung** und verschieben Sie mindestens zwei Objekte in diese Sammlung.
- Versehen Sie mindestens drei Objekte mit sinnvollen **Tags**.
- Markieren Sie mindestens drei Objekte mit entsprechenden **Lernkontexten**.
- Erstellen Sie mindestens zwei **Lernkontexte** mit mehr als einer **Hierarchie**ebene

Suche von Objekten

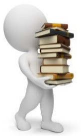
- Machen Sie sich mit dem **Filtern** anhand von **Lernkontexten** und **Tags** vertraut (Klicks auf einzelne Elemente) um Elemente ein- und ausblenden zu können.
- Stellen Sie das **Suchfeld** oberhalb des mittleren Bildschirmbereichs so ein, dass auch Inhalte von Snapshots und PDF-Dateien durchsucht werden. Testen Sie diese Einstellung.

Abschluss

- Richten Sie sich Zotero so ein, wie Sie es für Ihre Arbeit für sinnvoll halten (Veränderung von Fenstergrößen, angezeigten Spalten usw.).
- Löschen Sie **alle Inhalte** Ihres Systems vollständig um für die nächste Aufgabe mit einem leeren System beginnen zu können.

Präsidentschaftswahlen der Vereinigten Staaten 2012

Quelle: http://german.germany.usembassy.gov/politik/wahlen/



In gut einer Woche findet in den Vereinigten Staaten von Amerika die 57. Wahl des neuen Präsidenten statt. **Führen Sie eine Recherche zu diesem Thema unter Berücksichtigung der folgenden Fragestellungen und Schwerpunkte durch.**

The Nominees Are…
Kandidaten der Präsidentschaftswahlen –Parteien, Personen und Historie

How to Become President?
Wahlsysteme – Ablauf, Vergleiche und Kritik

The Art of Campaigning
Wahlkampf – Reden, Fernsehduelle und die Rolle der zukünftigen First Lady

America's Next President
Wahlprognosen –Super Tuesday, Umfragen ,Hochrechnungen 2012

Arbeitsanweisung

Arbeiten Sie mit Zotero um die Ergebnisse Ihrer Recherche zu speichern und aufzubereiten. Beschäftigen Sie sich mit jedem Schwerpunkt maximal 10 Minuten. Beachten Sie dabei insbesondere folgende Punkte:

1. Nutzen Sie die Möglichkeiten von Zotero, die Ihrer Meinung nach einen **Mehrwert** gegenüber einer herkömmlichen **Linksammlung** bieten.
2. Bedenken Sie, dass es eine **Vielzahl an Quellen** gibt die interessante Informationen aus unterschiedlichen Bereichen zur Verfügung stellen – und die in Ihrer Recherche berücksichtigt werden können:
    - allgemeine Informationen (z.B. Google, Wikipedia, Blogs)
    - wissenschaftliche Quellen (z.B. Springerlink, IEEExplore)
    - aktuelle Zeitungs- und Zeitschriftenartikel (z.B. New York Times, Die Zeit, Frankfurter Allgemeine)
    - „andere" Betrachtungsweisen (z.B. satirische Videos)
3. Versuchen Sie die Inhalte so **aufzubereiten**, dass Sie sie zur nächsten Präsidentschaftswahl in vier Jahren problemlos erweitern und wiederverwenden könnten.

A.2 The Questionnaire

EvaSys	Evaluation Nutzertests	Electric Paper

Universität Bamberg — Dipl.-Wirtsch.Inf. Stefanie Gooren-Sieber

Fakultät Wirtschaftsinformatik / Angewandte Informatik — Nutzertests Zotero komplett

Mark as shown: ☐ ☒ ☐ ☐ ☐ Please use a ball-point pen or a thin felt tip. This form will be processed automatically.

Correction: ☐ ■ ☐ ☒ ☐ Please follow the examples shown on the left hand side to help optimize the reading results.

1. Allgemeines zur Person

1.1 Was haben Sie vor der Aufnahme Ihres derzeitigen Studienganges gemacht? ☐ Schule ☐ ein anderes Studium ☐ eine Berufsausbildung ☐ Sonstiges

1.2 Bitte geben Sie Ihr Geschlecht an: ☐ weiblich ☐ männlich

1.3 An welcher Fakultät sind Sie eingeschrieben? ☐ GuK ☐ SoWi ☐ Huwi ☐ WIAI ☐ Sonstige

1.4 Welchen Abschluss streben Sie an? ☐ Bachelor ☐ Master ☐ Diplom ☐ Lehramt ☐ Magister ☐ sonstiger Abschluss

1.5 In welchem Fachsemester befinden Sie sich? ☐ 1. oder 2. ☐ 3. oder 4. ☐ 5. oder 6. ☐ 7. oder 8. ☐ 9. oder 10. ☐ > 10.

2. Allgemeine Fragen zum Lernverhalten

2.1 Zusätzlich zu bereitgestellten Lehrbüchern und Skripten nutze ich folgende Quellen zum Lernen (Mehrfachauswahl möglich):
☐ Internet ☐ Bibliotheken ☐ Zeitungen/Zeitschriften
☐ Fernsehen/Filme ☐ Sonstige

2.2 Die Internetrecherche beim Lernen hat einen hohen Stellenwert für mich. trifft voll zu ☐ ☐ ☐ ☐ ☐ trifft überhaupt nicht zu

2.3 Ich nutze regelmäßig eine Suchmaschine um Informationen zum Lernen zu finden. trifft voll zu ☐ ☐ ☐ ☐ ☐ trifft überhaupt nicht zu

2.4 Ich bin mit der persönlichen Organisation meiner Lernmaterialien zufrieden. trifft voll zu ☐ ☐ ☐ ☐ ☐ trifft überhaupt nicht zu

2.5 Es fällt mir leicht, den Überblick über alle meine Lernmaterialien zu behalten. trifft voll zu ☐ ☐ ☐ ☐ ☐ trifft überhaupt nicht zu

2.6 Es fällt mir leicht, Informationen die ich bereits recherchiert habe zu einem späteren Zeitpunkt wiederzufinden. trifft voll zu ☐ ☐ ☐ ☐ ☐ trifft überhaupt nicht zu

3. Allgemeine Usability

3.1 Ich konnte Zotero im Anschluss an die Einführung von Anfang an bedienen, ohne die Hilfe anderer in Anspruch nehmen zu müssen. trifft voll zu ☐ ☐ ☐ ☐ ☐ trifft überhaupt nicht zu

3.2 Es fällt mir leicht zu lernen, wie man Zotero benutzt. trifft voll zu ☐ ☐ ☐ ☐ ☐ trifft überhaupt nicht zu

3.3 Zotero zu benutzen finde ich einfach. trifft voll zu ☐ ☐ ☐ ☐ ☐ trifft überhaupt nicht zu

EvaSys	Evaluation Nutzertests	Electric Paper

3. Allgemeine Usability [Fortsetzung]

3.4 Ich nehme Zotero als einfach bedienbar wahr.	trifft voll zu	☐	☐	☐	☐	☐	trifft überhaupt nicht zu
3.5 Die Oberfläche von Zotero ist verständlich und leicht zu handhaben.	trifft voll zu	☐	☐	☐	☐	☐	trifft überhaupt nicht zu
3.6 Ich empfinde die Oberfläche des Systems als flexibel.	trifft voll zu	☐	☐	☐	☐	☐	trifft überhaupt nicht zu
3.7 Das System wirkt auf mich klar und verständlich.	trifft voll zu	☐	☐	☐	☐	☐	trifft überhaupt nicht zu
3.8 Die Benutzung von Zotero erfordert nicht zu viel geistige Anstrengung.	trifft voll zu	☐	☐	☐	☐	☐	trifft überhaupt nicht zu

4. Detaillierte Systembetrachtung

4.1 Sammlungen in Zotero eignen sich gut um Lernmaterialien zu organisieren.	trifft voll zu	☐	☐	☐	☐	☐	trifft überhaupt nicht zu
4.2 Tags in Zotero eignen sich gut um Lernmaterialien zu organisieren.	trifft voll zu	☐	☐	☐	☐	☐	trifft überhaupt nicht zu
4.3 Lernkontexte in Zotero eignen sich gut um Lernmaterialien zu organisieren.	trifft voll zu	☐	☐	☐	☐	☐	trifft überhaupt nicht zu

4.4 Folgende Hilfsmittel zur Strukturierung halte ich für sinnvoll (Mehrfachauswahl möglich):
☐ Sammlungen ☐ Tags ☐ Lernkontexte

4.5 Translator (Übersetzer) unterstützen mich sinnvoll beim Hinzufügen von Objekten zu meiner Bibliothek.	trifft voll zu	☐	☐	☐	☐	☐	trifft überhaupt nicht zu
4.6 Das Hinzufügen von Lernmaterial aus dem Virtuellen Campus über einen Translator ist hilfreich.	trifft voll zu	☐	☐	☐	☐	☐	trifft überhaupt nicht zu
4.7 Der Translator zu den Seiten des Virtuellen Campus liefert mir die benötigten Informationen.	trifft voll zu	☐	☐	☐	☐	☐	trifft überhaupt nicht zu

5. Fazit

5.1 Zotero unterstützt mich bei der Organisation meiner Lernmaterialien.	trifft voll zu	☐	☐	☐	☐	☐	trifft überhaupt nicht zu
5.2 Zotero bietet mir einen Mehrwert gegenüber herkömmlichen Linksammlungen.	trifft voll zu	☐	☐	☐	☐	☐	trifft überhaupt nicht zu
5.3 Zotero bietet mir einen Mehrwert gegenüber meinem bisherigen Vorgehen zur Organisation von Lernmaterialien.	trifft voll zu	☐	☐	☐	☐	☐	trifft überhaupt nicht zu

EvaSys	Evaluation Nutzertests	Electric Paper

5. Fazit [Fortsetzung]

5.4	Ich kann mir vorstellen Zotero zukünftig zur Organisation meiner Lernmaterialien zu verwenden.	trifft voll zu	☐	☐	☐	☐	☐	trifft überhaupt nicht zu

6. Offenes Feedback

6.1 Ich finde es gut, dass...

6.2 Ich finde es nicht gut, dass...

6.3 Ich habe folgende Anregungen:

A.3 Results of the Evaluation

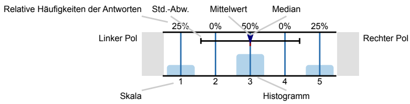
Dipl.-Wirtsch.Inf. Stefanie Gooren-Sieber, Nutzertests Zotero komplett

Dipl.-Wirtsch.Inf. Stefanie Gooren-Sieber
Dipl.-Wirtsch.Inf.
Nutzertests Zotero komplett ()
Erfasste Fragebögen = 18

Auswertungsteil der geschlossenen Fragen

Legende

Fragetext



n=Anzahl
mw=Mittelwert
md=Median
s=Std.-Abw.
E.=Enthaltung

1. Allgemeines zur Person

1.1) Was haben Sie vor der Aufnahme Ihres derzeitigen Studienganges gemacht?

Schule	37.5%	n=16
ein anderes Studium	37.5%	
eine Berufsausbildung	0%	
Sonstiges	25%	

1.2) Bitte geben Sie Ihr Geschlecht an:

weiblich	33.3%	n=18
männlich	66.7%	

1.3) An welcher Fakultät sind Sie eingeschrieben?

GuK	6.7%	n=15
SoWi	0%	
Huwi	0%	
WIAI	86.7%	
Sonstige	6.7%	

1.4) Welchen Abschluss streben Sie an?

Bachelor	50%	n=16
Master	43.8%	
Diplom	0%	
Lehramt	0%	
Magister	0%	
sonstiger Abschluss	6.3%	

1.5) In welchem Fachsemester befinden Sie sich?

1. oder 2.	50%	n=16
3. oder 4.	18.8%	
5. oder 6.	18.8%	
7. oder 8.	0%	
9. oder 10.	6.3%	
> 10.	6.3%	

2. Allgemeine Fragen zum Lernverhalten

2.1) Zusätzlich zu bereitgestellten Lehrbüchern und Skripten nutze ich folgende Quellen zum Lernen (Mehrfachauswahl möglich):

Internet	94.4%	n=18
Bibliotheken	77.8%	
Zeitungen/Zeitschriften	38.9%	
Fernsehen/Filme	22.2%	
Sonstige	16.7%	

Frage	trifft voll zu	1	2	3	4	5	trifft überhaupt nicht zu	Statistik
2.2) Die Internetrecherche beim Lernen hat einen hohen Stellenwert für mich.		77,8%	22,2%	0%	0%	0%		n=18 mw=1,2 md=1 s=0,4
2.3) Ich nutze regelmäßig eine Suchmaschine um Informationen zum Lernen zu finden.		94,4%	5,6%	0%	0%	0%		n=18 mw=1,1 md=1 s=0,2
2.4) Ich bin mit der persönlichen Organisation meiner Lernmaterialien zufrieden.		11,1%	33,3%	33,3%	22,2%	0%		n=18 mw=2,7 md=3 s=1
2.5) Es fällt mir leicht, den Überblick über alle meine Lernmaterialien zu behalten.		5,6%	38,9%	27,8%	27,8%	0%		n=18 mw=2,8 md=3 s=0,9
2.6) Es fällt mir leicht, Informationen die ich bereits recherchiert habe zu einem späteren Zeitpunkt wiederzufinden.		22,2%	27,8%	33,3%	16,7%	0%		n=18 mw=2,4 md=2,5 s=1

3. Allgemeine Usability

Frage	trifft voll zu	1	2	3	4	5	trifft überhaupt nicht zu	Statistik
3.1) Ich konnte Zotero im Anschluss an die Einführung von Anfang an bedienen, ohne die Hilfe anderer in Anspruch nehmen zu müssen.		55,6%	33,3%	5,6%	0%	5,6%		n=18 mw=1,7 md=1 s=1
3.2) Es fällt mir leicht zu lernen, wie man Zotero benutzt.		61,1%	27,8%	5,6%	5,6%	0%		n=18 mw=1,6 md=1 s=0,9
3.3) Zotero zu benutzen finde ich einfach.		33,3%	55,6%	5,6%	5,6%	0%		n=18 mw=1,8 md=2 s=0,8

3.4) Ich nehme Zotero als einfach bedienbar wahr.

	1	2	3	4	5		
trifft voll zu	17,6%	76,5%	5,9%	0%	0%	trifft überhaupt nicht zu	n=17 mw=1,9 md=2 s=0,5

3.5) Die Oberfläche von Zotero ist verständlich und leicht zu handhaben.

	1	2	3	4	5		
trifft voll zu	41,2%	47,1%	11,8%	0%	0%	trifft überhaupt nicht zu	n=17 mw=1,7 md=2 s=0,7

3.6) Ich empfinde die Oberfläche des Systems als flexibel.

	1	2	3	4	5		
trifft voll zu	41,2%	41,2%	11,8%	5,9%	0%	trifft überhaupt nicht zu	n=17 mw=1,8 md=2 s=0,9

3.7) Das System wirkt auf mich klar und verständlich.

	1	2	3	4	5		
trifft voll zu	35,3%	52,9%	11,8%	0%	0%	trifft überhaupt nicht zu	n=17 mw=1,8 md=2 s=0,7

3.8) Die Benutzung von Zotero erfordert nicht zu viel geistige Anstrengung.

	1	2	3	4	5		
trifft voll zu	25%	62,5%	12,5%	0%	0%	trifft überhaupt nicht zu	n=16 mw=1,9 md=2 s=0,6

4. Detaillierte Systembetrachtung

4.1) Sammlungen in Zotero eignen sich gut um Lernmaterialien zu organisieren.

	1	2	3	4	5		
trifft voll zu	82,4%	5,9%	5,9%	5,9%	0%	trifft überhaupt nicht zu	n=17 mw=1,4 md=1 s=0,9

4.2) Tags in Zotero eignen sich gut um Lernmaterialien zu organisieren.

	1	2	3	4	5		
trifft voll zu	70,6%	17,6%	5,9%	5,9%	0%	trifft überhaupt nicht zu	n=17 mw=1,5 md=1 s=0,9

4.3) Lernkontexte in Zotero eignen sich gut um Lernmaterialien zu organisieren.

	1	2	3	4	5		
trifft voll zu	37,5%	25%	31,3%	6,3%	0%	trifft überhaupt nicht zu	n=16 mw=2,1 md=2 s=1

4.4) Folgende Hilfsmittel zur Strukturierung halte ich für sinnvoll (Mehrfachauswahl möglich):

Sammlungen	94.4%	n=18
Tags	83.3%	
Lernkontexte	22.2%	

4.5) Translator (Übersetzer) unterstützen mich sinnvoll beim Hinzufügen von Objekten zu meiner Bibliothek.

	1	2	3	4	5		
trifft voll zu	58,8%	35,3%	0%	5,9%	0%	trifft überhaupt nicht zu	n=17 mw=1,5 md=1 s=0,8

4.6) Das Hinzufügen von Lernmaterial aus dem Virtuellen Campus über einen Translator ist hilfreich.

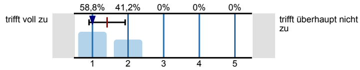
	1	2	3	4	5		
trifft voll zu	70,6%	17,6%	11,8%	0%	0%	trifft überhaupt nicht zu	n=17 mw=1,4 md=1 s=0,7

4.7) Der Translator zu den Seiten des Virtuellen Campus liefert mir die benötigten Informationen.

	1	2	3	4	5		
trifft voll zu	58,8%	41,2%	0%	0%	0%	trifft überhaupt nicht zu	n=17 mw=1,4 md=1 s=0,5

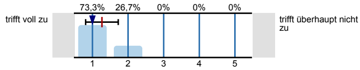
5. Fazit

5.1) Zotero unterstützt mich bei der Organisation meiner Lernmaterialien.



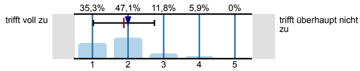
n=17
mw=1,4
md=1
s=0,5

5.2) Zotero bietet mir einen Mehrwert gegenüber herkömmlichen Linksammlungen.



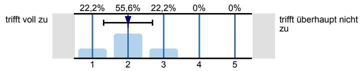
n=15
mw=1,3
md=1
s=0,5

5.3) Zotero bietet mir einen Mehrwert gegenüber meinem bisherigen Vorgehen zur Organisation von Lernmaterialien.



n=17
mw=1,9
md=2
s=0,9

5.4) Ich kann mir vorstellen Zotero zukünftig zur Organisation meiner Lernmaterialien zu verwenden.



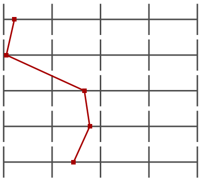
n=18
mw=2
md=2
s=0,7

Profillinie

Teilbereich: Fakultät Wirtschaftsinformatik / Angewandte Informatik
Name der/des Lehrenden: Dipl.-Wirtsch.Inf. Stefanie Gooren-Sieber
Titel der Lehrveranstaltung: (Name der Umfrage) Nutzertests Zotero komplett

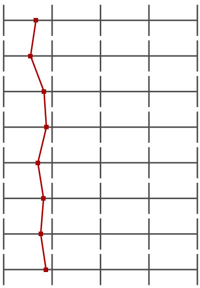
Verwendete Werte in der Profillinie: Mittelwert

2. Allgemeine Fragen zum Lernverhalten



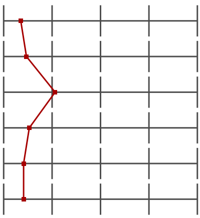
2.2)	Die Internetrecherche beim Lernen hat einen hohen Stellenwert für mich.	trifft voll zu	trifft überhaupt nicht zu	n=18	mw=1,2	md=1,0	s=0,4
2.3)	Ich nutze regelmäßig eine Suchmaschine um Informationen zum Lernen zu	trifft voll zu	trifft überhaupt nicht zu	n=18	mw=1,1	md=1,0	s=0,2
2.4)	Ich bin mit der persönlichen Organisation meiner Lernmaterialien zufrieden.	trifft voll zu	trifft überhaupt nicht zu	n=18	mw=2,7	md=3,0	s=1,0
2.5)	Es fällt mir leicht, den Überblick über alle meine Lernmaterialien zu behalten.	trifft voll zu	trifft überhaupt nicht zu	n=18	mw=2,8	md=3,0	s=0,9
2.6)	Es fällt mir leicht, Informationen die ich bereits recherchiert habe zu einem	trifft voll zu	trifft überhaupt nicht zu	n=18	mw=2,4	md=2,5	s=1,0

3. Allgemeine Usability



3.1)	Ich konnte Zotero im Anschluss an die Einführung von Anfang an bedienen, ohne	trifft voll zu	trifft überhaupt nicht zu	n=18	mw=1,7	md=1,0	s=1,0
3.2)	Es fällt mir leicht zu lernen, wie man Zotero benutzt.	trifft voll zu	trifft überhaupt nicht zu	n=18	mw=1,6	md=1,0	s=0,9
3.3)	Zotero zu benutzen finde ich einfach.	trifft voll zu	trifft überhaupt nicht zu	n=18	mw=1,8	md=2,0	s=0,8
3.4)	Ich nehme Zotero als einfach bedienbar wahr.	trifft voll zu	trifft überhaupt nicht zu	n=17	mw=1,9	md=2,0	s=0,5
3.5)	Die Oberfläche von Zotero ist verständlich und leicht zu handhaben.	trifft voll zu	trifft überhaupt nicht zu	n=17	mw=1,7	md=2,0	s=0,7
3.6)	Ich empfinde die Oberfläche des Systems als flexibel.	trifft voll zu	trifft überhaupt nicht zu	n=17	mw=1,8	md=2,0	s=0,9
3.7)	Das System wirkt auf mich klar und verständlich.	trifft voll zu	trifft überhaupt nicht zu	n=17	mw=1,8	md=2,0	s=0,7
3.8)	Die Benutzung von Zotero erfordert nicht zu viel geistige Anstrengung.	trifft voll zu	trifft überhaupt nicht zu	n=16	mw=1,9	md=2,0	s=0,6

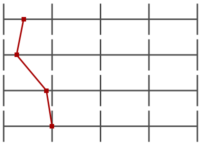
4. Detaillierte Systembetrachtung



4.1)	Sammlungen in Zotero eignen sich gut um Lernmaterialien zu organisieren.	trifft voll zu	trifft überhaupt nicht zu	n=17	mw=1,4	md=1,0	s=0,9
4.2)	Tags in Zotero eignen sich gut um Lernmaterialien zu organisieren.	trifft voll zu	trifft überhaupt nicht zu	n=17	mw=1,5	md=1,0	s=0,9
4.3)	Lernkontexte in Zotero eignen sich gut um Lernmaterialien zu organisieren.	trifft voll zu	trifft überhaupt nicht zu	n=16	mw=2,1	md=2,0	s=1,0
4.5)	Translator (Übersetzer) unterstützen mich sinnvoll beim Hinzufügen von	trifft voll zu	trifft überhaupt nicht zu	n=17	mw=1,5	md=1,0	s=0,8
4.6)	Das Hinzufügen von Lernmaterial aus dem Virtuellen Campus über einen	trifft voll zu	trifft überhaupt nicht zu	n=17	mw=1,4	md=1,0	s=0,7
4.7)	Der Translator zu den Seiten des Virtuellen Campus liefert mir die benötigten	trifft voll zu	trifft überhaupt nicht zu	n=17	mw=1,4	md=1,0	s=0,5

5. Fazit

5.1)	Zotero unterstützt mich bei der Organisation meiner Lernmaterialien.	trifft voll zu	trifft überhaupt nicht zu	n=17	mw=1,4	md=1,0	s=0,5
5.2)	Zotero bietet mir einen Mehrwert gegenüber herkömmlichen	trifft voll zu	trifft überhaupt nicht zu	n=15	mw=1,3	md=1,0	s=0,5
5.3)	Zotero bietet mir einen Mehrwert gegenüber meinem bisherigen Vorgehen zur	trifft voll zu	trifft überhaupt nicht zu	n=17	mw=1,9	md=2,0	s=0,9
5.4)	Ich kann mir vorstellen Zotero zukünftig zur Organisation meiner Lernmaterialien zu	trifft voll zu	trifft überhaupt nicht zu	n=18	mw=2,0	md=2,0	s=0,7



A.4 Summary of Data Collected from the User Study

	No. of				No. of Items ass. to		
No.	Items	Tags	LC	Coll.	Tags	LC	Coll.
1	27	22	-	5	42	-	19
2	19	41	9	9	69	40	18
3	14	33	-	6	6	-	14
4	30	7	-	7	18	-	26
5	13	37	3	4	36	2	15
6	18	28	1	4	19	4	16
7	33	47	4	5	75	18	18
8	34	80	5	5	94	12	20
9	57	124	-	12	183	-	53
10	11	17	4	5	23	4	12
11	15	14	-	-	19	-	-
12	79	6	5	-	125	84	-
13	14	16	7	1	18	27	11
14	38	61	8	5	100	24	29
Ø	28.71	38.07	3.29	4.86	59.07	15.36	17.93

Table A.1: Number of items, tags, learning contexts (LC), and collections (coll.) as well as the number of items assigned each of them

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University of Bamberg Press

The current cultural transition of our society into a digital society influences all aspects of human life. New technologies like the Internet and mobile devices enable an unobstructed access to knowledge in worldwide networks. These advancements bring with them a great freedom in decisions and actions but also a growing demand for an appropriate mastering of this freedom of choice and the amount of knowledge that has become available today.

This thesis is dedicated to an examination of how learners can meet these requirements with the support of modern technology. This thesis places a particular emphasis: the explicit focus on individual learners and, hence, the examination, development, and implementation of personal information management in learning.

To establish a theoretical framework, the spheres of learning, e-learning, and personalised learning have been combined with theories of organisational and personal knowledge management to form a unique holistic view of personal information management in learning. This framework is transferred to a comprehensive technical concept that is strongly characterised by the utilisation of information retrieval techniques to support individual learners. The resulting system enables the unified acquisition, representation, and organisation of information related to an individual's learning and supports an improved find-ability of personal information across all relevant sources of information.

eISBN 978-3-86309-207-8

9 783863 092078

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