Doctoral Thesis

Intelligent Mobile Learning Interaction System (IMLIS)

A Personalized Learning System for People with Mental Disabilities

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"Research is to see what everybody else has seen,

and to think what nobody else has thought."

Albert Szent-Gyorgyi

Presented by Saeed Zare

Acknowledgments

And finally none of this would be possible without the loving support of my family, my parents my lovely sister Simin and my brother-in-law Masoud for always providing encouragement and making sure that I never lost sight of my vision.

Your loyal love and kind heart will always make my day brighter and your support and sacrifices made my dreams possible. You provided nothing short of unconditional love and support.

I also dedicate this thesis to my grandmother who died on the 2nd of July 2003, whom was praying for me all the time to do well at my life and studies. God bless her soul.

Finally to Ali, Mahnaz, and all my family and friends, without their constant support and encouragement, I would not have gotten this far in my life and education.

Abstract

The domain of learning context for people with special needs is a big challenge for digital media in education. This thesis describes the main ideas and the architecture of a system called "Intelligent Mobile Learning Interaction System (IMLIS)" that provides a mobile learning environment for people with mental disabilities. The design of IMLIS aims to enhance personalization aspects by using a decision engine, which makes decisions based on the user's abilities, learning history and reactions to processes. It allows for adaptation, adjustment and personalization of content, learning activities, and the user interface on different levels in a context where learners and teachers are targeting autonomous learning by personalized lessons and feedback. Due to IMLIS' dynamic structure and flexible patterns, it is able to meet the specific needs of individuals and to engage them in learning activities with new learning motivations. In addition to supporting learning material and educational aspects, mobile learning fosters learning across context and provides more social communication and collaboration for its users.

The suggested methodology defines a comprehensive learning process for the mentally disabled to support them in formal and informal learning. We apply knowledge from the field of research and practice to people with mental disabilities, as well as discuss the pedagogical and didactical aspects of the design.

Keywords: Mobile Learning, Mobile Technology, People with Mental Disabilities, Pedagogy, Learning Process, Interactive Learning Environments, Inclusive Design, and Accessibility.

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Zusammenfassung

Diese Forschungsarbeit stellt die grundsätzlichen Konzepte und die Architektur eines Mobilen Lernsystems (IMLIS) für "Menschen mit besonderem Bedarf" vor. Basis des implementierten Models ist das Konzept der personalisierten Lerneinheiten, das eine Anpassung an verschiedenste Aufgaben und Kontexte ermöglicht. Auf Grund der dynamischen Struktur des IMLIS-Systems und der flexiblen Interaktionspattern wird es möglich, dass sich das System dem individuellen Bedarf anpasst und den jeweiligen Lernenden motiviert, konzentriert dem Lernprozess zu folgen.

Im IMLIS-System wird der Prozess des personalisierten Lernens mit einer Decision-Engine realisiert, die das Lernverhalten analysiert und das System diesem Ergebnis anpasst. Des Weiteren geht es nicht nur um personalisierte Lernmaterialien und den damit verbundenen pädagogischen Aspekten, sondern auch um die Kommunikation und die Kollaboration zwischen den Nutzern, die durch diese Lernform angeregt werden kann.

Die vorgeschlagene Methode ermöglicht die spezifischen Charakteristiken des Lernprozesses und der Bedarfe dieser Zielgruppe zu verstehen und in Modelle zu übersetzen, die vielfältige Möglichkeiten bieten, sowohl für formelles als auch für informelles Lernen. Die Lehrenden werden ebenfalls bei der Erstellung personalisierter Lernmaterialien vom System geleitet und unterstützt. Für die beständige pädagogische Begleitung bietet das System weitere personalisierte Funktionalitäten. Der Lernverlauf eines jeden Lernenden kann nachvollzogen werden und ein individuell abgestimmter Lernentwicklungsplan kann spezifiziert für jeden Schüler zusammengestellt werden.

Zusammen mit Experten und Praktikern sowie Lernenden mit besonderem Bedarf wurden die Bedingungen für das System-Design in einem iterativen Prozess herausgearbeitet. Mit diesen Experten wurden die pädagogischen und didaktischen Aspekte dieses System-Entwurfes diskutiert und bewertet.

Stichwörter: Mobiles Lernen, Mobile Technologien, Menschen mit kognitiven Einschränkungen, Pädagogik, Lernprozess, interactive Lernumgebungen, Inklusives Design, und Barrierefreiheit.

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Acronym List

AAMR   American Association on Mental Retardation

API   Application Programming Interface

CORDRA   Content Object Repository Discovery Resolution Architecture

DIMDI   German Institute of Medical Documentation and Information

GSM   Global System for Mobile Communications

HCI   Human Computer Interaction

HTML   Hypertext Markup Language

HTTP   Hypertext Transfer Protocol

ICF   International Classification of Functioning

ICD-10   International Classification of Diseases (Version 10)

IMLIS   Intelligent Mobile Learning Interaction System

IQ   Intelligence Quotient

IxD   Interaction Design

Java ME   Java Micro Edition

LCD   Learner-Centered Design

PDA   Personal Digital Assistant

RFID   Radio Frequency Identification

SCORM   Sharable Content Object Reference Model

SMS   Short Message Service

UI   User Interface

URL   Uniform Resource Locator

USB   Universal Serial Bus

UxD   User Experience Design

WHO   World Health Organization

Wi-Fi   Wireless-Fidelity

XML   Extensible Markup Language

1 Introduction

This chapter introduces key components of this study. It describes the field of research, scope of the work, the researcher's motivation and highlights the objectives and research questions explored within the study. It ends with the structure of the thesis outline.

1.1 Scope of the Study

This thesis deals with the study of mobile learning and strives to improve the learning process by personalizing its content and contexts. Usage of mobile technology is growing, and it affects other technologies by bringing in new innovation and methods. The reason for this growth is not only ease of use and mobility, but also improvements in interaction and functionality in different contexts. Meanwhile, the difference between cell phones and handheld computers is becoming less and less evident. Such convergence offers the opportunity of ubiquitous learning "anytime, anywhere", so that the learners do not have to wait for a fixed time and place for learning to take place. Kevin Walker (Institute of education) [Walker et al. 2007:3] says:

> *"Mobile learning is not something that people do; **learning is what people do**. With technology getting smaller, more personal, ubiquitous, and powerful, it better supports a mobile society. (…) Mobile learning is not just about learning using portable devices, but **learning across contexts**."*

Mobile learning can be seen as a bridge between higher level of abstracted knowledge and practical experiences, which derived the advantages of e-learning and covers the restrictions of time and place of learning. A learning media that uses mobile technology needs further research to define extendable and working concepts and models. The model is created and explored to enable the design of a mobile learning system for the target group. This thesis describes the model and concept of an ongoing study on a learning system called Intelligent Mobile Learning Interaction System (IMLIS), which provides a mobile learning environment for people with mental/learning disabilities. IMLIS is based on personalized learning strategies and feeds students adaptable content, interactions, and presentation formats to engage them in learning activities and the possibility to enhance learner motivation.

The potential strengths of IMLIS are based on three major aspects. First, the system runs with a constant updated profile, which supports the "decision engine"[1] to provide learning units that are adapted to specific individual needs and their current development. Second, for teachers and tutors, the system visualizes the learning process of each student during a certain period according to educational objectives and a personalized target of advancement. Third, the system is also an authoring tool for designing models of personalized learning challenges, individualized adaptation and implementation of curriculum.

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[1] The decision engine is part of the IMLIS system and matches the characteristics of a learning unit to a learner profile (a detailed description will be given on page section 5.3.1).

The participating research fields and scope of this thesis examines the intersection of three of the following areas: mobile technology, education and disability.
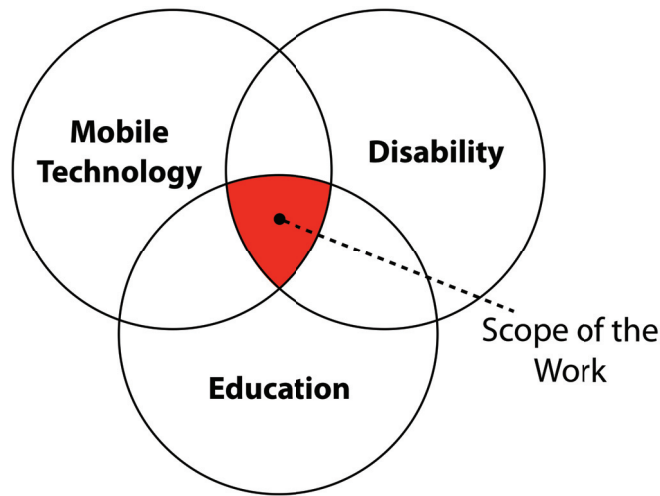
Figure 1: Interdisciplinary area from the participated research fields.

As shown in Figure 1, the focus of this thesis emphasizes on the overlapped areas from three mobile technology, disability and education. Challenges range from mobile technology aspects for educational purposes with respect to disability requirements as a learner-centered design model. Direct learner participation in the design process helped us to derive insights into user needs and to match these with functional and educational requirements. This led us to the development of a personalized mobile learning environment for the mentally disabled.

1.2 Motivation

This thesis deals with the empirical research on a mobile learning approach based on its personalization for people with mental disabilities. The motivation for working with people with disabilities came from my own childhood as I had a classmate who was disabled and had many physical and mental problems. At that time, I tried to spend time with him to keep him involved in social activities at school. Over the years, the idea assisting the disabled has become very important to me and has subsequently spearheaded my study. This interest is one of the motivations to choose this topic for my doctoral study.

In addition, during my studies I worked for nearly two years in sheltered workshops Martinshof in Bremen. In such kind of workshops, the people with diverse cognitive disabilities, psychological and multiple disabilities, and physical disabilities get further training and possibilities to work.

Special advisors, foremen, support the disabled to organize and do their own work. The administration with the foreman attract local business and secure contracts for specific work that can be done in the sheltered workshop. My job was to support the computer network and the administrative workstations.

Through this I stayed in closed contact with many workshop advisors. We discussed their work and my observations. They described to me how they adapted the existing work orders to the abilities of each worker. First of all, they analyze the incoming work order, then they decide which person might be able to do the work and then they discuss the abilities, needs and restrictions of the person with a pedagogical expert. From this analysis the tasks are adapted to the individual needs according to workflow and workload. Even the tools and machines are adapted to the ones' special needs. A written training plan is states how to prepare a certain person to become able to do specific work.

For me, it was really impressive to see this empathic way to make it possible for people with severe disabilities to participate in "normal" work life. It was touching to see the enthusiasm of the workers and their good fortune that they are able to produce useful things for society. It became clear to me that the practices of this institution, including adaptation to specific worker needs could be effectively managed. In developed countries, disabled people have many more facilities and possibilities to access social activities, public transportation, schools, and stores. However, in many countries community life for this target group can be difficult and accessibility next to impossible. I believe that new technologies can help ease their disabilities support the disabled to be more active in society.

"Mobile culture" infers that the implementation of mobile technologies may result in new community structures and culture. Such possibilities and challenges interested me to engage in mobile technologies. I also believe that for this target group, this technology is very valuable. On one hand existing e-learning applications may be adapted and migrated to mobile systems, and on the other hand, new kinds of learning tools and environments are developed based on mobile media specifications that is more than a miniaturized version of a laptop or PC.

In e-learning research, we need to understand how a system can adapt to learner needs during the learning process so that this personalized adaptation supports self-determined learning efforts. The efforts of advisors in sheltered workshops, where the tasks are personalized to the abilities of the persons with cognitive disabilities demonstrate these possibilities to adapt to individual needs. Understanding the possibilities that personalization can add to a learning system for the mentally disabled especially how it can be integrated into a mobile learning system is of interest in this study.

My personal achievements regarding mobile learning and people with mental disabilities will be discussed in this thesis. It also contains a literature review, a reverse engineering on analysis of different related projects and approaches, case studies, workshops and available evaluations throughout this period of time (2007-2010).

1.3   Thesis Objectives and Research Questions

The aim of this project is to develop a concept for a mobile learning system, which provides a personalized learning process for people with mental/learning disabilities based on their specific abilities. We especially want to recognize the factors that limit and influence the learning processes for this target group, in order to improve their learning opportunities. The objective of this research is to explore the first results designing a mobile application for the mentally disabled highlighting active learning to arouse their motivation and to improve their learning results. This study has highlighted various research issues and analyses a framework that enables the personalization and autonomy in a learning process. This is achieved by attaining the following objectives:

- Concentrating on mobile learning aspects as empirical research.

- Developing a personalized learning framework.

- Integrating and deploying the framework in disability issues.

- Building awareness about concepts of human-computer interaction and user interfaces in this context and for this specific target group.

The main ideas of the study are defined regarding the best solution for personalization on mobile learning. We scientifically researched and answered these questions:

1. How can mobile technology be used for learning purposes, and how can the learners be supported with the use of mobile learning?

2. Based on adaptive and personalized learning process in real classrooms as well as traditional learning, how can this transformation take place from traditional learning to mobile learning?

3. How should the learning process (in digital media) be designed to gain attention and to enhance the motivation for people with learning disabilities within a learning timeframe and how should the process be designed to correspond with the learner's needs and limitations?

4. How can a personalized system update its decision engine in a way to adapt as a learning system to a learner's current learning process? What are the challenges which can suit the requirements?

5. Which kind of learning system can support teachers to create and share learning materials for students with cognitive disabilities?

6. Which kind of system fits to the needs of students with cognitive disabilities and keeps them motivated to learn and train autonomously in varies contexts?

Exploring the wide body of research covering the learning process based on digital media (focused on mobile technology) for people with mental disabilities presents many challenges. Therefore, this research does not include exhaustive detail about system development, instead it attempts to cover the most important aspects of personalization based on mobile technology by providing a learning platform.

Problem Statement

On site at sheltered workshops (workplace for people with disabilities) and at inclusive schools (schools for people with disabilities) I observed and began to understand that people with mental disabilities need personalized direction during the learning process. Teachers and supervisors in sheltered workshops stated that classroom teaching for these learners means that the teacher, the tutor or assistant focuses on teaching individualized material prepared for each learner's ability. This strong reliance and dependency on the teaching staff during the learning process restricts the opportunities for autonomous learning activity. There is also a high need for learning activities across context in real targets by project work or training of skills. Improvements to the learning would occur if opportunities for learning across contexts could be provided. My short evaluation recommended that digital media could greatly enhance the learning motivations for these learners.

By confronting the two needs -personalization and learning activities across real context- to the abilities of new learning technologies, it became clear that mobile learning would support learning across contexts because it easily provides diverse contexts. But a major problem remained: how would it be possible for this target group to autonomously use via technologies?

Situated learning concentrates on the individual's needs and limitations according to [Lave and Wenger 1991]. In order to replace required individual interaction between teacher and learner, a mobile learning system needs to provide functionalities that adapt continuously to the needs of the user as well as avoiding to stress the user's mental capacity. In the field of learning technologies, several concepts for this interactive or automatic adaptation are discussed. Most of them address self-determined learners that have already learned to direct and organize their learning process themselves. But the general questions are what kind of concept fits to this target group specifications and how can existing concepts evolve and adapt to match to their needs. What limitations

have to be respected and how can personalized guidance lead the disabled to greater autonomy? How can a prototype be constructed that enables the development of a new model from gathering expert knowledge through specific interactions and evaluation?

1.4 Study Approach

This system is built to support mobile learning activities for people with cognitive disabilities within different contexts. We studied school children between six and seventeen years old, and young workers between twenty and forty years old. People with physical impairments should be able to use this system, unless they cannot move their hands. This system is not designed for the blind. The second target group is teachers and instructors of students with cognitive disabilities. These teachers need to prepare individualized learning material for each student. This mobile system supports them to prepare material in a virtual environment and helps them to reuse the implemented materials over a longer period. In addition, the system supports the teacher to prepare and orients them on a common set of categories so enabling work sharing for teacher groups. From this perspective, the tool can help to build a community of teachers that get preparation support.

The system could be implemented in the classroom, during leisure time activities and in the workplace. For these and related contexts two main activities are targeted. On one hand it should allow the independent practice of lessons that the teacher had prepared in order to train the student working and learning in an inclusive learning environment, on the other hand it should guide the learner by facilitating a task at work.

In inclusive classrooms[1], teachers and tutors face the challenges of preparing specific exercises for each of their students with cognitive disabilities that enable students to fully participate and benefits from this participation. For learners with cognitive disabilities limited learning resources exist. Most materials have to be custom-designed by the teacher for special uses according to student needs. During the teaching practice each teachers build their own collection of materials, to be reused and modified. Unfortunately, it appears as though a culture of sharing materials between teachers of students with cognitive disabilities has still not been established.

Statement of solution

A system is built that consists of a database-driven server application with the learning materials and user information processed and managed by specific functionalities. The

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[1] Inclusive classroom is a learning environment for all children with diverse abilities (disabled and non-disabled all together).

mobile clients (also via stationary PCs) can connect to the server application. The proto-typical system models are developed, discussed with experts, further developed and evaluated for mobile learning systems that focus on the needs of students with cognitive disabilities and their teachers and instructors. The learning units are composed of learn-ing assets such as words, audio comments or feedback, sounds, images, modifiable drawings, and movie sequences connected by patterns and interactions.

In order to build extendible models, mobile learning concepts are stated and models of learning processes used by teachers of students with cognitive disabilities are analyzed and conceptualized. Our approach takes into consideration workplace learning situations like small sequences of learning units for training of a certain skills, guided training for a particular machine, or workflows training for a specific task. This system should sup-port or enable the autonomous accomplishment of given tasks in order to foster the ex-perience that cognitive complex tasks can be completed autonomously.

The background intellectual infrastructure and support for this research project

This project is part of the research group of "Digital Media in Education" of the Univer-sity of Bremen. In this group are competent software development researchers involved in the didactical design of software, mobile applications and evaluation methodologies. For the system design and the evaluation, I received colleague support and advice espe-cially in prototype development and in the preparation and analysis of the workshops. When referring to this support, I use "we" throughout this document.

Beside this, I worked with experts from two special education centers (Förderzentrum Wahrnehmung und Entwicklung Rhododendron Park, Förderzentrum Wahrnehmung und Entwicklung Grolland), experts of a sheltered workshop (Martinshof Bremen) and the department of education and teacher training (research group for disability studies) at the University of Bremen. For specific workshops, I involved experts and teachers for students with cognitive impairments in Tehran (Noavaran Institute) and researchers in the United States (IDC 2008, HCII 2009, and AHFE 2010 conference workshops for people with special needs).

1.5   Thesis Outline

This thesis consists of seven chapters. The first three chapters deal with the foundations and provide theoretical, state-of-the-art information and the second three chapters pre-sent the IMLIS concept and work. The last chapter presents the tests, results, final dis-cussions, conclusion and future direction of this study.

Chapter 2 reviews the related research and literature analysis about mobile technology and the learning based on this technology as well as personalized learning and personalization methods. This includes an in-depth discussion on existing mobile learning projects and applications and demonstrates why existing solutions for mobile learning applications are not sufficient.

Chapter 3 provides the theoretical foundations and state-of-the-art knowledge about people with mental/learning disabilities, the levels of disability, diagnostic systems, classifications, educational aspects, and accessibility.

Chapter 4 is methodologically oriented and introduces the empirical research and requirements for a conceptual framework that supports the building and evolution of a mobile learning solution for this target group. This chapter is considered as a bridge between chapter 2 and chapter 3 (state-of-the-art) and chapter 5 and chapter 6 (IMLIS approach).

Chapter 5 provides the approach taken within the IMLIS solution to fulfill the requirements described in chapter 4. It includes related implementation processes and personalization methods. It also presents the current design process for this solution and shows how the architecture can be used to simplify it. Both prototype implementation and its design are discussed with respect to theoretical foundations mentioned in chapter 2 and chapter 3.

Chapter 6 expresses the evaluations and usability tests based on workshops, teacher training and expert interviews conducted during this study and conclude with their results. The workshops planned during this research are divided to three parts of pre-workshops, developmental workshops and post-workshops.

Chapter 7 contains the results, discussions and challenges within the entire study and highlights important aspects of the goals achieved. A general overview of the study in different personalized mobile learning approaches is presented in this chapter summing up the thesis results and conclusion. It also offers questions and topics for further research.

Finally, five appendices are included. Appendix A contains the World Health Organization general classification including ICF and ICD-10 standards for people with disabilities. Appendix B includes the highlighted parts of the IMLIS prototype source code from a mobile client, server and teacher portal. Appendix C presents different screenshots from the IMLIS mobile client and teacher portal. Appendix D is the list of author publications on IMLIS during this study. Appendix E lists the content of attached DVD to this thesis.

2 Mobile Learning and Personalization

Mobile learning is a widely accepted term for describing a learning process with mobile technologies. The purpose of this chapter is to present the literature review and theoretical foundation to show the ways that mobile technology and personalization methods can be used in educational solutions. This chapter will focus on state-of-the art mobile learning including: personalized learning, learner-centered design, user interaction design, user interface design, e-/m-learning standards, and feedback during the learning process. Current mobile learning research projects in both real and virtual situations will also be examined.

2.1 Review on Mobile Learning Projects

As the use of mobile technology grows, so too does the increase of projects for education and learning based on this technology. In our initial research we analyzed and reviewed different related projects in this field. Many research areas are attempting to address mobile learning [Ally 2009][Druin 2009][Naismith et al. 2004][Keegan 2005][Pachler et al. 2009]. Many authors in their studies focus on the migration of learning content from e-learning platforms to mobile devices. According to the Traxler classification these projects fit into six approaches [Traxler 2009:12]:

1. **Technology-driven mobile learning** – Specific technological aspects are developed further on, mostly in an academic context to analyze technical use cases and the possibility to have pedagogical effects.

2. **Miniature but portable e-learning** – In first step scenarios that already work in conventional e-learning extended to a mobile device. Virtual Learning Environment (VLE) can be adapted to another context with a mobile device. The mobile device adds greater flexibility to such solutions.

3. **Connected classroom learning** – Technologies that are used in collaborative classroom learning can also be used with mobile technologies. Other classroom technologies such as the interactive whiteboard, for example can enhance classroom learning.

4. **Informal, personalized, situated mobile learning** – The learning technologies mentioned above can be expanded by technologies and possibilities enhanced by mobile technologies, for example the GPS location-awareness enables learning assignments in real location contexts.

5. **Mobile training/ performance support** – Mobile workers get supported by mobile technologies that are adapted to the context of work tasks so that information is delivered according to context, workflow, and situation.

6. **Remote/rural/development mobile learning** – Mobile learning can support contexts with environmental or infrastructural challenges where classical e-learning would fail.

This study's approach falls under two of the six category classifications above: "connected classroom learning" and "informal, personalized, situated mobile learning".

We have assessed diverse mobile learning scenarios from different views with respect to their strategies, architecture, functionality, target group, technical implementation, and requirements, interactivity and designed learning process. Some of these projects were selected according to their similarity in mobile learning approaches. In some cases they

contain personalization aspects, some can be used in the workplace and some can be used for leisure. Projects are listed in (Table 1) based on their context and Traxler classification.

Table 1: Some of mobile learning research projects.

Project	Description
MOBIlearn	**MOBIlearn** is a worldwide European-led research and development project exploring context-sensitive approaches to informal, problem-based and workplace learning by using key advances in mobile technologies. The goal of this project is the development of a concept for creation, delivery, brokerage and tracing of learning content using multimedia and distributed databases [MOBIlearn]. **Highlights:** Situated learning, ambient intelligence, personalization **Category:** Miniature but portable e-learning **Website:** http://www.mobilearn.org
PIMS	**Personalized Intelligent Mobile Learning System for Supporting Effective English Learning (PIMS)** is an approach for a recommendation system, which suggests English news articles to the learners based on their reading abilities. The Fuzzy Item Response Theory (FIRT) evaluates these reading abilities for the non-native English learners [Chen and Hsu 2008]. **Highlights:** Personalized learning **Category:** Informal, personalized, situated mobile learning
M-CALL	**Mobile Computer-Assisted Language Learning Courseware for Korean Language Learners (M-CALL)** is a project for learning language courseware for Korean language learners. It presents a cyber pet game for increasing the learner's motivations [Cho et al. 2004]. **Highlights:** Game-based learning **Category:** Miniature but portable e-learning

MoLeNET	**Mobile Learning Network (MoLeNET)** is a "unique collaborative approach to encouraging, supporting, expanding and promoting mobile learning, primarily in the English Further Education sector, via a supported, shared cost mobile learning projects" [MoLeNET]. **Highlights:** Collaborative learning **Category:** Miniature but portable e-learning **Website:** http://www.molenet.org.uk
GoKnow	**GoKnow** is a mobile learning project based on a learner-centered approach. It provides a suite of productivity applications for mobile devices. Its dynamic mobile environment lets teachers and instructors generate coordinated, curriculum-based learning and it enables collaborative learning through the easy file transfer and sharing [GoKnow]. **Highlights:** Curriculum-based learning, learner-centered design **Category:** Connected classroom learning **Website:** http://www.goknow.com
Flocabulary	**Flocabulary** is a project for bringing hip-hop music into high school classrooms. Flocabulary combines music and books to engage the students and teach standards-based academic content. The goal of this project is for learning language by adapting to mobile culture [Flocabulary]. **Highlights:** Fun in learning and adapting to mobile culture **Category:** Technology-driven mobile learning **Website:** http://www.flocabulary.com
Vila-b	**Vila-b** is a virtual learning in construction sites project, based on mobile technology [Vila-b]. It is coordinated by "Institute Technology and Education" (ITB) in Bremen and "Digital Media in Education" (dimeb) research group is a partner in this project. **Highlights:** Onsite workplace learning **Category:** Mobile training / performance support **Website:** http://www.vila-b.de

Learning2Go	**Learning2Go** is an "initiative run by Wolverhampton Local Authority to use mobile handheld computers to engage learners by delivering multimedia content, Internet and authoring tools to the palm of a learner's hand" [Learning2Go]. **Highlights:** Collaborative learning **Category:** Connected classroom learning **Website:** http://www.learning2go.org
mGBL	**mobile Game-Based Learning (mGBL)** is a "platform for the presentation of educational content in a playful and emotional way on mobile devices" [mGBL]. **Highlights:** Game based learning **Category:** Technology-driven mobile learning **Website:** http://www.mg-bl.com
MoULe	**Mobile and Ubiquitous Learning (MoULe)** "is an on-line environment for collaborative learning. It integrates smart phones and portable devices to enable educational activities based on the exploration of a geographical place" [MoULe]. **Highlights:** Collaborative learning, context driven learning **Category:** Informal, personalized, situated mobile learning **Website:** http://moule.pa.itd.cnr.it
Math4Mobile	**Math4Mobile** is a project, "which examines the opportunities of ubiquitous and personal technologies for educational purposes, using the mobile phone for teaching and learning mathematics" [Math4Mobile]. **Highlights:** Mobile phone for teaching **Category:** Remote/rural/development mobile learning **Website:** http://www.math4mobile.com
MoLeap	**The Mobile Learning Project Database (MoLeaP)** is a mobile learning project database. "Its public and free-of-charge online database is for teachers, researchers and other (education) professionals interested in learning and teaching with mobile media" [MoLeaP]. **Highlights:** Support teachers and instructors

	Category: Technology-driven mobile learning
	Website: http://www.moleap.net
MST	**Mobile Support Tools** for people with life-threatening anaphylactic allergies is a project for designing and building useful electronic tools to support people with the anaphylactic allergy [MST].
	Highlights: Learning support for people with special needs
	Category: Remote/rural/development mobile learning
	Website: http://www.eee.bham.ac.uk/woolleysi/research/mlt.htm
MOBI	**MOBI** is a mobile learning project for secondary school learners in South Africa. It provides math support via multiple-choice assessments. Once a learner's the math ability is determined by the system, the MOBI application forwards the learner to math areas where the learner is weak or requires review [MOBI].
	Highlights: Personalization, interactive assessment
	Category: Informal, personalized, situated mobile learning
	Website: http://www.mymobi.co.za

Table 1 outlines the application of unique features of mobile technology to enhance learning. Mobile devices were used and combined with mobile client software and network server applications (mostly web-based). Most important, a mobile device was geared to support personal requirements. The aspects that are explored partly by different projects are:

- The opportunity and context for a successful use and the design of use cases
- The meaning of context provided by mobile devices and the challenges that come from this for learning
- The specification of applying content especially when the content is coupled or attached to additional features
- Different user experiences based on mobile device and extended mobility

The following concepts are further developed:

- Situated learning
- Personalization

- Ambient intelligence

- Game-based learning

- Portable learning

- Collaborative learning

- Individual interactive assessment

IMLIS addresses complexities as it provides an open, concrete model whereby the system can evolve to take into consideration the diverse needs of the end-user. Its personalization technology allows for the individual needs of the disabled to be supported.

Table 1 outlines the adaptation of mobile technologies to real-life work and leisure situations. Their respective applications are implemented and analyzed. Although these approaches are interesting, none of them address mobile learning for the needs of the mentally and physically challenged, nor do they consider personalization for this target group. Our research did not find applications for the personalization of mobile learning for the mentally disabled or for their teachers and tutors.

2.2   Mobile Technology

With the expansion of mobile, new qualities for media contextual use cases and ubiquitous computing arise. The mobility feature makes this technology revolutionary compared to other information technology devices and applications. People are using mobile devices as private storage tools and carry them as they would their watches, keys, or wallets. Mobile technology allows people remote access to services such as voice, messaging, controlling, Internet etc. In some cases mobile embedded systems make user accessibility easier. Today's youth welcome technology with enthusiasm and they are motivated to use it. Elliot Soloway says [Soloway]:

> *"The kids these days are not digital kids. The digital kids were in the '90s. The kids today are mobile, and there's a difference. Digital is the old way of thinking, mobile is the new way."*

The term "Mobile Technology" covers a huge range of mobile devices. Krannich classified the digital mobile electronic devices in three categories according to their transport ability, weight, form, components, capacity, and connectivity [Krannich 2010:76]. These categories are transportable devices, mobile devices, and wearable devices (Figure 2). This research predominantly focuses on handheld devices (except special single purpose devices) containing cell phones, smart phones, PDAs, mobile Internet devices, Internet tablets (e.g. iPad), and ultra portable devices highlighted by an orange frame in Figure 2.
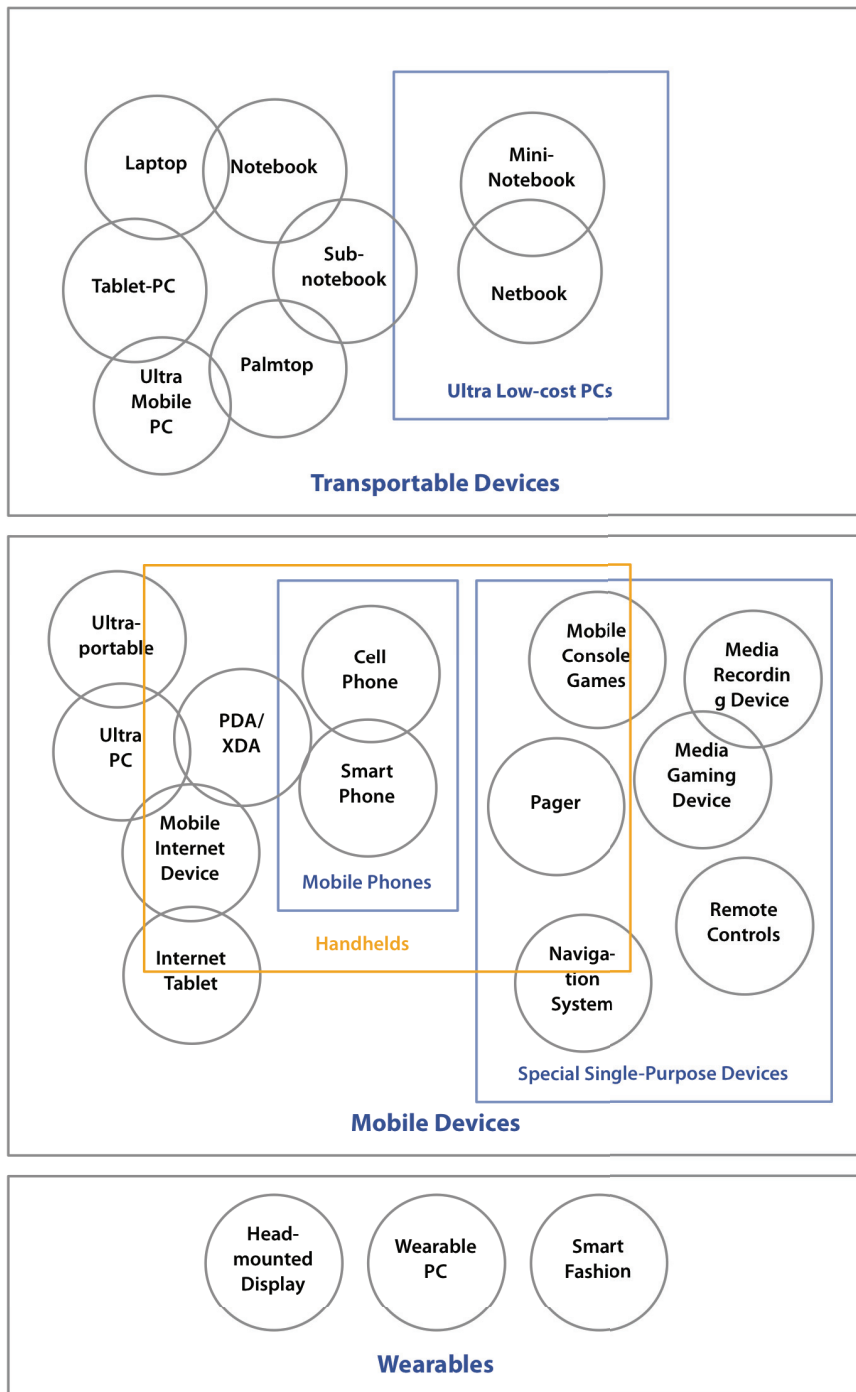
Figure 2: General classification of mobile devices [Krannich 2010:77].

Mobile devices depend on the strength of their respective software and hardware features. These devices can be classified into three categories: mobile phones (cell phones and smart phones), special single purpose devices (usually with embedded systems), and handheld devices.

Figure 3: Sample mobile device from OQO.

Mobile technology is becoming a focal point of new technologies. New technologies provide new designs, new interfaces, and new interactions. Mobile technology and their devices are revolutionizing the computer use. Tablet PCs, and handheld devices let users perform tasks in flexible, mobile environments, work which used to occur only at the desktop. Kakihara and Sørensen point out different views about extended perspectives on spatial, temporal and contextual dimensions of mobility [Kakihara and Sørensen 2002:4]. See Table 2.

Table 2: The spatial, temporal and contextual dimensions of mobility and the extended perspectives [Kakihara and Sørensen 2002:4].

Dimensions of Mobility	Aspects of Interaction	Extended Perspectives
Spatiality	- Where	- Geographical movement of not just human but objects, symbols, images, voice, etc.
Temporality	- When	- Clock time vs. Social time (Objective vs. Subjective) - Monochronicity vs. Polychronicity
Contextuality	- In what way - In what circumstance - Towards which actor(s)	- Multi modality of interaction • Unobtrusive vs. Obtrusive • Ephemeral vs. Persistent - Weakly & strongly tied social networks

Keegan points to a hypothetically optimum mobile device, simple and small enough to fit into a pocket with a foldable A4 size screen, secure in data, high-level wireless connectivity, media supported such as camera and players, storage capacity, easy Internet surfing performance and integrated with mobile communication protocols [Keegan 2005:123].

The optimal device matching all of Keegan's expectations, if currently unavailable in the market will soon appear in new generations of mobile devices. The Apple iPhone and iPad are revolutionary devices, which may match Keegan's criteria.

Figure 4: The Apple iPad and iPhone, revolutionary devices [Apple].

New generations of mobile technology are moving towards optimization and improving previous versions' shortcomings. In some cases Nanotechnology[1] is part of some mobile technologies. Moreover, wearable computing systems are gaining in popularity and may one day be as a part of our every day wardrobe. These types of devices are worn on the body and allow for interactions, modeling, monitoring systems, and personal independence. The convergence of wearable computing with mobile learning is expected in the near future; this may facilitate the learning process.

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[1] "Nanotechnology is the engineering of functional systems at the molecular scale." Source: Center for Responsible Nanotechnology. www.crnano.org/whatis.htm

2.3   Towards Mobile Learning

General literary and dictionary definitions of learning refer to "the acquiring of knowledge or skill". Usually when we learn, we try to increase and organize and retain knowledge meaningful way. This information can be acquired step-by-step or stored at once.

One may argue learning helps the learner to adapt to circumstances, contexts and requirements of life. Specifically, learning can mean a relatively stable alteration of behavior, thinking or sense and emotional processing driven by experience, comprehension, awareness and insight. Memory, recall and application take important roles in this alternation process. In other words, learning is a constant alteration of knowledge or of the cognitive structures that causes specific changes in motor skills or verbal skills, which result in changes in individual behavior [Bednorz and Schuster 2002:25].

Learning can be intentional, incidental or implicit [Bednorz and Schuster 2002:107-109]. For intentional learning, facts can be verbalized. Central to implicit learning, skills or complex contexts have to be controlled. You can learn through self-determination, by actively doing something or by co-operatively interacting with others. In all of these ways you gather know-how and develop skills or comprehension. Through verbal learning, motor learning [Bednorz and Schuster 2002:109-112] or socialization activities, one begins the learning process with perception and cognition of motor skills. Usually, the amount of knowledge available for real context application relates directly to its presentation form and interaction during the learning process. Learners often easily remember what they learned and apply it at workplace or in daily life if they personally experience it. This retention is strongly based on the learner's memory ability, but memory and learning should not be confused. Dr. Eric R. Kandel[1] defines the difference between learning and memory as [Kandel 2007]:

> *"Learning is how you acquire new information about the world, and memory is how you store that information over time."*

Over the past two decades, learning is no longer limited to the one-way traditional learning (push model) and is moving toward becoming a multilateral process. Formal learning is considered as a push model, and informal learning as a pull model. Informal learning, a process of everyday life, can happen through interactions as unscheduled activities and as a part of an intentional motivated process of knowledge and practice in the course of practical adaptation and skill development.

Piaget's constructivism theory posits that learning in an active process in which learners build the knowledge according to their own cognitive activities [Piaget 1974]. In con-

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[1] Dr. Eric R. Kandel is Nobel Prize winner in Physiology or Medicine, year 2000.

structivism, the learner's focus is compared to a black box, a field with knowledge, which provides a view of where learning becomes an active process in order to understand the world. Radical constructivism questions whether knowledge can be impartial. In social constructivism, social interaction of knowledge construction is stressed. To engage learners more in the learning, they should actively participate in the process and should not simply act as passive receivers of information.

Beside this constructive viewpoint on learning, we partook in the ongoing discussion on the practical design of a learning application. There the learning activities are analyzed on specific interactions supported or processed by the application. Learning can be categorized into four groups: self-learning, presentational, instructor-initiated and collaborative [Frescha et al. 2004:3-6]. The following diagram shows the last three learning types and the differences between traditional learning part (a) and (b) and new types of learning (c).
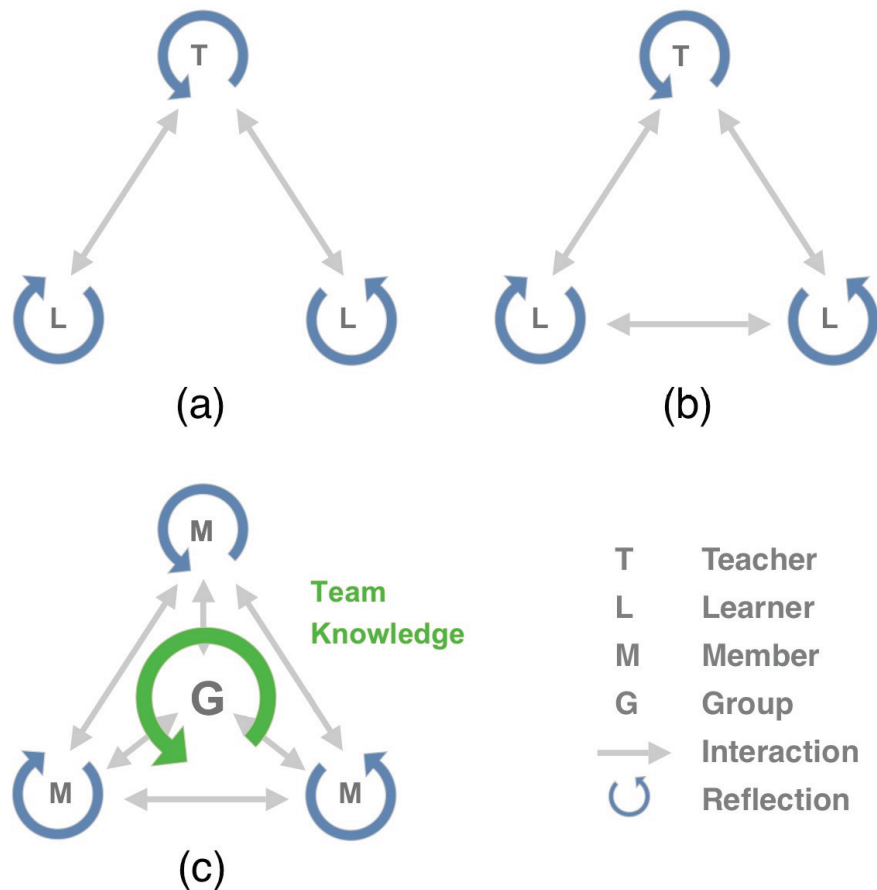
Figure 5: Comparison of different types of formal learning. Picture adapted from [Frescha et al. 2004:4-6].

In Figure 5, part (a) represents the presentational learning type based on teacher transmission learner reception. In this model the teacher is an information presenter to the learners who do not communicate with each other. Part (b) represents instructor-

initiated learning whereby teachers share information and learning materials with learners. Learners can also interact and communicate amongst themselves during this process. Part (c) shows collaborative learning, which is evolving (used in web 2.0). In this type of learning, the teacher's role adapts to a collaborative member group process in which all collaborate in the learning process and it occurs via discourse and discussion between members and the teacher.

In Web 2.0, observed learning via the Web 2.0 appears as an active learning process of knowledge production combined with social support. Michael Kerres points out that Web 2.0 for education is an open system and that a closed learning environment becomes open to a gateway into the web to existing resources [Kerres 2006:6]. As a result of this, the relationship between teacher and content changes, and teachers are no longer owners of the knowledge; instead, they become pathfinders or learning consultants who provide opportunities for learning.

In Web 2.0 the lines between learners and teachers are blur. New learning methods, ownership and authorship are difficult to determine. Discriminating between consumers and producers of knowledge becomes a challenge. Participant in Web 2.0 learning environments may contribute and receive something from their community. Transparency in the knowledge process and steps of knowledge construction can help participants to better understand material. Frescha and colleagues [Frescha et al. 2004:9] emphasis on providing awareness says:

> *"To enable people to not only learn side by side but together, it is crucial*
> *to provide awareness not only about the other team members' state but*
> *also about the team itself and the activities carried out in its context."*

Teaching and learning activities can be categorized into four areas of dissemination, discussion, discovery and demonstration [Siemens and Tittenberger 2009:18].

- **Dissemination:** preparing the specific learning assets and key components to face the learners in process.

- **Discussion:** conducting the learning process into a bilateral contact based on the activity to push the learner into a thinking phase.

- **Discovery:** involving learners in the learning process by "doing it themselves".

- **Demonstration:** presenting the learning materials as a self-assessment and evaluating by the teachers.

According to the above rationale, it may be argued that people with learning disabilities should interact directly in their own learning process. They need guidance in the process of dissemination by the teacher, tutor or the interactive system. Our interactive approach

partly supports social interactions, the possibility to ask for teacher help and working with others to share results.

The presentation of activities and results is important development of methods is ongoing. These can be implemented to support the target group to make small presentations for their results and enable teachers to create a meaningful visualization for learning. In the well-known didactical model of Reggio education [Lewin-Benham 2008] presentation results by adults are important aspects, which enable skills development.

2.3.1 From E-/ to Mobile Learning

Mobile learning inherits many features of e-learning although they have many differences such as knowledge input, output, memory capacity, application types etc. This overlap brings the basis of pedagogical learning theories from e-learning to mobile learning and even results in new learning theory implications in mobile learning. Ally points to mobile learning as a delivery of electronic context-based learning content on mobile devices [Ally 2009]; however in e-learning solutions, content delivery is via personal computers.

By transforming learning content from e-learning platforms to mobile learning applications, the limitations in the presentation of content, processor performance and learning activities appear. To cover the limitations of small presentation screens on mobile technology, the learning strategies should be designed with consideration to aspects significant to individual learners. The mentioned considerations can have more complexity with different types of mobile devices as they have each different screen features. The new generation of mobile technology is trying to address these limitations in convergence.

E-learning applications have the possibility to be executed in multitask environments and learners can access different references and hyperlinks. With mobile devices, multitask functionality is still developing.

2.3.2 Mobile Learning

New technologies provide new conditions for learning in different contexts. The mobile learning field is advancing and offering various solutions to unsolved problems with the use of innovative tools. There are many stakeholders and reasons for conceptualizing mobile learning and its possible outcomes. Many researchers believe that mobile learning is situated in the future of learning [Keegan 2005][Sharples et al. 2007], ubiquitous learning [Rogers et al. 2005:1] and seamless learning [Chan et al. 2006:5]. John Traxler believes in a transformation toward mobile learning and says [Traxler 2007:1]:

*"Looking at mobile learning in a wider context, we have to recognize that mobile, personal, and wireless devices are now **radically transforming societal notions of discourse and knowledge**, and are responsible for new forms of art, employment, language, commerce, deprivation, and crime, as well as learning.*

*With increased popular access to information and knowledge anywhere, anytime, the role of education, perhaps especially formal education, is challenged and the relationships between education, society, and technology are **now more dynamic than ever**."*

and Niall Winters pointed to [Winters et al. 2007:10]:

"Mobile learning applications are best viewed as mediating tools in the learning process."

Mobile learning can influence both the individual and community at large. Therefore, these tools impact two-way learning between groups and individuals. Learners are no longer limited to one place. Moreover, mobile devices support collaborative learning. They also let the learner interact with others face to face, instead of sitting at a personal computer. Mobile Learning Network [MoLeNET] uses a broader definition of mobile learning:

"The exploitation of ubiquitous handheld technologies, together with wireless and mobile phone networks, to facilitate, support, enhance and extend the reach of teaching and learning."

Mobile learning is neither an extended version of e-learning nor a portable Computer-Based Training (CBT). It has its own characteristics and didactical methods as well as direct interaction between learners in context. The specific quality of this learning activity is that the learner is not fixed to a certain predetermined location. This mobile activity is embedded in a didactical framework. One leading aspect of this framework is that mobile learning is adapting to a specific context. In this context the social interaction becomes meaningful to cognition. Not only social contexts but also relationships to objects become an important part of the context.

Certainly, the Internet demonstrates the increase of learning tools away from traditional learning toward distance learning. An ideal online mobile learning application demands high bandwidth connectivity, high quality of user interface presentation, and a powerful content database. M-learning systems represent a variety of learning interactions in mobile environments, which can be used in a dynamic learning context. They also enable the combination, cooperation and exchange of advice with self-determined action in real-life situations. These interactions are important to the completion of tasks. With mobile learning, unproductive "waiting time" can easily become better-used learning

time. The challenge is in the transfer of knowledge from the classroom to the workplace or daily life, which may result in partial loss of content. To avoid this loss, mobile learning can provide a good solution. With the capacity of mobile devices, abstract knowledge can be bridged to practical action which reduces this loss. In result, a new culture of knowledge transfer can be established. Pachler and colleagues [Pachler et al. 2009:1] note that:

> *"Mobile learning is explored as an emergent field of educational enquiry at the interface between cultural transformation and changing cultural practices in everyday life and pedagogical approaches in formal educational contexts."*

Significant Advantages and Highlights of Mobile Learning

- Can provide the learning process in real context.

- Can enhance the motivations for learners to be engaged more in learning process.

- Helps the learners to feel their autonomy and self-confidence in learning.

- Inherit the advantages of e-learning.

- Covers the restrictions of time and place of learning.

- Can support personalized learning.

- Can be used in two forms of individual or collaborative learning as well as social communications.

- Can be used as learner-centered content.

- Helps the situated learning on workplace (Just-in-time learning).

- Can be used as a tool for mobile assessment and surveys.

- Can provide new and different types of interactions.

- Can facilitate the communication during learning process.

- Can support easy learning material administration and updates.

[Ally 2009][Woodill et al. 2008:2][Keegan 2005]

Despite the many advantages of mobile learning, these potential "wins" do come with challenges.

Challenges of Mobile Learning:

- Small screens and limited amount of information on screen.

- Limited storage capacity.

- Lack of operating system (in many cases).

- Can make the sense of isolation from other colleagues or classmates.

- Can cause cheating in learning process.

- Can make problem in different learning platforms and devices.

- Limitation in publishing learning materials in different devices.

- Mobile devices can be out of date very quick (fast moving market).

- Wireless connectivity reception problem.

- Problem in multi-device capabilities.

[Ally 2009][Woodill et al. 2008:2][Keegan 2005]

Mobile learning can be used in the following situations based on the requirements and needs [Ally 2009][Keegan 2005]:

- Attending in virtual learning environments for training or teaching.

- Access to different digital libraries and archives.

- Access to different learning material pools (Quiz, test, interactions…).

- Live broadcasting and podcasts.

- Bringing the possibility of "Fun in Learning" as well as "Joy of Use".

- Facilitate offline-learning content.

Marguerite Koole in the "Mobile Learning" book [Ally 2009:27] points to the following frame model of mobile learning context in Venn diagram. In a cooperative learning process, learners consume and in a way create the information. Figure 6 shows the intersection between three aspects, learner and social aspects is mobile learning. The information becomes meaningful and useful depending on the complexity of the interaction and the type of interaction with the user.
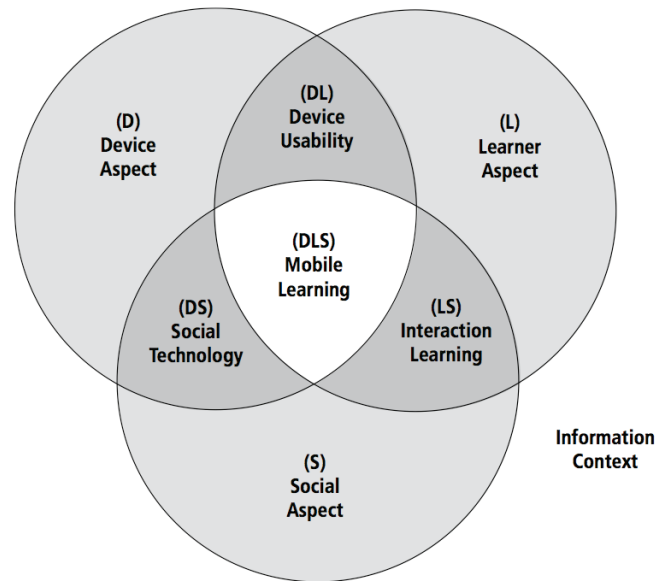
Figure 6: The mobile learning frame model [Ally 2009:27].

The overlapped areas in Venn diagram figure 6 involve the attributes of two circles in the area. The focus of this project will be on two areas of mobile learning, the center area (DLS) and the interaction learning area (LS). This point joins the learner and social aspects. Mobile learning can support several functions that enable orientation in context and space of a certain field or task. "A new m-learning architecture will support creation, brokerage, delivery and tracking of learning and information content using ambient intelligence, location-dependence, personalization, multi-media, instant messaging (text, video) and distributed databases" [MOBIlearn]. Jones suggests the following six reasons why mobile learning might be motivating and fruitful for learners [Jones et al. 2006:251-252]:

- Control (over goals)
- Ownership
- Fun
- Communication
- Learning-in-context
- Continuity between contexts

Learning that is considered self-paced allow learners to control their own content and pace of learning giving them easier ways to reach their goals. Constraints that enforce or limit user interface or design in specific cases present challenges within current mobile technology. Mobile learning systems offer a variety of learning interactions in mobile environments that can be used in a dynamic learning context [Ally 2009]. To perform real-life tasks, these systems enable user-determined collaboration, co-operation and exchange of advice within a given situation.

2.3.3 Learning across Context

As previously discussed and according to Kevin Walker's citation "Mobile learning is not just about learning using portable devices, but learning across contexts" [Walker et al. 2007:3]. Dey defines the context as [Dey 2000:4]:

> *"Context is any information that can be used to characterize the situation of an entity. An entity is a person, place, or object that is considered relevant to the interaction between a user and an application, including the user and application themselves."*

Dourish points to context as "embodied interaction" [Dourish 2004:6] and asks the following question for context as an interactional or representational problem:

> *"How and why, in the course of their interactions, do people achieve and maintain a mutual understanding of the context for their actions?"*

This question poses an interesting view on everyday life. The term "embodied interaction" is effective because mobile system connect users to situations where they may act as "an integrated individual" linking physical actions of the body to abstract processes of understanding. Further development of mobile technologies challenges society to search for a deeper understanding of context in relation to the cognitive processes of learners. In human computer interaction (HCI), context is seen as additional information that gives meaning during the interaction; context is used as technical issues of information filtering and data integration [Schmidt 2000:1-2]. Context can be looked in details for modeling solutions that fit with computer systems [Sharples 2009:9].

- **Context:** everything that happens in a defined sequence of time can be captured.

- **Context state:** describes the point concerning a specific sequence of time or certain space or specific goal.

- **Context sub-state:** describes the point concerning a specific sequence of time or certain space or specific goal, but filtered according current focus of learning and desired level of context awareness.

Sharples and colleagues explain the shifting of new learning and new technology and their well-publicized convergence [Sharples et al. 2006:3]. They highlight the connection between emerging personal and mobile technologies and a new understanding of learning as a self-managed lifelong activity. Mobile technology in and of itself provides specific value. Somehow, mobile learning may be viewed as a new kind of media that establishes new possibilities. These qualities and possibilities inherent in these emerging technologies support learning in a specific way.

Two approaches to this view arise: firstly, the development of technologies with their new or extended capabilities and secondly, the development of new learning concepts adapted to the needs of current principles of lifelong learning.

Table 3: Convergence between learning and technology [Sharples et al. 2006:3].

New Learning	New Technology
Personalized	Personal
Learner-centered	User-centered
Situated	Mobile
Collaborative	Networked
Ubiquitous	Ubiquitous
Lifelong	Durable

Table 3 matches learning concepts to features of their respective new technologies. In lifelong learning, the central focus is on learners and their needs and concerns. This means learners own and direct their learning process. Personalization in the field of education means a broader flexibility in the ways of providing knowledge. The request, ambitions and motivation to learn are all important. Strength, limits and learning strategies with adapted methods become important for the teaching staff who cooperate to fulfill these requirements.

The student participates on the development of the curriculum and knowledge acquisition, and finally the evaluation methods have to be adapted to these conditions. Concepts of new technology development drive the specification of mobile devices and services. Beside this, there is a growing focus on adapting new learning for every day personal use by using personalized devices and services.

Let's examine a new learning paradigm on table 3 "situated learning". These learning processes occur in a social context where meaning (construction of knowledge in a social interaction) is negotiated. Real problems within a negotiation stance bring the problem into context and situation. In this interrelation between social context and the effects on it, knowledge is reflected as collaboration. Mobile devices go beyond network solutions by enabling learning to be ported to diverse contexts and locations to support collaboration. Ubiquitous learning is the next aspect of learning that happens in a setting of pervasive education where learners can evolve within their desired field of learning.

Mobility, flexibility and miniaturization of technology make it easy for learning to fit into one's daily life regardless of location; anytime anywhere learning becomes possible. The current demand of lifelong learning is related to technology development based on a durable use of technology that also increase standardization in software formats.

In recent years learning softwares tend to be moving away from learning objects to learning activities. The design process for new learning solutions emphasizes integrating learning materials with learning activities and interactions according to JISC learning and teaching committee [JISC 2007:1]. In new learning strategies learners are responsible for their own learning activities under unified structures in a framework. The use of custom software solutions on mobile devices can make learning, progress tracking and evaluation more effective.

2.3.4 Mobile Learning Pedagogical Implications

Mobile technology offers different opportunities for learning process as it introduces learning flexibility for time and location. In order to take advantage of mobile learning, one needs to understand and employ appropriate educational strategies, which facilitate learning and optimize the activities performed with the device. The challenge is understanding the impact of mobile technology on teaching and learning. These pedagogical implications are closely connected to general e-learning considerations. While young people are extremely motivated to use mobile technology for a variety of reasons such as accessories, data privacy, and even fashion but how will this interest be transferred into real learning? The mobile applications provide the opportunities for both learners and teachers to freely use the devices in a variety of flexible ways. However, to be successful, instruction on the advantages of mobile learning processes needs to take place. Likewise, Niall Winters [Winters et al. 2007:11] confirms:

> *"New learning applications emerge through interaction and communication between key participants in the development cycle."*

Corbeil and Valdes-Corbeil explain the following point of view based on Naismith hypothesis [Naismith et al. 2004] claiming that mobile technology has a very large impact on learning [Corbeil and Valdes-Corbeil 2007].

- Learning provides conditions for learners to create their learning by meaningful connections to learning materials and other learners as social communications.

- Learning forces learners to organize and publish their conclusions, experiences and observations in their own learning process.

- Collaborative learning is enhancing day by day and can be supported by mobile solutions.

- Learning process is now in the center of the learner environment more than traditional classrooms.

- Learners can easier recall and reflect on the daily-life learning material as they are facing and capturing daily life events.

These points relay the pedagogical implications which support the usage of mobile learning and its advancement. As discussed in section 2.3, learning is longer going to be a one-way process. Teachers are members of a learning process; as they know more in comparison to other members, they publish and transmit the knowledge to other members. Transferring knowledge from learning systems to people with mental disabilities should be an exact design process in construction of learning content and activities. The transferred knowledge should be in a way reconstructed[1] in the learners' brain according to learner his/her individual requirements and abilities.

In a learning process, what the learner gets from the system and the hypothesis constructed in his mind in order to understand the context, is known as the constructivism learning theory which can be divided to into social and cognitive constructivism [Mandl and Huber 1983], each with their own characteristics with influences on the learning process. Constructivism pushes learners to an independency in thinking, deciding and problem solving in order to build meaning and context [Mandl and Huber 1983].

The ideas Naismith recommends for the adaptation of mobile learning to different learning theories and learning methods [Naismith et al. 2004] can be extended to:

- **Constructivism:** Mobile learning is a challenge for learners to build and find their own solutions during the learning process and to construct direct connections to real contexts.

- **Behaviorism:** Mobile learning enables contextual and immediate feedback, which fosters ongoing training.

- **Personalized learning:** Mobile technology with the potential of different interaction and activities can enable the personalization algorithm methods in mobile learning.

- **Adaptive learning:** As there are different types of mobile devices, and different adaptive algorithms in learning applications, adaptive learning can be easily supported by mobile learning.

- **Collaborative learning:** Mobile technology easily supports the social communication aspects in which the learners can communicate during learning process with each other via different protocols.

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[1] Based on Jean Piaget's constructivist theory of knowing.

- **Informal and lifelong learning:** Mobile devices can store data needed by people in their daily activities. Beyond tools for communication and information, mobile devices can serve as learning assistants.

- **Situated learning:** Learners can learn directly in any context-aware environment. Environments include workplaces, museums, hospitals etc.

- **Just-in-time learning:** Mobile learning can easily support just-in-time learning with its anytime anywhere capabilities. This allows learners to access resources such as news in different locations around the clock.

The learning possibilities outlined above show how mobile learning provides a flexible companion to learners. Furthermore, Pachler examines the individual needs of learners through the following four aspects: identity formation, social interaction, meaning-making, and entertainment [Pachler 2009:4]. As a flexible companion, mobile technology links individual needs to everyday life contexts and further extends the possibilities of autonomous and self-determined learning.

2.4   Personalized Learning

According research in software design, the analysis finds that models tend to associate personalization with individualization [Clarke 2003:4]. Clarke clarifies the difference between personalization and individualization; it lies in the end-user's ability to control the device and its related data [Clarke 2003:4]. According to this expert, individualization lets teachers and learning software designers tailor materials to match scaled assessments of learner's interest whereas personalization lets the learner interact with the material on the device. In other words, individualization is a one-way process from teacher to learners while personalization is two-way. Personalization means fitting specific content or presenting information according to an individual learner's needs. It is the capacity to tailor learning content and interactions to match learner abilities and needs that make the use of mobile technologies unique.

Figure 7 depicts the differences between personalization, individualization, and customization. In customization, the control of process is from the learner side and learners select material and leaning processes according to their own interests.
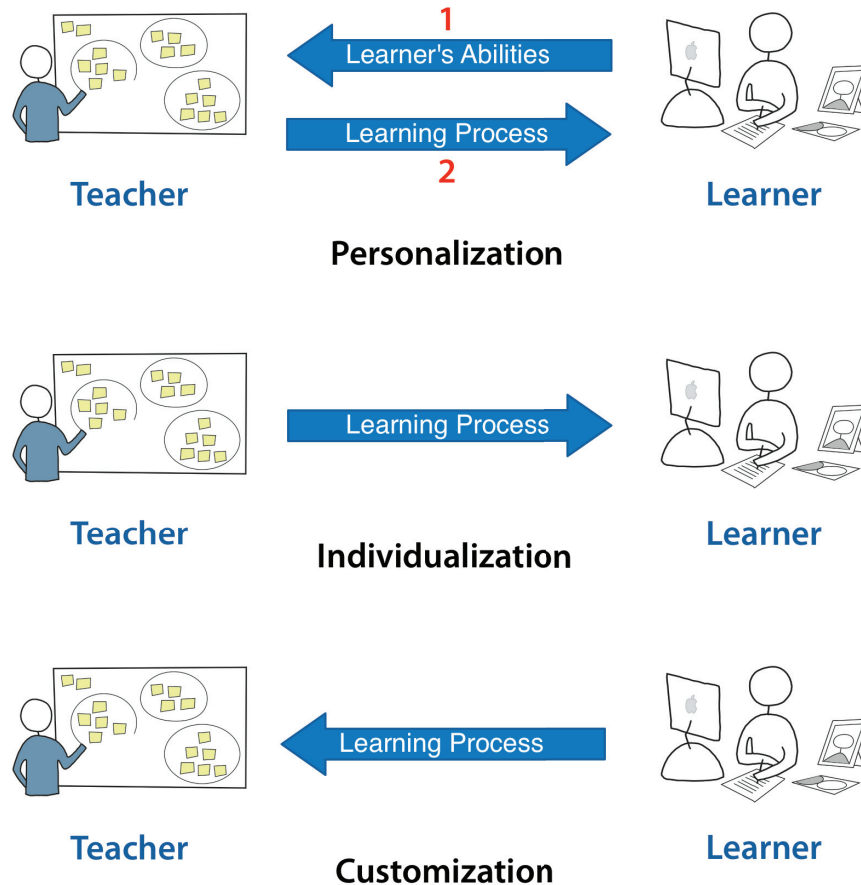
Figure 7: Personalization, Individualization, and Customization.

Personalization is one of the principles in the design of this study. Personalized learning usually occurs in traditional learning in informal ways. Traditionally, successful trainers using this method by differentiate between a learner's attitude and behaviors and through receiving learner feedback. The report of the teaching and learning in 2020 review group [Vision 2006:6] argues personalization serves a moral purpose and social justice and stating:

> *"Put simply, personalizing learning and teaching means taking a highly structured and responsive approach to each child's and young person's learning, in order that all are able to progress, achieve and participate.*
>
> *It means strengthening the link between learning and teaching by engaging pupils – and their parents – as partners in learning."*

John Traxler in his book "Mobile Learning" points to diversities, differences and individualities, which can be recognized by personalized learning and adapted to the user. Ally claims that mobile technologies support productive and meaningful processes for the learners to enhance their abilities according to their own autonomy [Ally 2009:17].

Hawkridge and Vincent's discussions about the use of digital media and computers by people with learning disabilities further determine the limitations and lack of this kind of personalization for learners [Hawkridge and Vincent 1992:21]:

> *"Computers can ease learning difficulties. They can help learners to overcome their difficulties. They cannot work magic. They are not necessarily the best solution. Because each learner's needs are slightly different, there are few standard rules."*

In 1992, Hawkridge and Vincent's citation was revolutionary. They looked toward the possibilities that digital media could provide for people with learning difficulties. At that time graphical user interfaces (GUI) were not intuitive and interactive functionalities had not been developed. However, they saw certain use cases for the disabled where the computer might be helpful.

At that time, interface limitations and hardware interactions made the early tools a less appropriate choice for teachers looking for helpful learning aids. Since this time, there have been tremendous improvements in computer technologies including: hardware, user interface, interaction patterns, database, web technologies and audio-visual capabilities. Today intelligent software implemented on client-server solutions, based on fully developed interactive patterns enable us to focus on personalization and individualization. Nevertheless, developers still face challenges in building fully personalized functionalities in the core of a learning system.
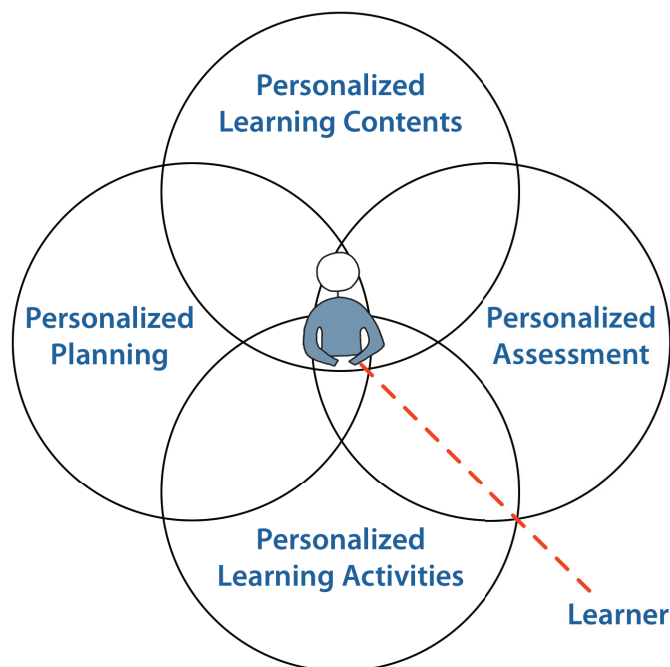
Figure 8: Learner central to a personalized learning system.

Figure 8 visualizes the main concepts of personalization mentioned by [Vision 2006][Ally 2009][Clarke 2003] studies. It depicts the learner position in a personalized learning system where the learner is supported by personalized learning content, activities, assessment, evaluations and personalized planning of the learning process. Even though in this case, everything is personalized for the learner, the learner's role can be improved with the following possibilities within a learning process:

- Open questioning (anytime)

- Sharing learning objectives/activities

- Success criteria

- Focused marking

- Flexible/enough time for a specific learning activity

In non-personalized systems, learners may receive high level, redundant or irrelevant blocks of information which causes disinterest and boredom. A personalized mobile learning system identifies an individual's profile and history as it designed to provide appropriate learning patterns, attributes and interactions based on the learners' profile. The tool is set to meet the individual needs at a time and place when and where the learner needs it.

Personalized learning contains key components that have direct affects on the learner's psychological, cognitive and social abilities. An optimal personalized learning system should focus on the importance of user autonomy, self-motivation and self-management. Learner autonomy can be greatly increased as learners improve their feelings about what they learn in their own personalized learning environment.

2.5 Designing Mobile Learning Systems

2.5.1 Learner-Centered Design

Traditional learning is typically recognized as teacher-centered design [Danielsson et al. 2004][Soloway 1994], but recently a shift from teacher-centered design to learner-centered design appear. This focuses on the learner's abilities to adapt to the learning process. The difference between user-centered design and learner-centered design [Quintana et al. 2000] is discussed under the following views related to learner-centered design as mentioned by Soloway and Pryor [Soloway and Pryor 1996:17] and completed by Quintana [Quintana et al. 2000].

- **Growth**

  Focusing on "learning by doing" for the learners. The main learner educational target should be the main aspect for developers and designers.

- **Diversity**

  Learners are different in cognitive, social and cultural backgrounds and learning styles. Learners, even when they seem to be similar are more heterogeneous than users in user-centered design model. Between users the work culture is more or less similar, but between learners the level of expertise in the work practice and the common culture can be diverse according to their experiences. They are complicated in sharing their own cultures more than users in a work practice.

- **Engagement**

  The context of learners predicts that their engagement should be supported by the design. Often for professionals an additional effort is needed to comprehend the need of the user to get motivated, or focused. As the professional designer has an intrinsic interest in his work the gap between the user's view and his view is not prominent in his mind.

Learner-centered design is based on learner's skills and knowledge and provides them for their own experience [Sharples et al. 2006]. Learner-centered design is also moving beyond usability aspects and the related methods [Quintana et al. 2001].
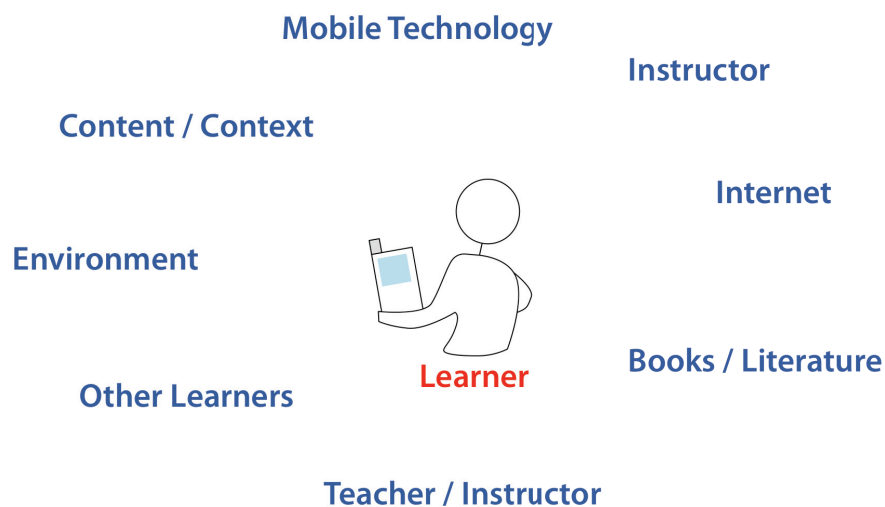
Figure 9: Learner-centered design in a mobile learning system.

Figure 9 depicts learner-centered design in a personalized mobile learning environment and shows that different direct aspects influence this method. This model tries to fill the gap between the learner's needs and designers view contributing to better performance of the learning process.

Respecting the special needs of students with cognitive disabilities presents a challenge for teachers of inclusive classrooms. Implementation of learning media to target this need and learning process may also pose difficulties. To address these problems, an

effective system should adapt to the needs and abilities of the student and should permanently recognize changes in mood, motivation and status of learning [Mawhinney et al. 2006]. The first step should provide guidance and direction in relation to the individual needs and restrictions. Secondly, a learning system should enable autonomous access to exercises and training material. Of course, orientation and guidance is needed. Thirdly, the students' autonomy should be fostered by personalized orientation in combination with a growing of choice and self-directed exercises.

Within personalization, contradictions arise. A focus on guidance according individual disposition and changes due to evolution and failure, and the concept of learner-centered design, where the learner becomes the owner of his learning process tend to generate questions about the learning model. The aim of the tool is to provide guidance during the exercise sequence as it provides increasing opportunities for successful choices. While the system guides a personalized user learning path, it also enables specific opportunities for free choice. In this case, the user is able to select part of a learning path within a bigger personalized learning path frame.

In general, learner centered design should effectively capture the needs and developing requirements of the target group as evidenced by the map on these models. Modeling is becoming an increasingly important part of software technology development. The primary range of technology development consists of the construction of models for user interaction.

2.5.2 Interaction Design

Interaction Design (IxD) is an irresolvable part of every learning process and focuses on designing for people. A learning system should somehow be designed to build content meaning through the interaction between the user and the respective technology. A Chinese proverb says: "If I hear, I know. If I see, I remember. If I do, I understand". Sharp and colleagues define the interaction design as "designing interactive products to support the way people communicate and interact in their everyday and working lives [Sharp et al. 2007:8] however Lowgren says: "interaction design refers to the shaping of interactive products and services with a specific focus on their use" [Lowgren 2008:1]. Applications partly supported by interactions that help users to learn better make sense. An impressive interactive design has a high impact on the quality and performance of a learning process [Moggridge 2007]. Interactive designers need to pay attention to the appropriate types of technology to support learners, provide the right content and help them achieve their goals.

Bill Verplank points to three "How do you…?" questions, to be considered in the design of an interactive tool and should be answered by interactive designers (Figure 10) [Verplank 2007:127].
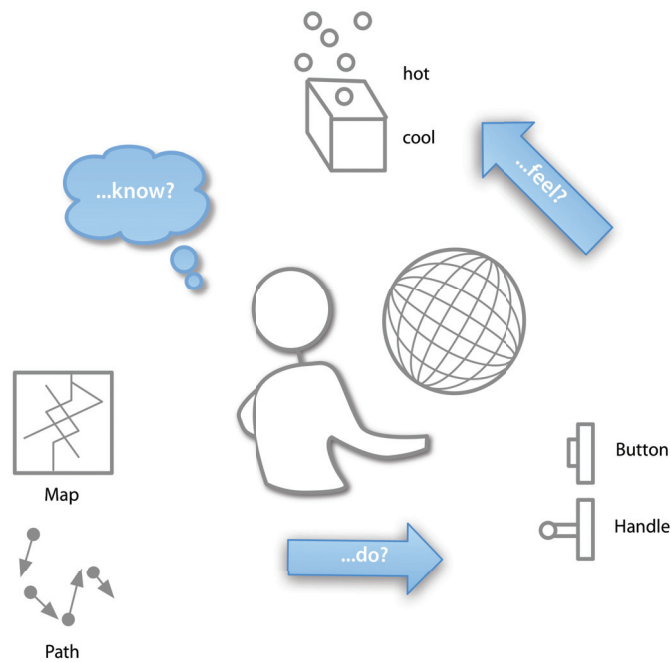
Figure 10: Interaction design based on Verplank's idea.
Compare to [Verplank 2007:127].

The three questions from Verplank are:

- **"How do you do?"**

    How do you affect the world? How do you expect the user to act with interactions? How are you going to make a control for them? Providing affordances for users with discreet and continuous controls via buttons, handles or scrolls.

- **"How do you feel?"**

    How do you get feedback from the world? The feeling and distinction between fuzzy and cool media, and distinct and hot media. It refers to the feelings of user about the product. The idea of cool and hot media is well known from Marshall McLuhan[1] [McLuhan 1964]. He believes that hot media are mostly "visual media" which enhance one single sense as well as a single vision. A hot media is noticeably highlighted from its background. For example, a book with careful printing or a picture with detailed information is hot. In contrast, cool media are mostly associated with sense of hearing and the senses, which need more active participation from the user. Television, seminars and audios are cool media.

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[1] Herbert Marshall McLuhan (1911-1980) was a Canadian philosopher and educator of English literature, a rhetorician, a literary critic, and a communication theorist.

- **"How do you know?"**

  To show users how the system works. How do they navigate through the world? These can be presented to the users by a map (in a complex system), a path (in a single task) or a navigation guide (in every system).

Moore points to three types of interactions in a learning process [Moore 1989:1-6], which are the interactions between:

- Learner and Content

- Learner and Expert

- Learner and Learner

The first interaction is defined as interactions between learner and learning content. Many learning applications are content interactive in design. The second interaction is defined as interactions between learners and the teacher/tutor or in a way the creator of learning content. These interactions can be via lessons structure, quizzes, video chatting with tutors, email communications etc. The third interaction is the interaction between and amongst learners, which can be done alone, or in teams via conversations during learning, chat etc.

Lowgren believes in interaction design from these two perspectives 1) as a design discipline which is distinguished by its focus on the digital design materials: software, electronics and telecommunications, and 2) interaction design as an extension of Human Computer Interaction. He lays out these design disciplines [Lowgren 2008:1]:

- "Design work is about exploring possible futures, starting from a situation at hand.

- It intends to change the situation for the better by developing and deploying some sort of product or service, i.e., the concrete outcome of the design process.

- It considers instrumental and technical as well as aesthetic and ethical qualities throughout the design process.

- Design work involves developing an understanding of the task - the "problem", or the goal of the design work - in parallel with an understanding of the space of possible solutions.

- Finally, it entails thinking by sketching, building models, and expressing potential ideas in other tangible forms."

In personalized learning systems, the interactions should be personalized according to learner abilities. As the learners have different potential and abilities, the interactions

should be tailored to their differences. This means that to be effective, amount and type of interactions in personalized learning systems need to be much more specialized than commonly used learning systems.

2.5.3 User Interface Design

User interface (UI) design addresses the techniques and factors of computer screen design. Elements, frames and learning objects are considered in interface design [Raskin 2000]. These days, UI technologies are moving toward mobility and portability. And as a result, the visual representation on hand held devices for example is becoming smaller and smaller. Presenting material on such a small screen has its limitations. Smaller displays present the biggest critical challenge in mobile learning [Ballard 2007:73]. On these small screens, most with low resolution, presenting all functions is difficult. This is why effective UI design is crucial.

Mobile user interface (MUI) should be designed to generate a positive user experience for a heterogeneous set of learners who interact with their mobile devices. Commonly, UI designers recommend avoiding and eliminating unnecessary objects and items from the screen. This helps present a comprehensible UI [Marcus 2010]. A challenge for designers is to simplify UI so that end-users don't have to think too much. In a limited frame space designers need to "take less and make the most of it". Some factors, which should be considered in the design process, are [Marcus 2010][Raskin 2000]:

- Symmetry with target group
- Adaptive
- Interactive
- Scalability
- User-friendly
- Robustness
- Accessibility
- Reusability

The MUI should be intuitively designed and simple as it optimizes screen space. The simplicity in design plays an important role in mobile learning applications [Landers 2005:2] and this is crucial for people with learning disabilities. Landers recommends the following in the design of mobile learning applications [Landers 2005]:

- Simplify
- Use selection data entry like combo boxes or choices
- Avoid large blocks of data

- Use short sentences and words

- Always provide the learner with a link to main menu and avoid blind navigation routes

- Avoid underlined text which may conflict with links

- Provide consistent information throughout an application

- Use titles for navigation

In addition to these tips above, designers should build and test the content on final devices with emulators and simulators [Marcus 2010]. They should control if the content fits within the screen, if the audio and video can be transmitted correctly, if the interactions run accurately, and if the space available on screen is acceptable [Ballard 2007].

The two main challenges concerning the use of mobile devices in learning are: a) to find an acceptable way of to present content adapted to the small screen and b) limited data transfer rate and processing power in mobile devices [Ally 2009:53]. The MUI should be highly intuitive for learners. Usually UI designers try to model real human interactions in their design. All the interactions and activities should be clear because they are derived from successful user tests of real-life experience

Learning Feedback and Assessment

Feedback on learning activities is very important in building a successful process. It easily can influence the performance and the quality of learning. Besides, real time assessments known as formative assessment [Druin 2009:186] provide the possibility for systematic and regular measurements in a learning progress. Druin continues with the main objective of formative assessments, which is a guide for instruction rather than a measuring system and she believes that an effective formative assessment acts as a tool to monitor the learner's advancement [Druin 2009].

Generally, feedback and assessment can provide both positive and negative input. These may be classified as logical and emotional feedback. The focus of this study is personalized learning; therefore the feedback gathered is personalized according to user behavior. Our feedback can be classified in the following categories based on different studies with respect to emotion classes [Perrin 2006:13]:

- **Positive emotion feedback**

  This signifies the positive emotions, which usually affect sympathy, passion, and hope and even increases motivation, satisfaction and excitement.

- **Control of negative emotion feedback**

  It controls negative emotional reactions in different ways. Some negative emotions include: fear, shame, anger, apathy, and self-frustration, sense of the blues (sadness), nervousness and disappointment.

- **Negative emotion feedback**

  It turns the negative emotions back to the learner. The aim of negative feedback is alert the learner to engage, collaborate and commit more to the task at hand. This kind of feedback can be reflected in different acceptable ways like cool entertainment reactions, comic feedback, goodwill phrases, surprise phrases, praise and encouragement.

Studies printed in "The International Journal of Instructional Technology and Distance Learning" [Perrin 2006:5] point to three kinds of feedback according to their chronological order:

- **In advance feedback:** this kind of feedback appears before the learning event or interaction. It can warm up the learner for the coming event. It can prevent the stress and anxiety and cause the learner to relax.

- **Immediate feedback:** this kind of feedback occurs immediately after the learning activity finishes. In many situations, the feedback should appear immediately after action in order to a correct or keep the learner in the same mood. This feedback is appropriate for training (and non-assessment) tests.

- **Delayed feedback:** this feedback appears with delay after a learning task. In some cases the learner should be tranquilized or calm down after a test. Or this feedback can be used for kinds of assessments.

The quality and type of feedback can impact learning quality. In some cases feedback can be combined with interactions to influence the learner more. For the disabled, receiving feedback from system plays a critical role. Usually, disability experts [Pitsch 2003][Wendeler 1993] recommend immediate feedback, if possible. Every success should be praised and every mistake should be supported with positive feedback for correction.

Pitsch points to feedback from people with mental disabilities [Pitsch 2003:134], which are generally oriented toward their own goals and not toward the trainer requirements. So when designing feedback tools, designers should pay attention to the individual learning activities and goals to balance them with teacher expectations.

2.6 Mobile Learning Content

2.6.1 E- / Mobile Learning Standards

Different standards have appeared in recent years to facilitate the decision-making process for learning developers and instructors. These standards are inseparable from most learning management systems. Different standard organizations [Masie Consortium] [ADL] outline the following features in every e-/m-learning standard:

- **Reusability:** Reuse of learning objects or blocks in different systems with the same functionality.

- **Accessibility:** Having equal access for different users regardless of their abilities/disabilities.

- **Durability:** New versions of applications do not need considerable modifications or redesign over time.

- **Interoperability:** The information can be shared by multiple platforms.

- **Affordability:** Both time and expense are reduced in the development phase and during application usage.

- **Adaptability:** Content and activities can be customized according to user needs.

- **Manageability:** Monitoring and maintenance of system.

- **Scalability:** Adaptation of various scales of information and data for a learning application.

The following are the most widely used standards for e-learning and mobile learning solutions, which are supported by most learning (content) management systems.

SCORM

Sharable Content Object Reference Model (SCORM) is an e-learning content packaging methodology standard for web-based courseware usage [ADL]. SCORM contains a collection of specifications combined with XML based framework technology and provides a run-time environment model for developing embedded interaction and navigation (JavaScript based arguments) in learning pages for learners. SCORM has migrated from e-learning systems to mobile learning systems.

This technique provides an easy navigation on learning pages and as it helps instructors to prepare their learning content as a SCORM package which can be used with the same functionality in every learning platform. SCORM contains three main components. These are Content Aggregation Model (CAM), Run-Time Environment (RTE) and Sequencing and Navigation (SN). SCORM is a standard for combining the learning content (ZIP files) to be adapted for different learning management systems [ADL].

CORDRA

Content Object Repository Discovery and Registration/Resolution Architecture (CORDRA) is a model standard for e-learning and mobile learning systems to build, share and reuse learning content.

AICC[1]

Aviation Industry CBT Committee (AICC) is an international association of technology-based training. AICC is one of the pioneers of specifications and standards for e-learning systems. AICC deals directly with content structure and runtime environment, which launch various content and activities for the learners.

IMS Global Learning Consortium[2]

International Management System (IMS) is a global, non-profit association, which coordinates, leads and shapes the growth of educational technology industries through supporting standards and specifications. IMS provides rich contribution of metadata and content packaging in e-learning and mobile learning solutions.

IEEE LTSC[3]

IEEE Learning Technology Standards Committee (LTSC) has developed different world wide accredited standards and guides for learning technology. LTSC published different standards for learning technology system architectures, data model for learning content in learning management systems, IEEE standard for metadata for learning objects, ECMAscripts[4] APIs for runtime environment programming, XML schema data model for content object communication and XML schema data model for learning object metadata.

LRN[5]

Learning Resource iNterchange is a standard implemented by Microsoft to support IMS metadata/content packaging specifications and the SCORM model. LRN is an XML based standard for defining and organizing learning content.

2.6.2 Learning Materials

Learning materials are the composed elements in a learning process, which are consumed by learners and created by developers and authors [Lapp et al. 2007]. The learn-

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[1] http://www.aicc.org

[2] http://www.imsglobal.org

[3] http://www.ieeeltsc.org

[4] ECMAScript is a scripting language administrated by European Computer Manufacturers Association (ECMA), widely used on web mostly for JavaScript, ActionScript, and Jscript web programming.

[5] http://www.microsoft.com/elearn

ing materials can be presented in different frame and forms of learning such as lessons, quizzes or tests for the learners. According to the definitions [Harman and Koohang 2007][ADL], the lifecycle of learning object can be derived as follows:

> Author/designer → evaluating, finding and developing the learning objects → storage in Learning Object Repository (LOR) → delivery/publish → learners (target groups)

Learning Object Repository (LOR) is a content collection pool, which manages all the learning assets, and learning objects to include authoring, version management and content delivery [Harman and Koohang 2007:134]. Also in a learning object repository, related metadata can be assigned to the learning content. Learning objects should be context free; but they can contain useful descriptive information. The data, which can be included in a learning object are:

- General information about the learning objects (identifiers, version, status, language etc.)

- Level of learning objects

- Type of content (Text, Image, Media, HTML etc.)

- Questions and answers (if the type of learning object is a quiz)

- Associations with other learning objects (Prerequisite learning objects or courses)

- Authority rights

The learning objects can be used or reused statically or dynamically from a learning object repository in the system. By reusability, in some cases, the learning object is needed to repurpose in some specific sections [ADL]. This can be done by changing the same learning object or creating a new one and "copy - paste" the needed sections from other learning objects. It is also recommended by experts [ADL][Harman and Koohang 2007] to design the reusable learning objects more flexibly and dynamic in order to be changeable in later use. The main definition of learning objects concept is given by IEEE-Learning Technology Standard Committee (LTSC). This committee defined these concept protocols in P1484.12.1. IEEE2003.

Metadata, Learning Assets and Learning Objects

Concisely, metadata is data about data and is structured information of explanation and description about the content and components in order to facilitate managing, indexing

and discovering of data [ADL]. National Information Standards Organization defines the metadata as [NISO 2004:1]:

> *"Metadata is key to ensuring that resources will survive and continue to be accessible into the future."*

Metadata in personalization solutions should be accurate, complete and cost effective. Information about resources, development instructions, implementation processes, delivery and maintenance also can be included in metadata [ADL]. In fact, metadata covers two main basic objectives in an optimal system:

- To support learning objects for identifying and discovering.

- To supply direct and indirect accessibility for learning objects.

The collection of metadata is based on the requirements and the existing IEEE learning object metadata. Metadata can be given for a complete module, a chapter, a page or even for a small picture or text. In mobile/e-learning approaches, some information like difficulty level, technical aspects, implementation information, or author's comments can be stored as metadata for a learning object.

Learning assets are the smallest and simplest reusable pieces of data in learning content and can be any file such as text, image, video, audio, flash file or even an XML document, which can be browsed in web browsers [Harman and Koohang 2007]. In mobile/e-learning applications, the size of assets depends on their usage and every asset can be associated with metadata. This metadata, which can be identifier tags, or structure information like technical conditions tags, indicate how the asset should be launched in learning environments.

Learning objects are small, modular and stand-alone pieces that support reusability, simplicity, flexibility, transferability and accessibility in e-/m-learning environments for learning purposes and can be used independently or in an aggregation [Harman and Koohang 2007][ADL]. The size of learning objects should be carefully designed so they can be reused and delivered within diverse contexts. Learning object designers should try to facilitate maximum reusability in their basic design for the learning objects. Learning objects for e-learning purposes in teaching and learning can come in the form of digital materials, graphics, texts, multimedia (audio and video), interaction parts or simulations in learning courses to simulate a semi-real world for the target groups and learners.

3   Mental Disabilities

This chapter describes people with mental and learning disabilities. Some theoretical foundations, literature reviews, standards and experience analysis will be discussed, as well as the pedagogical and psychological backgrounds. The system requirements in next chapter are mainly derived from the discussions in this chapter and partly from the previous chapter.

3.1 People with Mental Disabilities

We often hear about disabled people in our daily life. In recent years, the belief that disabled people are "differently abled" is increasingly becoming well-known. They may not be able to see, but they can compensate for their missing sense [Jantzen 2001]. In most cases, people with physical disabilities can adapt to the difficulties if the environment and conditions are prepared for them. They know how to use the possible ways according to their disability. While people with mental disabilities face difficulties adapting to situations alone and they need to be guided in a process.

Based on statistics and census from Federal Statistical Office of Germany (Statistisches Bundesamt) [DeStatis 2010:154], 10.5[1] percent of the total population in Germany has disabilities (nearly one in every ten persons), in which 8.2 percent are severely disabled and 2.3 percent mildly disabled. Also 4.2[2] percent of people in Germany are affected by severe mental disabilities[3] [DeStatis 2010] and need to be involved in personalized and individualized process of learning.

The first impression of normal people of a disabled people is a person sitting on a wheelchair. But the persons in wheelchairs are just one category of disabled people. According to the World Health Organization definitions [WHO], a disability is:

> *"Any restriction or lack (resulting from any impairment) of ability to perform an activity in the manner or within the range considered normal for a human being."*

Generally, disabilities can be divided into following categories [WHO][IDEA]:

- Physically or orthopedically (e.g. the persons sitting on wheelchairs)
- Sensory (e.g. difficulties in vision or hearing)
- Cognitive and mental (e.g. people with learning disabilities)
- Psychological disorders (e.g. problems with mood, feeling or behavior)
- Multiple (combination of the mentioned disabilities together)

It is scientifically proven that a mental disability is an intellectual impairment [Barbotte et al. 2001]. It is commonly called a cognitive disability [Clark 2002] that points to the mental process of knowing. Most of these people have difficulties in thought processes (perception, awareness, reasoning, memory and judgment) and to gain new knowledge

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[1] Statistics till December 2006 from Federal Statistical Office of Germany. www.destatis.de

[2] 4.7% Male, 3.7%Female. Statistics till 31 December 2007 in Germany [DeStatis 2010:154].

[3] As learning disability is a comparative scale, the statistics can be different in different classifications.

to be applied in daily life and work [Hardy et al. 2009:19-20]. Especially, transferring knowledge learned from the classroom to real life or workplace, a loss of parts of it has to be expected. Department of Health in England [DH 2001] defined learning disabilities as a combination of the following three:

- *"A significantly reduced ability to understand new or complex information, to learn new skills (impaired intelligence); along with*

- *A reduced ability to cope independently (impaired social functioning)*

- *An onset of disability which started before adulthood, with a lasting effect on development."*

And World Health Organization defined the learning disabilities generally as [WHO]:

"A state of arrested or incomplete development of mind."

Learning disabilities have great influences on how that person can react and respond to information, understands, pays attention, remembers and acts. People with learning disabilities have usually difficulties in social adjustments, which should be learned during the life [Hardy et al. 2009].

Most causes of mental disabilities can be categorized into the following factors, which depend on biological, psychological and social influences [WHO 2003][Miles 1990:26]:

- Neurological Causes

- Heredity or genetic causes

- Teratogenic and Pollution Factors

Based on new definitions from American Association on Intellectual and Developmental Disabilities in 1992 [AAIDD] and DSM-IV[1], a person is mentally disabled if he/she meets three criteria of: intelligence quotient below 70 to 75, series limitations in more than two adaptive skills, and the behavioral attitude and condition from childhood (under age 18).

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[1] Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM-IV) is published by American Psychiatric Association and includes all recognized mental disabilities as a classification code system.

3.2 Mental Disability Types

Mental and intellectual disabilities are described by a significantly below-average score on a mental test or by limitations in the abilities to function in different daily life activities [CDC 2005]. Any person can have a mental disability, regardless gender, age, intelligence, environment, wealth, and cultural background. Mental disabilities are in different degrees and can appear in different types as follow.

3.2.1 Learning Disabilities (LD)

Learning disabilities or learning disorder (LD) is one of the most common impairments in people with mental disabilities. The people in this category are usually smart and behave normally but have difficulties acquiring knowledge and social skills in their learning process [LD Online 2008]. The following areas can be affected by learning disabilities [Bradley et al. 2002][NCLD 2010]:

- Spoken daily language as well as reading and writing

- Mathematics and logic

- Memory

- Reasoning

- Social behavior and communications

- Physical coordination

- Metacognition (thinking about thinking)

The knowledge and information of instructor or parents about learning disabilities has a direct influence on the learning performance of people with learning disabilities. One of the most important factors in their successful acquisition of "self-development skills" fosters their own "learning by doing" to incrementally build their autonomy and skills. The skills area can be in self-creation, self-awareness and self-advocacy [Bradley et al. 2002].

3.2.2 Dyslexia

People with dyslexia have difficulties and severe problems in reading, writing, speaking, listening and spelling [NINDS 2009]. People with dyslexia have serious problems in learning processes, which often results in behavior their problems. In different cases, some exceptional strength may appear which makes them stand out in an activity. Some of signs of dyslexia are: difficulties in speech (usually with delay), problems in spelling and syllabus, problems in writing (Dysgraphia), difficulties in memorizing etc. [IDA 2007].

3.2.3 Attention Deficit Hyperactivity Disorder (ADHD)

Attention Deficit Hyperactivity Disorder is a developmental chronic disorder, which is most common in children and can be a life long condition. People with ADHD have different nervous tics and usually repetitive mannerisms [LD Online 2008][NIMH 2010]. ADHD can be diagnosed based on several criteria together. Diagnosis in children is easier than in adults because of the appearance of certain age set symptoms. According to statistics from American Psychiatric Association, 3% to 7% of school-aged children have ADHD [APA 2000].

3.2.4 Autism

Autism causes people to act in unusual ways. They face challenges fitting into society. National Institute of Neurological Disorders and Stroke defines autism as "a range of complex neurodevelopment disorders, characterized by social impairments, communication difficulties, and restricted, repetitive, and stereotyped patterns of behavior" [NINDS 2009:1]. The main problem for people with autism is that they cannot make a connection between what they are doing, and what affect it causes in a social context.

3.2.5 Brain Injury

A brain injury is a condition where there is long-term or temporary disruption in brain function resulting from injury to the brain [NAMI]. It can occur at birth and stay with a person their entire life. Brain injury can be a total or partial functional impairment and also can affect different parameters such as: memory, attention, communication, problem solving, concentration, cognition and even physical behaviors [NINDS 2009].

3.2.6 Genetic Disorders

The genetic science-learning center defines "a genetic disorder as a disease that is caused by an abnormality in an individual's DNA. Abnormalities can range from a small mutation in a single gene to the addition or absence of an entire chromosome or set of chromosomes" [Learn Genetics 2010]. Genetic birth disorders can not be prevented prior to birth; you inherit them from your parents. Genetic disorders are often detected in utero and have different types.

3.3 Mental Disability Diagnose

There have been different methods in different cultural systems for the diagnosis of mental disability. Mental disability has comparative scale, which makes it complicated to diagnose. Many different factors comprise a disability. Environment and culture may also affect disabilities [WHO]. One of the most significant diagnosis systems is from

the American Association on Intellectual and Developmental Disabilities which define a three step method to diagnose mental disability [AAIDD].

- **Step 1:** providing the individual with different standardized intelligence tests or adaptive skills[1] tests.

- **Step 2:** analyzing individual's weak points and strengths, which can be determined by formal testing methods, observations, or interviews. The analysis should be based on the following four dimensions:

    o Intellectual and adaptive behavior skills

    o Psychological/emotional considerations

    o Physical/health/etiological considerations

    o Environmental considerations

- **Step 3:** determining the needed supports across the four dimensions mentioned above by an interdisciplinary team.

Hardy and colleagues from the Royal College of Nursing in England suggest a couple of possible indicators of mental and learning disability [Hardy et al. 2009:6]. These indicators are divided to three categories of activities, memory, and life experience, which are shown in the following table:

Table 4: Possible indicators of learning disability in an individual [Hardy et al. 2009:6].

Activities	**Remember**	**Life experience**
Can they: • read, write • manage money • look after their personal care • cook? Do they have difficulty in communicating with other people?	Can they remember: • significant things about themselves (e.g. birthday) • significant things about their environment • when to do things (get up, what time dinner is) • what you have said?	Have/do they: • attended a special school • attend a day center • live(d) in a hospital or a learning disability service • have people who support them • manage in social situations?

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[1] Adaptive skills are the skills, which are required for normal daily life. e.g. speaking language, self-care skills, or home living abilities.

As the persons with disability have a developmental process for the age, diagnosis of disability should be performed in different periods of time to determine an accurate result. Another method used in schools to diagnose mental disabilities is the K-ABC tests [K-ABC]. The Kaufman Assessment Battery for Children (K-ABC)[1] is an intelligence test set consisting of 16 subtests for assessing mental and cognitive impairments. The Kaufman test strongly emphasizes memory and analyzes intelligence as a problem solving ability rather than knowledge of facts.

Figure 11: Kaufman Assessment Battery for children (K-ABC) test set.

The Kaufman test can be used for children from two to twelve years old and is especially helpful in providing information and evaluations about nonverbal intellectual abilities. In most German schools, in addition to K-ABC, the "Tübinger Luria Christensen Test Set for children" (TÜKI) is used [TÜKI]. The Tübinger Luria-Christensen is a neurological diagnosis instrument for children that consists of a neuropsychological examination series in a standardized box. The method is structured in following subtests (neurology and central nervous system) [TÜKI]:

- Embodied cognition or total body coordination

- Sensor motor operational capability of hands

- Motility of the tongue

- Regulation of speech production

- Acoustic-motor coordination

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[1] Developed by Alan S. Kaufman.

- Kinesthetic sensibility of the skin

- Stereo gnosis

- Functioning of visual abilities

- Spatial cognition and imagination

- Receptive and expressive speech

- Learning abilities

- Memory and remember

- Thought process

Neurological impairments can be analyzed with TÜKI and therapeutically interventions can be planned for children from five to sixteen years old. To the test localize the problem and quantifies the degree of disorder and the structure of the specific impairment.

A similar test "Luria-Nebraska Neuropsychological Battery" is a standardized test based on the theories of Luria regarding neuropsychological functioning [LNNB]. The Luria-Nebraska test attempts to combine the qualitative methods of some neuropsychological tests with the quantitative methods of others. This test is mostly used in the United States and its components are similar to the TÜKI test.

Medical Aspects of Mental Disabilities

Several hundred reasons have been discovered from medical points of view for causes of mental disabilities and impairments [WHO]. There are different medical causes for intellectual disabilities. The causes can be [AAIDD]:

- Genetic conditions and heredity (e.g. down syndrome)

- Difficulties during pregnancy (e.g. alcoholic mother)

- Problems at birth (e.g. lack of oxygen)

- Health limitations and problems (e.g. different diseases and illnesses)

- Poor living conditions (e.g. extreme malnutrition)

In many cases, impairments can be treated or improved by drugs but not always. Beyond medication, the disability can be treated by social support and caring.

3.4 Intelligence

Intelligence is a difficult term to define, as it can be different in different people and in various situations. Stephen Jay Gould defines intelligence in his book "The Mismeasure of Man" [Gould 1996]:

> *"Intelligence is the ability to face problems in an unprogrammed (creative) manner."*

He claims the interpretation of intelligence can be derived from which points to abilities of mind and the potential of abstracts in thought, reasoning, learning, problem solving and social communications. The most common way of intelligence measuring is Intelligent Quotient (IQ). IQ score is described as a score for measuring cognitive ability compared to society in. The intelligent quotient calculation formula (developed by Terman [Terman 1916]) can be computed as follows:

$$IQ = 100 * Mental\ Age\ /\ Chronological\ Age$$

IQ tests are different and are designed for measuring general abilities such as problem solving, reasoning ability, information retention and retrieval, and perceived ability. IQ scores can be used in different contexts such as education, psychology and sociology. There have been many discussions between experts regarding IQ score and the question that if the IQ score can show all intelligence aspects of a person or not. Concerning this debate, Gardner points to a new strategy on intelligence and states in his book "Frames of Mind" [Gardner 1993] that:

> *"I regard Multiple Intelligence theory as a ringing endorsement of three key propositions:*
>
> *• we are not all the same;*
>
> *• we do not all have the same kind of minds (that is, we are not all distinct points on a single bell curve); and*
>
> *• education works most effectively if these differences are taken into account rather than denied or ignored."*

Gardner's Multiple-intelligence theory [Gardner 2006] suggests at least eight types of intelligence as follows instead of general intelligence for all.

1. **Linguistics intelligence:** sensitivity and ability of using language for daily life and achieving goals (words, language, poetry, storytelling).

2. **Logical mathematical intelligence:** ability to analyze and understand logical and mathematical operations (logic, numbers, mathematics, navigation).

3. **Musical intelligence:** skills and talents in music composition and understanding (music, rhythm, composing). Gardner believes musical intelligence runs parallel to linguistic intelligence meaning, people who have difficulties in linguistic intelligence, also have difficulties in musical intelligence.

4. **Bodily-Kinesthetic intelligence:** ability and creativity of using whole or part of body to solve problems (body movement control, dance, and sport). Gardner believes in a relationship between mental and physical activities.

5. **Spatial-Visual intelligence:** ability of pattern and image recognition (images, patterns, spaces).

6. **Interpersonal intelligence:** understanding the emotions of others, motivations and intentions (other people's feelings and emotions). This intelligence helps to understand the other's feelings in order to facilitate communications and group work.

7. **Intrapersonal intelligence:** understanding oneself and creating self-mental models (self-awareness, motivations).

8. **Naturalist intelligence:** natural environment

Gardner believes that traditional intelligence measurements like IQ, does not encompass all human abilities and capabilities. Although many scientists and psychologists have not confirmed Gardner's theory, but it has been strongly welcomed by educators.

3.5   Levels of Mental Abilities

Mental disabilities are considered as developmental disabilities that appear in childhood under the age of 18. Levels of mental disability based on the classification of the American Association on Mental Deficiency (AAMD uses IQ testing which shows the intelligence quotient, function performance of a person and the score from which their IQ test. People with the average score between 70 and 85 are considered slow learners, but not learning disabled, and people under 70 are called learning disabled [Pitsch 2003:127].

The following table is a redesigned table from [AAIDD][Speck 1993][WHO 2006] and shows the level classification as well as World Health Organization's facts for target group's results.

Table 5: Classification for IQ categories [AAIDD][Speck 1993][WHO 2006] (table re-designed).

Levels of Mental Ability	Theoretical IQ	Stanford-Binet[1] IQ	Adults Attainments
Normal	85 - 115		
Borderline	70 - 85	68 - 85	Literacy ++ Self-help skills ++ Excellent speech ++ Semi-skilled work ++
Mild	55 - 70	52 - 67	Literacy + Self-help skills ++ Good speech ++ Semi-skilled work +
Moderate	40 - 55	36 - 51	Literacy +/- Self-help skills + Domestic speech + Unskilled work with or without supervision +
Severe	25 - 40	20 - 35	Assisted self-help skills + Minimum speech + Assisted household chores +
Profound	< 25	< 20	Speech +/- Self-help skills +/-

Note: + means attainable, ++ means definitely attainable, +/- means sometimes attainable

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[1] Stanford-Binet Intelligence Scales is a modern field of intelligence testing and classification. It initiated from Alfred Binet and later in 1916 completed by Stanford psychologist Lewis Terman.

The classification system of mental ability levels is different in United States than in Europe. In the US, the IQ system is used, while in the European system (particularly the German system) the categorization of levels like mild, moderate and severe is used.
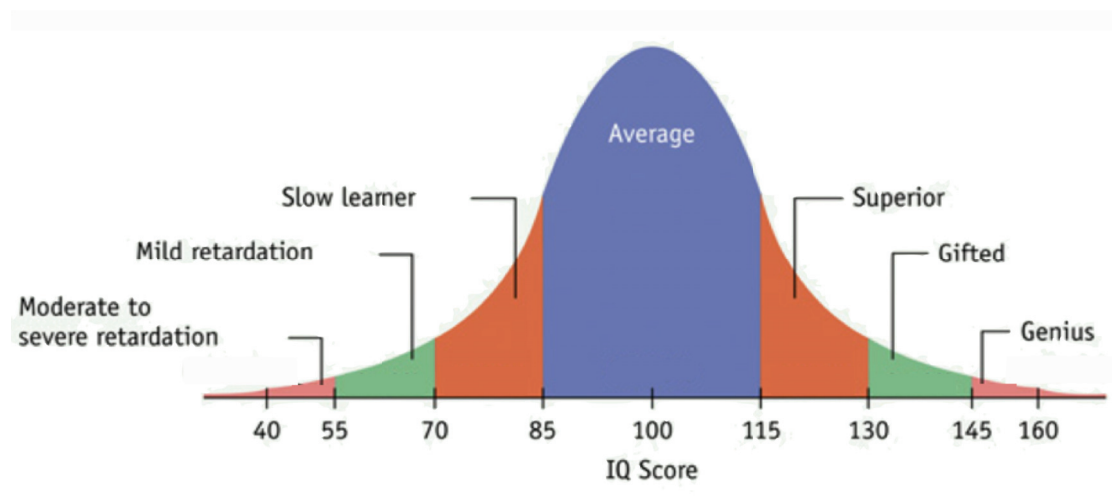
Figure 12: Theoretical distribution of IQ scores bell curve [Lacefield 2008:10].

IQ scores are used internationally to define a person's mental ability. Success in schools can be associated to high IQ scores. IQ values can help educators provide treatment and necessary help for individuals. All measuring systems have their specific use, limits, and problems, but generally, IQ levels have a strong relevance for the ability to do exercises in schools; although in many cases, IQ-tests can measure only specific intellectual skills that are related to speech, mathematical thinking or more abstract levels of thinking.

In many countries like the United States, IQ scores are common to describe the mental development of a person with mental impairments. Screenings from different populations show that about 70% of individuals range between 85 and 115, which is the norm [Lacefield 2008]. Persons with values over 115 are superior, gifted and genius. People with values less then 85 have intellectual difficulties or impairments; in this way a bell curve is drawn. (See figure 12). According to socio-cultural background and ethnicity the peak of the curve seems to differ which can prove controversial because cultural aspects of test design can impact results. Even though the allocation for the levels less than 85 have a certain relevance for the decision which kind of teaching might produce the best results for students with cognitive disabilities.

For the teaching practice, it is helpful to observe the levels from borderline to severe [Pitsch 2003]. Teachers from the inclusive schools in Bremen discuss their experiences with students not in a pre-determined fixed level. Through specified teaching efforts some students develop and reach another level. This kind of adaptive profiling and long

term monitoring of each learner can bring the learning progress on the curve indicates where the teacher may direct and foster the potential of each student.

The American Association on Intellectual and Developmental Disabilities [AAIDD] has defined another diagnostic and classification system for people with mental disabilities. It focuses on the functioning level of individuals and their capabilities. The support categories for the levels of intellectual disabilities are:

- **Intermittent support:** a short-term support needed occasionally based on situations, and significant changes. Mostly used for mildly disabled (not a constant and continuous support).

- **Limited support:** minimum support for life long activities.

- **Extensive support:** regular support in specific environments like daily supports at home for the individual (long-term support and not limited by time).

- **Pervasive support:** constant support for all daily activities and self-care (comprehensive life support).

This classification relates to most diagnostics in the American standard system, the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV) codes that define four categories of mild, moderate, severe, and profound disability based on functioning level [APA 2000].

3.5.1 Borderline

This category represents the largest segment of people with mental disabilities. They have IQs between 70 and 85 [WHO][AAIDD]. There are many discussions if they should be considered mentally disabled because this group faces learning difficulties and are often considered slow learners [Pitsch 2003:127]. Borderline is merely a classification, not a reference to a disease.

3.5.2 Mild

The members of this category have an IQ between 55 and 70 [WHO][AAIDD] and represent the largest group after borderline. WHO reports on their experience finding that this group can often reach an academic level up to the 6th grade [WHO]. Mostly, they can live independently, acquire vocational skills and can interact socially within supported environments. They may need assistance and direction in special situations and to address social stresses [Sulkes 2006].

3.5.3 Moderate

Those in the moderate category have IQs between 40 and 55 [WHO][AAIDD]. With enough supervision, they are able to accomplish their own work and take care of themselves. Social interaction is achievable based on conditions. Their social awareness is poor, but they can learn if the learning process is appropriate and personalized. They can progress to the levels of elementary school and they may achieve self-support by engaging in unskilled or semiskilled tasks under sheltered conditions (e.g. in sheltered workshops) [Sulkes 2006].

3.5.4 Severe

The people the moderate category have IQs between 25 and 40 and are severely disabled [WHO][AAIDD]. They are able to live in a group home but usually live under close supervision [WHO 2006]. They speak mostly with difficulty and limitations [Sulkes 2006]. They can learn simple and primary hygiene (e.g. tooth brushing) and may accomplish partial self-care under supervision [Sulkes 2006].

3.5.5 Profound

This category refers to people with the lowest IQ below 20 [WHO][AAIDD]. They have extreme cognitive limitations and may hardly learn, speak, care for themselves, or communicate with others. These kinds of disabilities are often caused by neurological and medical disorders. Beyond all the other categories, this group needs a high level of supervision as well as nursing care. They can acquire very limited and simple self-care [Sulkes 2006].

3.6 Education for People with Mental Disabilities

People with mental and learning disabilities have the potential to learn, to progress, and to advance based on their own capacity and according to their own abilities. Parents, teachers, and caregivers can play a complementary role in helping them to meet their needs. Wilson and colleagues define metacognition[1] as learner's ability to manage and control his/her cognitive process [Wilson et al. 1993] and continues that it allows the transfer of tacit knowledge[2] [Polanyi 1983] to explicit knowledge.

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[1] "Metacognition refers to our ability to monitor and consequently effectively use our cognitive processes, and in brief it is "cognition about cognition" and one's knowledge of and control over her/his own thinking" [Liang et al. 2007:146].

[2] Polanyi, Michael.: The Tacit Dimension. First published Doubleday & Co. (1966); Reprinted Mass.: Peter S. (1983).

Tacit knowledge is embodied in the personality and in order to communicate this knowledge it must be explainable so that it can be put into words. For this process of making knowledge explicit, meta-cognition is needed to enable a higher level of abstraction. Applied metacognition is also needed to translate explicit knowledge into tacit knowledge that enables it to adapt and use this knowledge for new problems. The meta-cognition extends the cognitive dimension of learning and prepares the individual for further ongoing learning experiences and knowledge sharing.

People with mental disabilities have problems with metacognition because the step to reflect on one's own action and to put this on an abstract level is often part of their disability. They mostly need guidance during the process of adapting explicit knowledge and/or in the process of translating tacit knowledge into language. Mobile learning offers bridges that can help to reduce the gap between tacit knowledge and language. How so? The system can take the place of a guide that moderates between the world of the disabled and the non-disabled world. Its functionality can foster metacognitive processes as the technology connects contexts so that the translation between the two worlds becomes less abstract.

The National Information Center for Children and Youth with Disabilities gives this advice to teachers, and caregivers to help them prepare the disabled for daily learning and communication [NICHCY 2009]:

- Avoiding defined learning environments like special schools for the mentally disabled, instead, trying to keep them in the regular school system.

- Presenting the information and guides in small and sequential portions.

- Reviewing and repeating the steps frequently during the process.

- Applying concrete materials mostly with a connection to real world concepts and daily usage.

- Providing the materials according to their age and levels.

- Remembering that easy tasks for non-disabled people can be hard for them, so tasks should be well structured for independent work.

- Providing frequent and relevant feedback for different interactions.

Special schools for children with special needs have opened in the past twenty years. In the evolution of the educational system, the integration of children with disabilities in normal classrooms is aimed by the governments. As a result of this coeducation, children with disabilities join other non-disabled children of their age in a unique classroom. To enable this integration and with respect to the needs of each child, a concept was developed that supports two cooperating teachers and two coupled classrooms. See Figure 13, map of a coupled classroom.
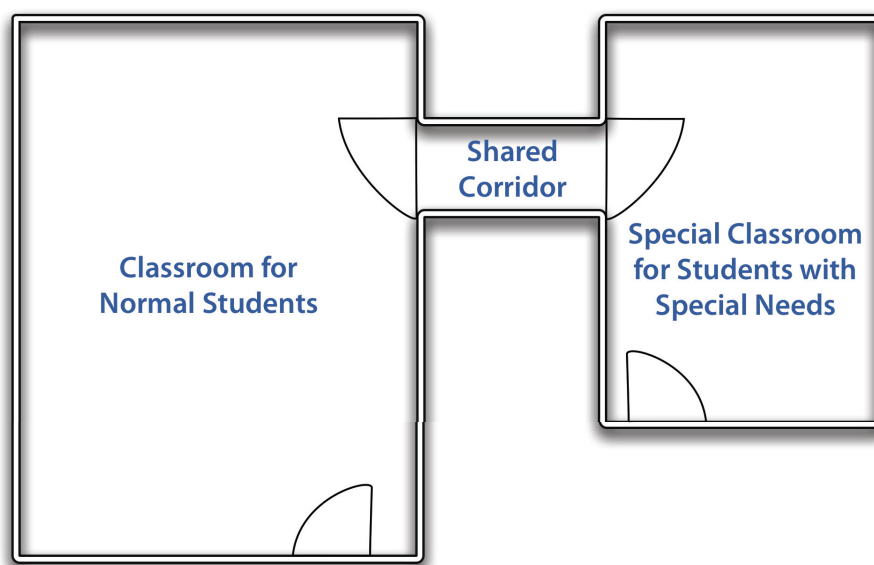
Figure 13: Model of inclusion, coupled classrooms facilitate cooperative learning for the diverse needs of children.

Some development modifications should be made to effectively implement this model. Existing school buildings need to be structurally altered and two classrooms connected, so that these rooms remain separate, but children can easily move between the rooms. One room is the home class and for the children with no disability. The connected one is home room for the children with special needs. Each group has a class teacher, responsible for planning, and scheduling combined class activities with the other teacher.

The special needs teacher is a qualified educator for the disabled. The main teaching routine for the whole class consists on sequences that both groups perform together. In addition there are special and separate lessons specified for each group. The special needs teach removes this group from the whole class and do lessons separately, as required.

The group of students with special needs is generally small, around four to seven children, so that the teacher can be aware of each of them and the other children are not overstrained. The children with special needs get the teaching that fits to their needs and additionally their social relations are enriched by friendship with non-disabled students.

Some teachers claim that students with borderline abilities can develop to reach higher standards. For others this coeducation offers added learning enrichment. Sometimes a disabled child has remarkable abilities in other areas [Jantzen 2001]; also a gifted child will do mistakes, so that both groups can develop through working together with more respect and responsibility.

Teaching staff should not emphasize the child's difficulties but instead should enable an atmosphere of inclusion. Most importantly, a clear and well-defined understanding of the limitations and status of development of a specific child has to be known. Experts in the field of disability use the following phrases when referring to disabled persons.

Table 6: Sample glossary of phrases which should be used for people with disability [Rose 2004:1][MCSS 2010:1].

Don't say	Do say
Impairments	Body functions / structures
Activity limitation	Activity
Handicap	Disability
Mentally handicapped	People with mental disabilities
Blind people	People who are blind / impaired vision
Lame	Unable to walk properly
Dwarf / Midget	Restricted growth
Wacked	Cognitive disability
Learning disabled	A person with a learning disability or people with learning disabilities
Mentally retarded	A person with an intellectual disability
Normal Person	A person without a disability or A person who is not disabled
Deaf and dumb	A person who is deaf and does not talk
Autistic	A person with autism

A person with Autism Spectrum Disorder |
| Wheelchair bound | A person who uses a wheelchair |

The "BBC's disability website, Ouch!" lists the top ten worst to be avoided when referring to people with disability [Rose 2004:1]. They are: Retard, Spastic, Window-licker, Mong, Special, Brave, Cripple, Psycho, Handicapped, and Wheelchair-bound.

Assistance

Assistance supports learners with mental disabilities to develop self-control by guided performance of acts of operations that stimulate autonomous actions. According to the Theunissen resource-oriented model of assistance, a personal assistant for the mentally disabled needs to consider that [Theunissen and Plaute 2003]:

- The learner with cognitive disability may ask for the favorite helper or assistant.

- The learner can choose the time of learning and can agree to the process.

- The learner is regarded as an expert for his own needs and can be asked for each step; he is able to decide during the process which kind of help he wants.

- A person with a disability may have suggestions for the place (room, location) of the learning process.

- A person with disability is able to check the result himself (with assistance).

- Support to reach self-determined aims in the learning process.

- Support to participate in social life and communicate.

These considerations regard the complementary values of assistance and intervention with the aim to empower the person. The assistant supports the disabled by extending their cognitive competence and mobility.

3.6.1 Psychological Aspects

In psychology there are different views on children with cognitive disabilities [Piaget 1974][Feuerstein et al. 2002][Bandura 1997]. Developmental psychologists compare the differences and similarities between the individual developments of different groups. Some psychologists focus on the cognitive development through case studies of children with cognitive disabilities. Other research examines the specifications of emotional problems and some aim to understand how to train groups to improve their abilities and potential.

Developmental psychologists Jean Piaget [Piaget 1974] and Bärbel Inhelder[1] look at learning theories. In cognitive development, they consider that the individual passes through different levels building on the previous levels. All individuals follow this process including children with cognitive impairments. Impairments tend to pin the individual down to a specific level. This tendency to fix on a prescribed level can be re-

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[1] Bärbel Inhelder (1913-1997) was a Swiss psychologist, the most famous co-worker of Jean Piaget.

moved by social interaction. In this model, the behavior of a person is connected to a situation of social interaction that can have an effect on mental structures.

Reuven Feuerstein analyzed the mild and moderate cognitive disabilities in children [Feuerstein et al. 2002]. His training exercises focus on the construction of concepts. Impressive results in IQ development were achieved by this practice. Firstly, cognitive impairments, specifically social impairments are considered. Social impairments were triggered by distal factors that influence social interaction within a given environment. A lack in social experiences causes a reduced exposure to learning experiences. By creating situations that stimulate social interaction and learning experiences, cognitive development can be fostered. From this view, Feuerstein focuses the role of human mediator in the learning process. He could show that there is a "significance of the human mediator as the decisive factor in accounting for differential cognitive development" [Feuerstein et al. 1999:302]. The human mediator moderates the interaction between stimuli[1] and child. The mediator can support the child by offering behavioral patterns that effect structural cognitive modifiability.

Between IQ and modifiability a relation can be analyzed. The IQ gives information (a score) about cognitive functions that can be understood as process variables depending on attitudes, work habits, learning history, motives and learning strategies. Also each age and level of cognitive development constructs its own set of process variables.

In this psychological model, IQ and mental processes variables are not fixed [Howe 1998:70-71][Feuerstein et al. 1999]; individuals are permanently in a process of change. Through stimuli, social communication and helpful mediators, which provide patterns, work habits, and behavioral strategies, learning capacities can be developed. These patterns and habits enable new learning and foster learner self-confidence. Learning strategies can be adapted by well-structured learning paths prepared and communicated through engaging the learner.

It may be argued that individuals can change their IQ value by developing their personal potential. For this process feedback from the learning process can be helpful, but instead of a single feedback, a continual feedback over a period is processed to show development and the growth potential.

The Montessori[2] perspective suggests each child has their own desire to learn and the teacher should build the right situation or context and provide conductive material so that the child can be involved in his own learning process [Lillard 1996][Montessori 1988:79-81]. Interaction with learning materials can show several steps based on each other. At first learner attention is diffuse and then it migrates between self and diverse

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[1] Stimuli are events in the environment that influence behavior.
[2] Maria Montessori (1870 - 1952) was an Italian physician, educator, philosopher, humanitarian.

objects and the material. When the child starts to play or work with the material, his /her attention fluctuates between the activity and the environment.

Attempts to put learning in precise words tend to cause the attention to polarize and oscillate between the audience and the learner. A break then causes tension in the learning and one's attention normally stops. This process describes complex interdependent relations between material, development and the mental system. Furthermore, learners need to be self-confident and trust their own capacities and abilities. Different parameters can affect learner self-confidence. These include: parent behavior and reactions to the learner, attitude, an emphasis on strengths, preparation and self-evaluation.

3.6.2 Learning Process for People with Mental Disabilities

People with mental disabilities are able to learn, but learn best through a step by step process. This should be carefully designed because an ineffective learning method can easily work at counter-purposes by turning the disabled off of learning. The United Nation guideline [UN 1995:2] provides these criteria consideration in physical planning and design of a learning environment:

- Accessibility

- Reach ability

- Usability

- Safety

- Workability

- Barrier-free or non-handicapping

Disorders in learning can appear in educational, social, self-skills, communication and daily life-skills. Nikolai discusses some teaching techniques to be considered in learning design for the mentally disabled [Nikolai]. These techniques can be summarized as follow:

- Breaking the learning blocks and tasks into several small learning nuggets.

- Keeping in mind that people with mental disabilities tend to be visual and viewable. An increased use of visual objects such as charts, graphics, and videos can help them to remember better.

- Focusing on a particular attribute of a task. Simplifying the tasks and avoiding complicated structures.

- Using clustered strategies with respect to short-term memory of learners, also repetition of materials over periods of time.

- People with mental disabilities are not aware of peripheral information in context. In these cases the instructor should provide facts and additional information.

- Using immediate feedback, to help them establish a connection between answers or behaviors and the instructor's response.

- Being sure after every process that the learner gains a sense of satisfaction. This factor contributes to motivating the learner to learn more in subsequent sessions.

Instructors need to analyze learning activities and interactions carefully before implementing them in a system. The analysis should be based on learner ability, synthetic skills[1], learning environment and system technical support [Nikolai]. Enough exercises, feedback, repetition and emphasis should be provided throughout the learning process. Pitsch points to the use of sensory perception concurrent with touch and movement stimulation (if applicable) in combination with word and picture activities [Pitsch 2003:130]. The time to complete every activity should be calculated, as the disabled usually need more time to complete work. Learning sessions need to be broken into small segments appropriate to the learner's stamina and capacity. Pitsch discusses the tactile learning style of people with mental disabilities [Pitsch 2003:131]:

> *"The mentally disabled learn less through listening, writing down, reading and understanding than through watching and imitating, or having their movements physically guided by the teacher or trainer or steered through demonstration".*

With mobile learning the mentally disabled can engage in real-time situations making learner-appropriate movements, and observations instead of sitting in isolation at a desktop computer. Mobile technologies address the special difficulties of transferring knowledge from the classroom to context by fostering the learning processes directly within the context of use (in real life with mobile devices). To ensure that the learner is engaged with the learning material, he becomes part of the learning process. This kind of interaction tends to provide better memorization and recall of work procedures.

Current technology provides opportunities for learners to control their learning process [Laurillard 2002]. It gives learners the chance to adapt to the learning environment and learn at their own rate according to their own preferences. But in the learning process for people with mental disabilities this option should be changed and limited. They should be guided by the program towards the learning steps and exercises, but not with

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[1] Synthetic skills: The ability to smoothly combine data and to integrate a complex multitude of data into a coherent whole. Being able to present alternatives and to develop them into a convincing conclusion. Source: https://admin.kuleuven.be/personeel/competentieprofiel/en/skills.html (Last viewed: 12 Aug. 2010).

respect to the learning speed. In other words, they need a flexible learning speed but a fixed structure managed by their instructor(s). Within this fixed structure, learners should be able to select and customize their learning process. Suta and colleague say [Suta et al. 2007:190]:

> *"Psychic (mental) processes like sensation, perception, representation, thinking and imagination are fundamentals for the learning ability. The efficiency of learning activities depends on the specific features of these mental processes and functions, which are part of the complex structure of the personality of each pupil."*

In this way, Chen points to the following principles of pedagogy, which should be considered in a learning process [Chen et al. 2002:1]:

- Urgency of learning need

- Initiative of knowledge acquisition

- Mobility of learning setting

- Interactivity of learning process

- Situations of instructional activities

- Integration of instructional content

From the principles mentioned, the last three are crucial for learning processes of people with mental disabilities. According to input from disability experts and teachers in Bremen schools and our workshop experience, we may conclude that learning approaches for this target group does not require slow learning, but instead a presentation of the learning material in a way which is understandable for learners which might be slow at particular junctures.

In this approach, different parameters are the basis of the learning process. These parameters such as the mental level, learner's memory ability, user preferences, user behavior etc. can affect the software's decision algorithms for a particular user. The results of these parameter experiments provide the background rationale for their weights and prioritization.

Literature recommends reducing redundant loads of content which learners should memorize [Pitsch 2003][Sierra 2006][Speck 1993]. As an example, Sierra refers to the following memory exercise and shows how effective the type of learning content presentation can be [Sierra 2006]. For a learning activity, the learner is asked to memorize (Figure 14) code symbols in part (a) without looking to part (b) within 30 seconds (part "b" is hidden for the first phase of activity).
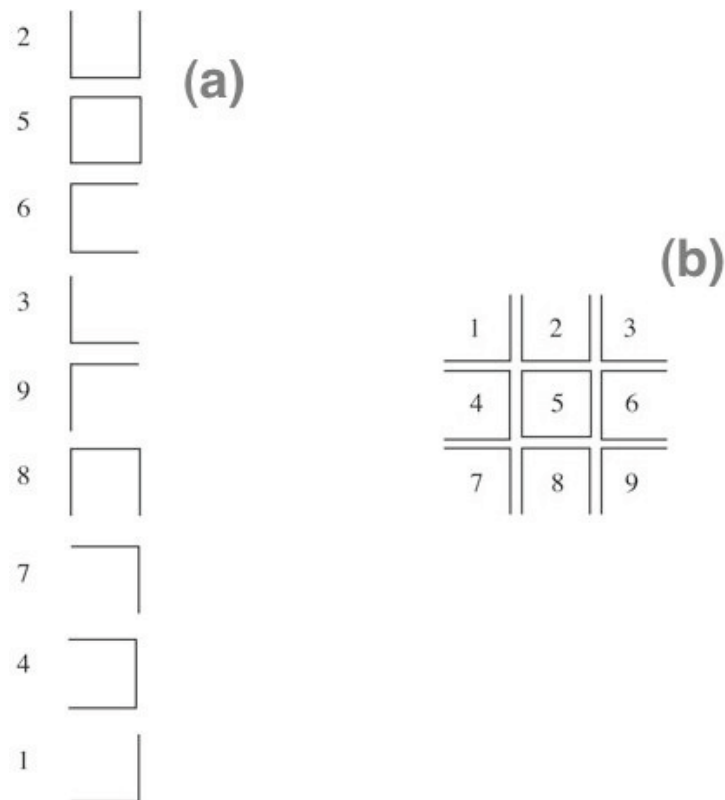
Figure 14: Memory exercise of code symbols [Sierra 2006].

A normal learner and in best case can memorize just 60% within 30 seconds. In workshops we tested similar exercises with the mentally disabled, and the average result was below 10%. With a simple change in the presentation of these code symbols and presenting them with a meaningful connection to a context and memorable pattern, the learner would be able to memorize it even within less than 30 seconds. By presenting part (b) for the learners, the memorizing results for this activity with normal learners became 100% and for people with learning disabilities became over 75%[1].

This small description of the memory capacity should cover the characteristics of the conceptualization and design of learning content and steps for the mentally disabled. In the following with a detailed view including examples we analyze the specifications of the design of learning materials within this context.

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[1] Results taken within our ongoing workshops with our target group.
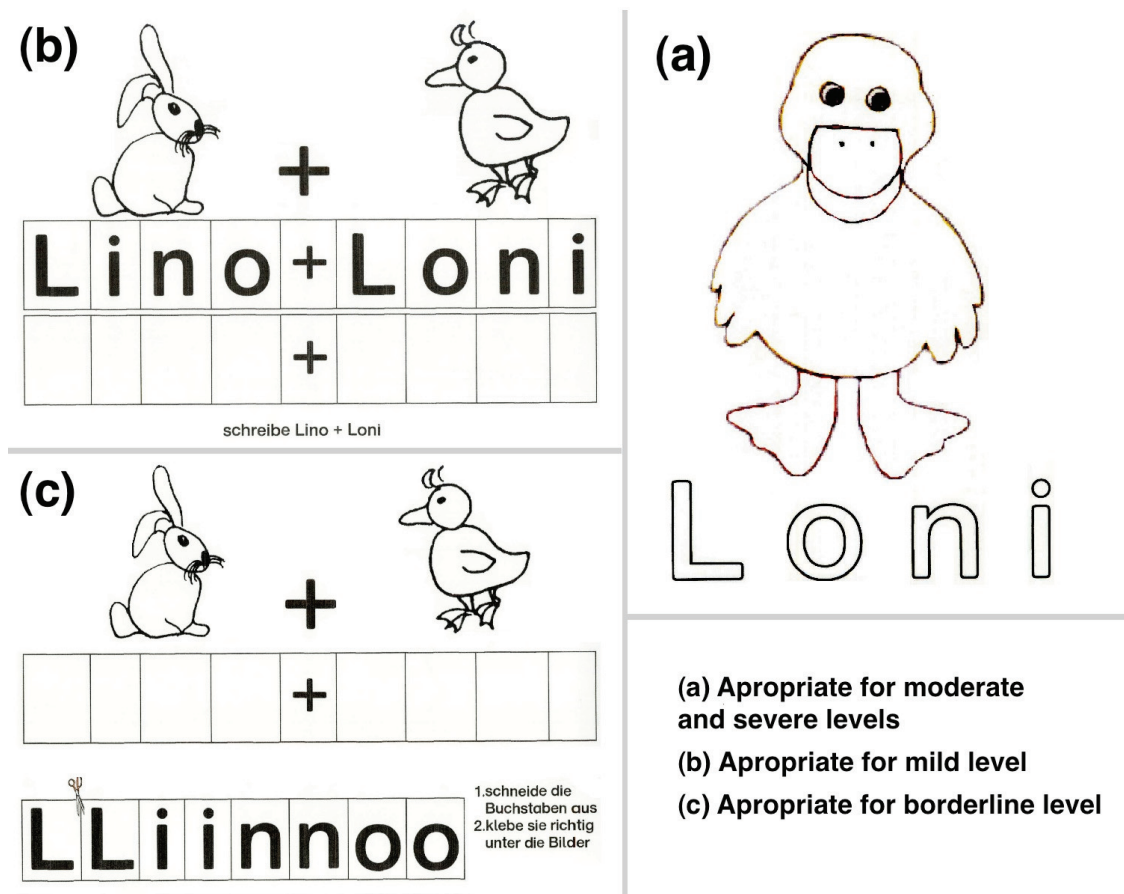
Figure 15: Non-digital learning material sample used in Bremen schools
for different levels of disability.

Figure 15 shows a sample of non-digital learning materials to test different levels of disability. In part (a) which is for moderate and severe disabled, they have to identify the shape in the picture and its related name "Loni". Part (b) is appropriate for the mild level and they have to identify the two shapes in the picture and write the same name under the given names. Part (c) is appropriate for the borderline level they have to distinguish the two shapes in the picture from each other and try to order the letters in the right positions.

The designing of learning materials for different levels is a time-consuming task. Pitsch lists key criteria for instructors and content designers to consider in their design[1] [Pitsch 2003:137-138]:

- Setting clear goals of learning for learner.

- Trying to build a connection between content and contexts for the learners.

- Trying giving them feeling of autonomy in learning.

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[1] The criteria are edited by author based on individual literature reviews, but mostly on Pitsch criteria.

- Providing learners with feelings of self-assurance and self-confidence.

- Using animation characters to put them in a semi-social communicative learning mode.

- Using meaningful signals in learning environments and teaching these though schemas for appropriate signals.

- Replacing words with models, pictures, and figures in many cases.

- Analyzing actions and synthesize partial actions as well as a clear demonstration.

- Giving direct guides and avoiding indirect help.

- Speaking clearly and distinctly.

- Using short and concise sentences.

- Providing the learner with repetition of concepts.

- Organizing and combining several modes of sensory perception.

- Being sure to included praise and encouragement within the design even for minimum progress.

- Motivating, reassuring and encouraging the learner constantly throughout the process.

- Correcting mistakes immediately with positive meaningful controlled feedback.

- Giving enough time to accomplish the activities (Patience).

- Breaking and stopping during the process, as necessary.

- Avoiding unnecessary assistance.

Implementing these criteria should result in a learning process of high quality learner performance.

3.7 World Health Organization Classifications

The World Health Organization (WHO) provides different classifications for the health of the world population. Different frameworks for describing the facets of human functioning that may be affected by a health condition are outlined. These standards can be supported by ICD-10 and health outcomes by ICF.

3.7.1 ICF Standards

"International Classification of Functioning" called usually ICF is a multipurpose classification designed to serve various disciplines and different sectors. It is a classification system not a measurement tool. ICF groups health and health-related domains and contains the classification of human functioning factors, restrictions and impairments. The ICF classification is categorized by set of principles, which refers to the interrelatedness of the levels and the hierarchy of classification (See Table 7) [WHO]. The following diagram outlines the hierarchy of classification in the ICF codes.
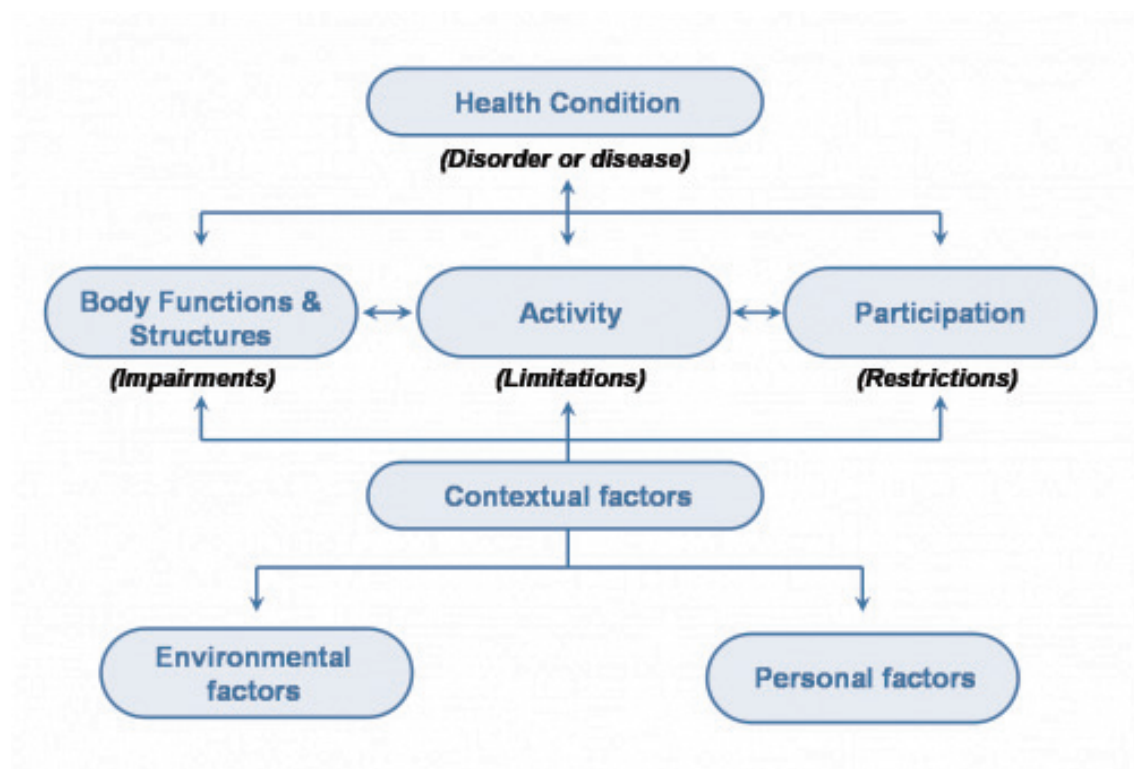
Figure 16: Interactions between the ICF components [WHO].

As shown in Figure 16, disabilities (impairments, limitations and restrictions) are in the middle of the diagram with interactions between health condition and contextual factors. Contextual factors are connected to personal factors (e.g. gender, age, job, educational level etc.) and environmental factors (e.g. social communications, climate, training situations etc.). WHO points to three levels of classification, which are: functioning at the level of body, the person, and the person in a social context [WHO]. The following table shows the ICF components and qualifiers.

Table 7: ICF qualifers table [WHO].

Components	First qualifier	Second qualifier
Body Functions (b)	Generic qualifier with the negative scale used to indicate the extent or magnitude of an impairment *Example: b167.3 to indicate a severe impairment in specific mental functions of language*	None
Body Structures (s)	Generic qualifier with the negative scale used to indicate the extent or magnitude of an impairment *Example: s730.3 to indicate a severe impairment of the upper extremity*	Used to indicate the nature of the change in the respective body structure: 0 no change in structure 1 total absence 2 partial absence 3 additional part 4 aberrant dimensions 5 discontinuity 6 deviating position 7 qualitative changes in structure, including accumulation of fluid 8 not specified 9 not applicable *Example: s730.32 to indicate the partial absence of the upper extremity*
Activities and Participation (d)	Performance Generic qualifier Problem in the person's current environment *Example: d5101.1_ to indicate mild difficulty with bathing the whole body with the use of assistive devices that are available to the person in his or her current environment*	Capacity Generic qualifier Limitation without assistance *Example: d5101._2 to indicate moderate difficulty with bathing the whole body; implies that there is moderate difficulty without the use of assistive devices or personal help*

Environmental Factors (e)	Generic qualifier, with negative and positive scale, to denote extent of barriers and facilitators respectively. *Example: e130.2 to indicate that products for education are a moderate barrier. Conversely, e130+2 would indicate that products for education are a moderate facilitator*	None

The picture below uses sample code from the above classification table.
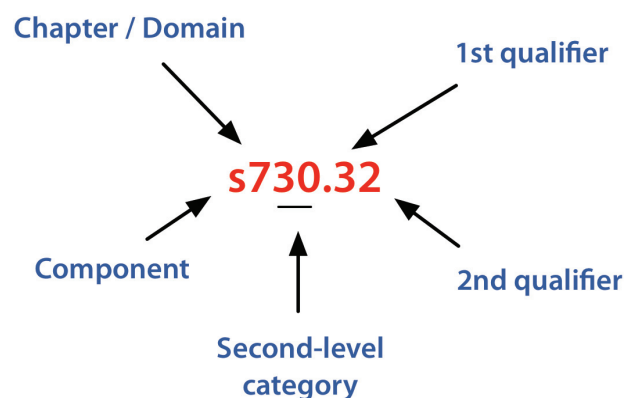
Figure 17: The format of ICF codes [WHO].

The code in Figure 17 indicates the component (in this example "body structure"), domains at the chapter level (e.g. mental functionality), secondary level of category and two qualifiers.

3.7.2 ICD-10 Standards

International Classification of Diseases (ICD) revision 10 is an etiological diagnostic coding system, which focuses on all general epidemiological, health management purposes and clinical use [WHO]. ICD-10 contains approximately 120,000 alphanumeric codes. The American Academy of Dermatology Association points to better data support of ICD-10 for the value demands of an increasingly global health care environment as follows [AAD]:

- Quality measurement and patient safety improvement activities

- Pay-for-performance initiatives

- Improved public health and bioterrorism monitoring

- More accurate reimbursement rates

World Health Organization provided an online interactive training tool[1] for IDC-10 [WHO], which structures possibilities for fast tracking different codes with respect to their classification. Chapter five of ICD-10 classifies mental and behavioral disorders.

3.8 Accessibility

Accessibility refers to how different people with different abilities access a device, product, situation, or a service and strongly emphasizes universal design to support a wider group of users. Accessibility is a key part of software application development for the disabled because it can facilitate their access in different situations.

In most cases, accessibility in digital media is defined as adaptation of materials and a kind of special delivery for those who need special support. W3C defines Web accessibility as [W3C WAI 2005]:

> *"Web accessibility means that people with disabilities can use the Web. More specifically, web accessibility means that people with disabilities can perceive, understand, navigate, and interact with the web, and that they can contribute to the web.*
>
> *Web accessibility also benefits others, including older people with changing abilities due to aging (…) Content is accessible when it may be used by someone with a disability."*

A similar definition can be applied to mobile learning applications. Accessibility in mobile learning can improve the understanding, perception, navigation and interaction throughout a learning process. A learning application can be accessible if every learner from the target group can easily use it regardless of technology, device type, learning content, or interaction. Learning application designers should consider accessibility techniques to design an effective UI. In mobile learning approaches, the success of the actual learning depends on client accessibility to the mobile device. For the disabled, mobile technology can be extremely useful as they have problems sitting in one spot.

3.9 Sheltered Workshops for People with Disabilities

To feel autonomous and independent the disabled need to actively participate in society. Getting a job is much more difficult for people with disabilities than for others [Burchardt 2000]. They can improve their skills and abilities by going through special vocational programs in sheltered workshops, which are mostly supported by governmental or

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[1] http://apps.who.int/classifications/apps/icd/ICD10Training (Last viewed 17 August 2010).

social institutions. Such programs are available for people with psychological disabilities, physical and cognitive disabilities. Sheltered workshops in Germany have developed over last fifty to sixty years. They offer daily opportunities for the disables to participate in a work life, to get trained to recover after severe health and psychological problems in order to turn back to normal work life if possible and to integrate into society. Social advocates strive to enable this target group to participate in normal work life; either by setting up special workplaces or by offering training for "normal" work opportunities.

Nelson has a definition for sheltered workshop adapted from the National Association of Sheltered Workshops and Homebound programs [Nelson 1971:127]:

> *"A sheltered workshop is a nonprofit rehabilitation facility utilizing individual goals, wages, supportive services, and a controlled work environment to help vocationally handicapped persons achieve or maintain their maximum potential as workers."*

The concept of sheltered workshop is to adapt the work to the people's ability and also to do the work as effective as possible so that the buyers of the products will be satisfied and the sheltered workshop can cooperate with the private sector to produce products that can be sold to earn profit. To a large extent, government supports the disabled while some of their income is derived from their work. Sheltered workshops are important because they foster self-confidence and help the disabled build meaningful lives. Most employ medical caregivers, disability experts and special staff. They offer workers:

- **Salary:** The workers get salary based on their working time and experience.

- **Sense of autonomy:** By working in workshops and earning money, the workers get an autonomous for their life style.

- **Social communications:** By working in workshops and contacting with colleagues and supervisors, they get social communication support and staying in touch with other people.

- **Responsibility:** They get the sense of responsibility for their assigned obligations and doing a job.

Martinshof (Established 1953) [Martinshof] is one of the largest sheltered workshops for people with mental disabilities and is located in Bremen, Germany. Martinshof provides one-on-one training for the mentally disabled. Programs there include adaptive activities for the workplace according to the ability of the worker instead of assigning people to the workplace. The personnel at Martinshof have special, adapted and personalized work environments. Workers are carefully supervised at this facility.

Figure 18: Sheltered workshops Martinshof in Bremen [Martinshof].

In general a person is chosen according to their ability to meet the requirements of the job. This also includes the workflow and its consequences. These environments allow the individual to adapt to the conditions of the work. Sometimes the job applicant needs specified training.

The focus is that each individual should find work that supports him/her to feel meaning in their life and useful to society. Workshop leaders acquire cooperation with local companies. They determine which individual might be able to do the required work under which conditions with which support and with what kinds of training. Secondly, they in cooperation with a master craftsman, they develop how the environment, the tools, machines and workflow can be changed so that this work can be adapted to a certain individual. Here the model is based on the idea that the work should be adapted to the ability and needs of a certain person.

Their goal is to create good products with respect to worker abilities. This inclusive approach lets individuals participate in the work world and in society. Beside this "work" model, the workshops include help participants with social insurance. Individual can contribute to their own rent and personal needs from the money they earn at the workshops. Over the past two years our researchers have collaborated with Martinshof and their experts have in return supported our activities. We have conducted several analytical workshops in different areas of study in Martinshof Bremen.

4 Concepts, Requirements and the Methodology of an Intelligent Mobile Learning Interaction System (IMLIS)

This chapter is methodologically oriented and discusses the analysis of concepts and requirements resulting from previous chapters. This provides the fundamentals for the next chapters. It covers the methodology, empirical research, and personalization analysis of two and three-dimensional learning cubic taken within this study. Five sample use case scenarios of the system usage are also explained to give a better impression. Generally, the demands and requirements for an approach are defined with respect to real contexts where they should be used.

This study is part of a broader collaboration with learners and teachers for a development process with specific requirements of an engineering process. The aim of this process is to generalize all the specific requirements of the targeted field and the actions of the mentally disabled. The goal is to enable existing practices with digital media and along with establishing media that provides opportunities for a new user-appropriate practice.

4.1 Methodology

All of this empirical research was done in the context of mobile learning for people with mental disabilities in "Digital Media in Education - dimeb" research group. After different brainstorming, colloquiums and group discussions on a consensus for personalized learning system based on mobile technology which can be adapted to the mentally disabled, we proceeded to design this system taking into consideration an iterative and learner-centered design to meet our requirements.

The methodological approach utilized reviews and analyses qualitative and in some cases quantitative aspects in this study. For the qualitative aspects, we could identify and reflect the key requirements of the system design based on the literature review of mobile technology, analysis of learning theories and previous research as well as interviews and workshops. The other part of the study emphasizes a technical development approach looking at the technical aspects of mobile technology.

Empirical research based on experimental prospects through structured workshops, interviews and feedback from disability experts is the primary focus of this study. Different design stakeholders both learners and teachers participated throughout the study at different times and supported us with appropriate feedback. In this way the developmental process became an iterative design process [Nielsen 1993][Dow et al. 2005]. Following learner-centered design principles [Quintana et al. 2000][Soloway et al. 1994], our application is based on learner needs and abilities. In learner-centered design scenarios, the development of the study is derived from the observations and information gathered from the learner. This enables a direct focus on user requirements throughout the learning process.

There have been several approaches in developing a learning system for the mentally disabled. Prototyping methods such as paper prototyping, horizontal and vertical prototyping, and evolutionary prototyping [Arnowitz et al. 2007] have been used in this study. The study begins with a literature review, previous solutions and projects, and continues with the crucial analysis phase. In this phase, the pitfalls and strong points of previous solutions, possible implementation technology, ability and limitations of the mentally disabled and finally development methods with qualitative and quantitative techniques were analyzed.

The analytical workshops conducted in the study allowed the researchers to observe the mentally disabled and their initial reactions as well as their behaviors while working with mobile devices. Through these observations, we could analyze basic requirements and highlight impediments to learning. From this analysis a clear "to do list" was developed.

4.2 Empirical Research

The following diagram shows the research goal approach to the development of personalized mobile learning model for people with mental disabilities through the evolution of a prototype. The complete process was carried out after in- depth empirical and theoretical research on three areas of mobile technology, disability and education was completed.
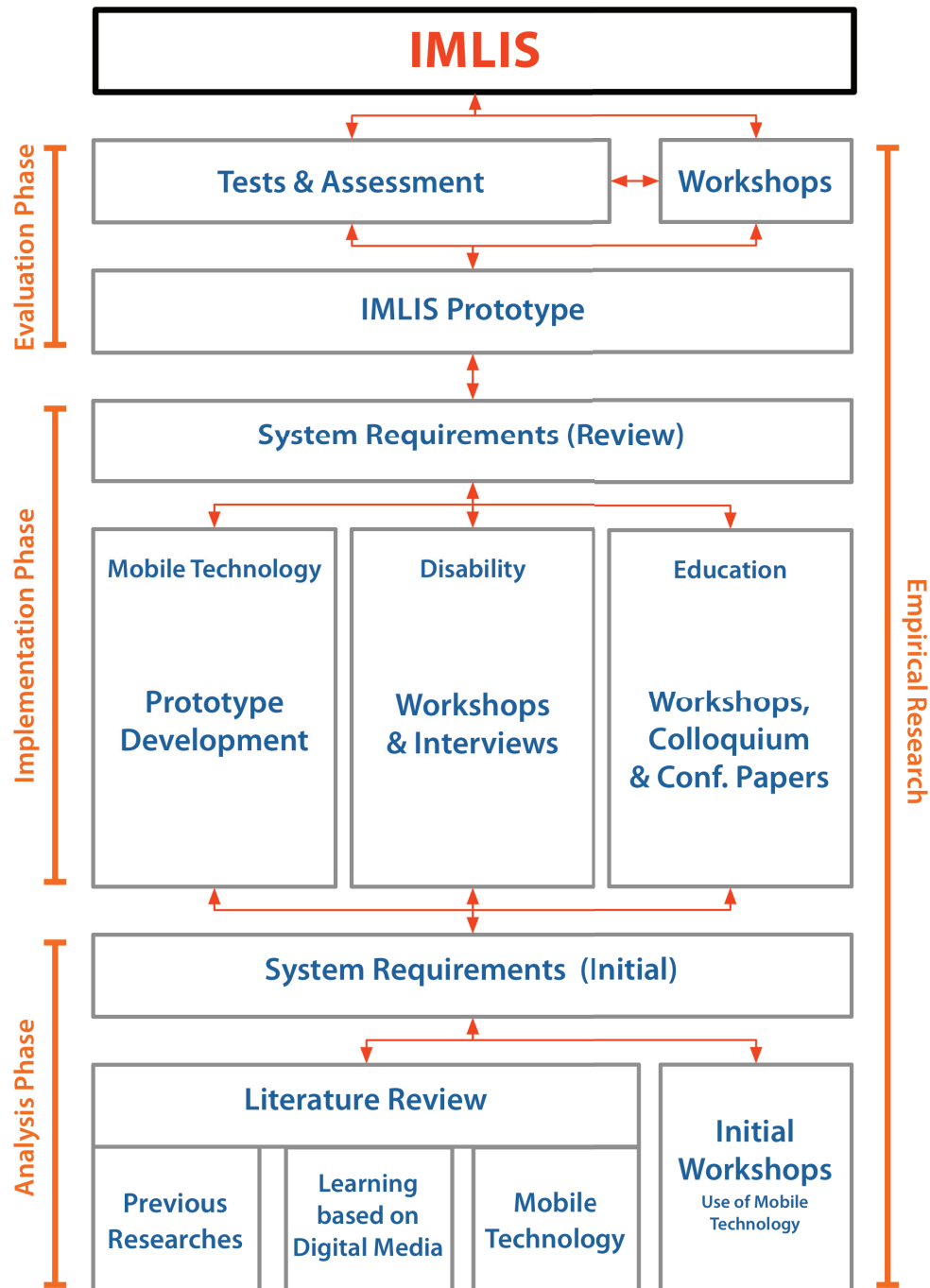
Figure 19: Concept of the IMLIS overall approach.

Figure 19 shows the concept of the overall IMLIS approach. The diagram consists of three analytical phases, an implementation phase and an evaluation phase. The analytical is based on a literature review of previous research, the affects of learning theories on digital media in education and the technical issues related to mobile technology. Parallel to the literature review, different initial workshops with the mentally disabled were conducted. They focused on the use of mobile technology and the users' first impressions using mobile learning. Clearly the initial system requirements are based on literature review and initial workshops.

Once the system requirements were complete, the implementation phase with three parallel processes of prototype development (from the mobile technology field), workshops with the mentally disabled and interviews with teachers and disability experts (disability field) and workshops, colloquiums and pedagogical discussions (educational field) began. The results of these three parallel processes led to the review of system requirements to be compared to initial system requirements and this led to the IMLIS prototype.

In the final phase, the prototype was tested and evaluated along with our results in different methods. In many cases, different interactive structured, mini questionnaires were used to gather information from disability experts to reflect their input in diagrams and finally to decision engine algorithms. By design, the experts were encouraged to provide relevant answers concerning an exact algorithm in decisions. Through these questions, we also investigated the current learning status of the mentally disabled to meet some of our requirements.

The final goal defined and developed a personalized, adaptive, interactive, robust, symmetric and reusable learning environment in order to increase the learning performance for people with mental disabilities at borderline, mild, and moderate levels. In order to obtain insight into different key parameters of the mentally disabled, our research needed to 'plug into" a concrete context with real users. We needed to have access to a wide pool of learners as well as learning materials to test our analysis and implementation(s).

4.3   Requirements Analysis

Why mobile learning?

Mobile learning is often seen as a kind of media-based learning that is not only an extension or another version of e-learning; instead it has specific qualities that cause different authors to state different definitions and requirements for mobile learning. The basis of this study is the focus on the mobility of the device and coupled with user abilities associated directly to this technology.

In several pre-evaluations we discovered that most disabled people have their own mobile phone and had learned to use it. It had become a part of their everyday life. The technology not only helps them access society it also helps them keep in contact with family and to ask for help. It is highly motivating for them to use it, because it increases their status as member of society. In comparison to PCs or laptops, a mobile phone is regarded as part of life that the disabled should be able to use on their own. A personal computer is part of the complex work world that can be managed by a limited number of the mentally disabled. This seems to indicate that people with disabilities are more motivated to use a mobile device than other computer technologies. They appear to feel more able to cope with technology difficulties even when more fine motor skills are challenged.

Also most of the students had their own mobile device but not their own personal computer. In school the computer room is only available in predefined time slots. Students in an integrative or inclusive class the require teaching interventions according to context and situation. The possibility for the instructor to leave the students on the device to train on a specific topic or sequence is important. Having one's own device allows for flexibility in the learning situation. Also the environment can play an important role. With a mobile learning device, multiple confidential learning situations can be arranged according to learner need.

4.3.1 The role of IMLIS-prototype in the development

Research complexity, the specification of the area and target group demand for a prototype fit in the following subtasks:

- Reduce the number of direct evaluation with students with cognitive disabilities, because the setting was focused on a group of teachers with their students. The teachers were very engaged in the study, however to accomplish our research we required an agreement to arrange the terms of testing and evaluation with students, sometimes even before that of the teachers. Student buy-in was a fundamental aspect of our work considering that the teachers tended to advocate on behalf of the students to help them cognitive "capacity overload".

- Find a common language that allows immediate comprehension, communication and exchange of models and concepts between diverse groups of teachers.

- Enable to instantaneously implement a certain variation of the interaction and to test with the teachers.

- To test different aspects separately and system reduce complexity in order gain insight into what disability experts need. To limit the number of functionalities and aspects to gain deeper detail level for analysis and expert feedback.

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First of all, several small interactive mock-ups were developed to analyze and create different aspects of the model. With these parts and the results a general prototype was built. Teacher collaboration in the interactive use and discussion throughout the use of self-determined tasks enabled us to gather results to refine the model. The leading concepts to develop the interlinked prototypes were the six research questions grouped to four foci. Real classroom learning is analyzed by the teacher concerns about transformation to digital media and the opportunities of mobile learning were discussed. As previously discussed, within these particular scenarios small mock-ups were implemented.

The target group has specific needs, restrictions and less stamina especially when they should learn autonomously. In order to find out their aspects regarding motivation, the study undertook a series of visits and interviews to expose the students to mobile devices, and ask them to interact with a favorite application. Thereafter, the observations were discussed with the teachers and using "cognitive walkthrough" [Blackmon et al. 2002] which allowed for the prototype problems and suggestions to be gathered. Student handling of mobile interfaces was also considered. The implemented personalization methods in the decision engine, during the learning process were evaluated by a group of teachers. Each teacher prepared a typical scenario for a typical student with specific problems.

4.3.2 Dynamic Learner Interactions in Diverse Situations of Traditional Learning and Learning with Digital Media

Continuing discussions with experts (teachers from the schools of people with special needs and scientific experts in disability, University of Bremen) and concerning the results about the interactions that learners have in different contexts with different media, the experts emphasized the need for dynamic visualization for changes that a learner experience by working with a digital media as well as in traditional classroom learning.

Moore points to three possible contingents of "learner-content" interaction, "learner-instructor" interaction and "learner-learner" interaction (presented in section 2.5.2) [Moore 1989:1-6], and designed a pie diagram to visualize the potential role of different interactions of a learner during working with an e-learning system. Based on this strategy, we mapped the contingent of these three interactions according our expectations and experience on a new pie chart based on our assumptions and observations (Figure 20). The hypothetical size of each section should visualize the dynamic changes of proportions between these interactions by using digital media instead of traditional classroom-based learning.

In a similar way we tried to visualize the changes of interactions in special teaching contexts for students with cognitive disabilities. Our interest was to discuss the possi-

bilities and needs for the students with cognitive disabilities concerning interactions. The following pie diagrams (Figure 20) are based on guesses and expert estimations (within our research group) and in discussions of these diagrams enabled helpful descriptions and analysis of our evaluations with students. Depending on the situation and the media used, each of these three interactions can have a different quantifier in proportion to each other. We explored the experience of teachers in four situations by trying to quantify the contingent of each learner interaction in a certain learning process.

The chosen situations are traditional learning in classroom, common learning by digital media (focus on e-learning), traditional learning for people with mental disabilities, and mobile learning for people with mental disabilities.

- For **traditional learning in classroom**, around fifty percent of the interactions are interactions from learner within content. The other interactions of the learner are social interactions that can be divided into a big part of an interaction with the expert (teacher) and a smaller part for learner interaction with other learners and classmates (Figure 20, top-left diagram).

- The second situation is **learning process with common learning applications**. In this case, nearly three quarter of the interactions of the learner can be described as an interaction with the content. The remaining parts of social interactions consist on a bigger part of interaction with expert and a smaller part of interaction with other learners (Figure 20, top-right diagram).

- The third situation maps a **traditional learning situation of learners with mental/learning disabilities.** During the learning process the expert (teacher) has to conduct the learning process, so the social interaction with the experts needs nearly two third of the entire interactions. The second part is the small social interactions with other learners. The third part is interaction with content included in the learning process; so the remaining part is the interaction between learner and content (Figure 20, bottom-left diagram).

- In the fourth situation, we tried to visualize the quantities of these interactions for the situation where a **learner with learning disabilities uses a mobile learning system**. As mentioned in previous chapters, mobile learning is learning across context; the fourth interaction between the learner and context can be added here. In this case, the interaction of the learner with the content comprises the largest part. There is a direct and indirect interaction with the expert and there is also an interaction with other learners. In this case the social interaction with experts and other learners is also extended to the context. In this learning situation the interaction from the learner with the content was enabled and supported by personalization (Figure 20, bottom-right diagram).

To complete the model of the four situations depicted in Figure 20, the three aspects of personalization, individualization and customization in diagram design were considered.
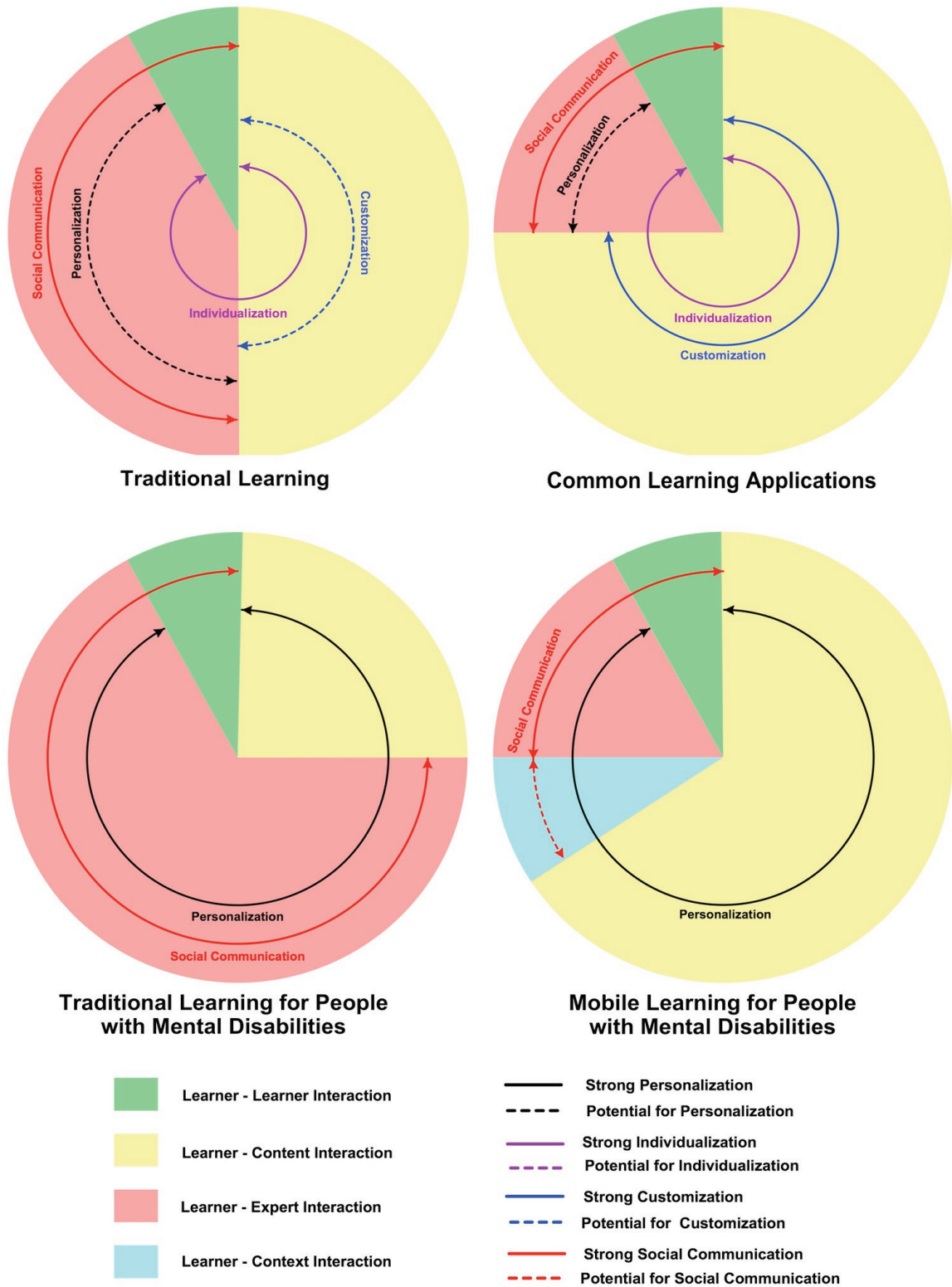
Figure 20: Visualization of indicators to define the dynamic of interactions according to specific learning cases.

In traditional classroom learning (first situation) the quantities of interactions can be viewed according to the involvement of teacher and learner for the decisions. The factors are:

- **Individualization:** the teacher decides according curriculum what should be learned; this is the most important criterion for selecting the content. It is valuable for the social interaction with the teacher and the interaction possibilities with the content.

- **Personalization:** the teacher sometimes takes the chance to differentiate a certain exercise according the needs of certain student; but this decision aspect is seldom used. It is basically a decision that is available in the social interaction with the expert or teacher.

- **Customization:** often the expert or teacher enables learners to choose different variations of content on their own but normally this quality is not strongly developed.

- **Social Communication:** in classroom two qualities of interactions are important and are interconnected with each other. Social communication is supported by interactions between learner and teacher and learner with other learners. Social communication helps motivations and the stability of the learning process.

These factors above are used in the second situation, common learning by digital media and e-learning platforms:

- **Individualization:** the expert decides according curriculum what kind of content in which variations could be provided. It is valuable for the interaction with the expert and the interaction possibilities with the content.

- **Personalization:** the expert sometimes implements possibilities that enable interactions or feedback to differentiate the learning path according the needs of a certain learner. But this quality of decision is seldom provided. It is basically a decision that is implemented by an expert, and is in a way an indirect interaction with the expert.

- **Customization:** in many cases the experts let the learners choose different variations of content, to adapt the design, to choose where to start in a learning process, or to select a chapter from the list to learn.

- **Social Communication:** in this case, social communication can be indirectly supported by the interaction of the learner with other learners and the tutor or instructor.

In traditional classroom learning for students with learning disabilities the quantities of interactions can be viewed according the involvement of teacher and learner in decision-making. The factors are:

- **Personalization:** the teacher has to customize a certain exercise and learning material according the needs of a certain student, which starts by choosing appropriate and engaging material. Teaching method and student handling has to be prepared according to the student's special needs. These are active decisions not only with respect to social interaction with the expert or teacher but also regarding the choice of content.

- **Social Communication:** in this situation the communication with teacher or tutor is vital and the leading interaction but there is also a small amount of social interaction with other learners.

The following two factors play an important role in the fourth situation, mobile learning for students with learning disabilities.

- **Personalization:** the teacher has to customize a certain exercise and learning material according the needs of a certain student. It starts by choosing the engaging topics and material. The teaching method and handling for the student has to be prepared according his/her special needs. According to this aspect the expert or teacher has to upload the learning material onto the device and to select the interactions. Via the decision engine, the system uses the criteria provided by the experts and teachers to produce needed material with supporting interactions that enable learning activities with the content.

- **Social Communication:** in this system indirect communication with the teacher or tutor is the leading interaction in the design of the learning material but there is also a possibility of social interaction with teacher and a social interaction with other learners. Learners sometimes get help to start an activity with the mobile device or together with a tutor they explore the learning system.

In a learning system, the social aspect is highly considerable and enhances the possibility of the learner to autonomously accomplish a lesson through personalization. Through visualization an important dynamic strategy can be detected. In traditional classrooms the learning process uses content as in a social dimension. With digital media, the use of personalized learning content can be highlighted.

In traditional classrooms for students with learning disabilities, the social interactions with teacher or tutor are the basic aspects that enable effective learning processes. By switching to digital media, a transformation to a mobile learning system demands the implementation of stronger social connections. In our case, personalization is directed by the interactions between the teacher with the system, whereby the teacher defines the

materials and interactions on the teacher portal. Although the role of content is highlighted more in digital media, the model is balanced and directed by the implemented personalization.

In order to validate the hypothesis that content is highlighted through digital media, we collected the evidence from literature and discussed our mapping with experts and teachers in schools and our research group. By reviewing the results, we got strong indications that the dynamic model which we observed is valuable for further system design that target and support the learning process of students with learning disabilities. Further research needs to be undertaken to precisely analyze these factors.

4.3.3 Applying Personalization

The visualization of a learning system is designed on the basic aspects of learner, content and technology. For mobile learning these three aspects remain important, but the technology interfers with the aspect context. Bringing learner and content to the context means reducing abstraction because the context makes the content details obvious. Contextualized learning material can enhance the motivations of learning and assist comprehension. This system guides functionalities that help to adapt to reality; this adaptation is also a source of empowerment.

The content should not be constructed from explicit knowledge alone; it should provide implicit aspects and practices, or it should help to make available implicit knowledge as well. In order to process this and to gain knowledge, interactions have to be implemented. The most important quality that a mobile learning system provides nowadays is its "extendibility" allowing for the addition of context to the learning process. The presence of context is valuable to because it allows experts to apply the knowledge as a bridge that supports the transformation from implicit knowledge to explicit knowledge, which can be easily used. This transformation means a reduction of abstraction. In contextualized situations, users become the actors of their own learning process and can be motivated to construct their links from the provided concepts of the knowledge to the context.

Each learner has a personal profile according to personal information that can be constructed by a detailed description of personal abilities, restrictions, previous knowledge and interests. The following diagram (Figure 21) depicts these three aspects of learner, content and context within the related parameters.
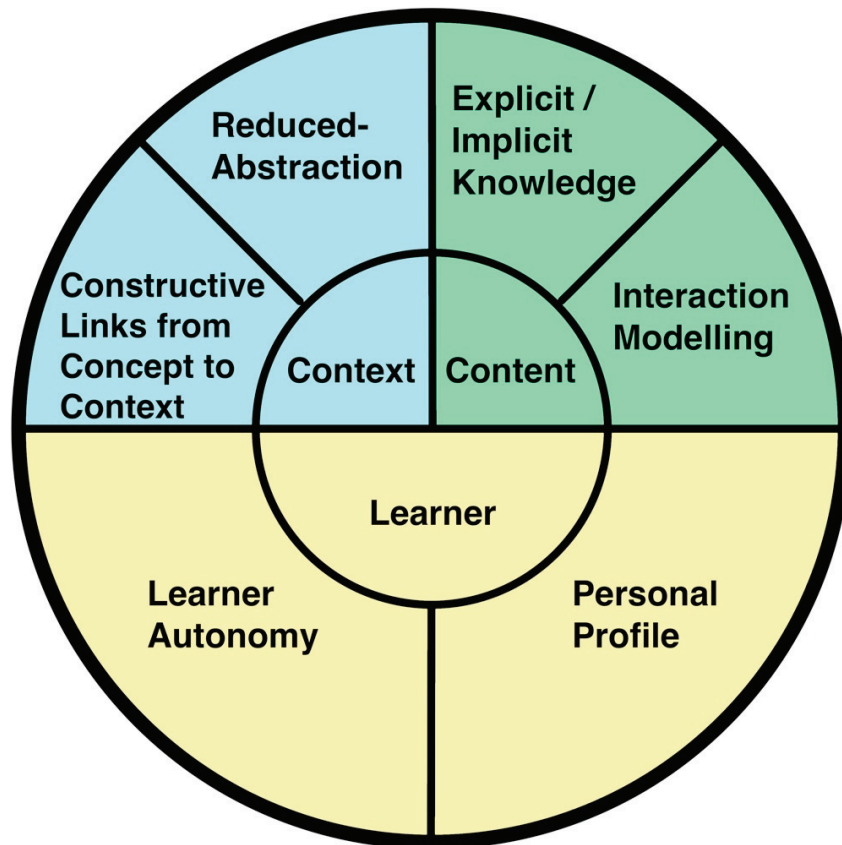
Figure 21: Three basis-learning components.

In order to comprehend the learning content, learners have to construct the knowledge on their own. This activity can be supported by functionality design. The main support comes from the intelligent personalization of the material according to the profile adjusted through a monitoring activity of the system.

In IMLIS, the mobile learning system is extended by a model for personalized interactions (Figure 22). The personal profile of the learner gets an extended value. It enables the system to provide content and interactions that fit the profile of a specific individual. In this process the content is adapted according the needs of an individual coupled with interactions that provide specific learning processes specialized for a profile called "personalized learning content".

The implemented model of personalization allows for other activities. These functions should build links from concept to context to support the learner. In this way, personalization in cognitive abilities gets activated according to learner profile, which is called "personalized activation of cognitive abilities". Generally, we can state that the implementation of a personalization model creates a learning system that adapts to the learner needs; and supports the learner to mobilize comprehension of the knowledge which enables the transformation to applicable knowledge. This is part of training especially for the development of skills.
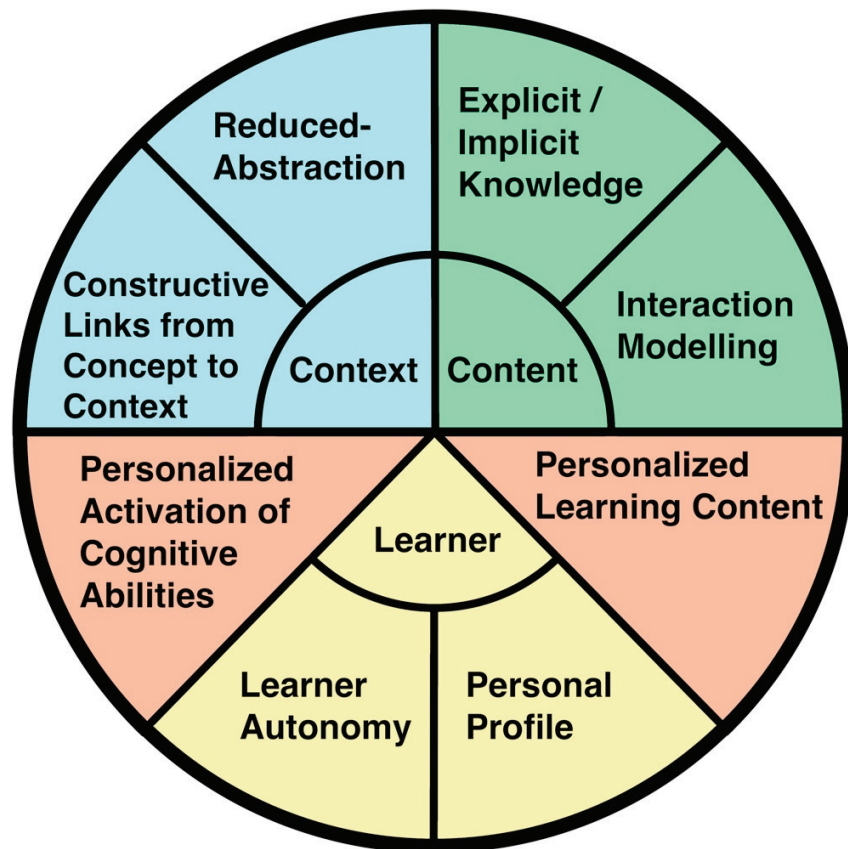
Figure 22: Inserting personalization in three basis-learning components.

The personalization aspects render further possibilities for developing mobile learning systems for diverse groups of users and contexts. We considered the following parameters in our concept to build a system that consists of technology, learner and teaching efforts:

- Adaptation of needs for the individual user and learning style

- The importance of personal well-being

- Motivating and encouraging design

- Orienting the user through the learning process

- Fostering competencies and self-confidence

- Supporting self-control or self-awareness of learner behavior during the performance, by focusing attention and recording behavior

- Different self-assessments which encourage the learners to self-regulate

- Modeling workflow according to the description of educational experts and teachers with respect to fortifying perceived competence and self-direction of the target group

4.4 Use Case Scenarios

For a better understanding of IMLIS usage in real contexts, the following scenarios were designed according to the concepts and requirements of IMLIS with respect to real cases studied during this research and conducted workshops.

In discussion with teachers and experts in the workshops, we analyzed which contexts are common to the target group where a mobile learning system can provide advantages. The use cases are in inclusive classrooms, workplaces and during the leisure time of students and workers with cognitive disabilities. Through the design of these scenarios we could review the requirements for refining the system. The following five use cases scenarios helped our researchers to reveal design considerations and build usability requirements.

4.4.1 Scenario 1: Mobile Learning in an Inclusive Classroom

Background Information

Tobias is a 9 year old boy who has been going to an inclusive class in Rhododendronpark School for two years. Tobias has a mild cognitive disability, major reading and writing problems, but he can speak well and his counting skills and calculations are impressive. He can differentiate letters and sometimes (when he had already seen it before) syllables, but he cannot read or write besides his name and his address. He didn't go to a special school and just started school in an inclusive class of 23 students with 3 other students with cognitive disabilities.

Tobias learns in a normal class with all the other students, but he has a personal tutor supporting him. If a very complex exercise is done he goes in a separate room, where he gets specialized training from his teacher. Sometimes when he becomes too excited or he cannot focus any more, he is separated from normal class and gets extra exercises.

Scenario #1

Step1: During the lesson Tobias was fascinated by all the pictures concerning weather. The following day after the introduction, Tobias was asked whether he would like to do the next topic of climate involving a small exercise for him according what he heard the day before. Mrs. Bergmann (his teacher) noted that Tobias often plays with his cell phone and he manages to use it well. Moreover, he is fascinated by this technology. His teacher asked if he would like to do a task with a mobile device. He had agreed and now he gets the chance to do his training with a mobile device, supported by his tutor. He went with his tutor into a separate room, and his tutor showed him how to use the IMLIS mobile application. With help from a tutor, a personal profile for Tobias was prepared and registered in the IMLIS system.

Now, Tobias logs in with his picture and a symbol as his password. Even though Tobias was excited, he managed to stay calm and attentive. He uses a pen device for interacting with the system. He very quickly managed to use the system.

Step 2: Tobias started his lesson and was asked whether he likes to do exercises with sky or temperature. Normally he would have started with numbers but the image of a cloud motivated him to choose the weather lesson. After clicking on the cloud he was welcomed by the recorded audio announcement from his teacher. He was asked to carefully look at the picture and the written word under the picture. Afterwards the order of the syllabus was disarranged and he was asked to restore the right order of letters again. During this presentation the voice of his teacher said "Cloud" and repeated this twice.

Afterwards he had to do the same procedure with an image of a sun and then with an image of rain and with an image that shows a storm with lightening. Tobias didn't make any mistakes and so he was rewarded with a music animation presented on his mobile device. For the next exercise, Tobias experienced difficulties solving it, so he stopped the learning process for a short time. Fifteen minutes later he started his second exercise again. This time he could manage to arrange the exercise easily and he got good feedback. After he had completed this exercise the system asked him to review the first exercise to train again in order to strengthen the effects of the training. When he had completed this work he told the teacher about his success. The teacher was so happy about his success that she asked him to present what he had learned to the class.

Scenario Highlights Pros and Cons

Pros

- With a basic support autonomous exercises are possible.

- The system can stimulate motivation.

- The system recognizes the level and needs of the user and offers only sufficient materials.

- The system recognizes if a user is able to fulfill the tasks or if he needs something else.

- If a person with less stamina is making mistakes, the system suggests small breaks. And after break, he can carry on at anytime.

Cons

- The profile creation (in the current situation of IMLIS) cannot be processed by the students alone.

- Communicating the results to classmates cannot be done directly with the device so the system doesn't offer direct social communication.

- The system is very directive and does not offer opportunity for self-defined tasks.

4.4.2 Scenario 2: Mobile Learning at Workplace

Background Information

Mr. Schmidt (31 years old) is a worker in the sheltered workshop Martinshof. He is mentally disabled in the level of borderline. Before starting his work in Martinshof, he received two weeks of training in automotive parts assembly, so he knows about the basics of auto parts. He carries always his cell phone and uses it as a communication tool with friends, emergency calls, as an mp3 player and integrated camera.

Sheltered workshops Martinshof provided the IMLIS system for workers in workshops in order to provide learning anytime for the workers during their working hours. Every department supervisor is trained on implemented mobile learning systems and keeps many mobile devices for the workers in case of need. The appropriate learning materials for different levels of disability are designed and uploaded via IMLIS teacher portal to the Martinshof IMLIS server by experts in Martinshof's training department.

Scenario #2

Mr. Schmidt started a new workday. He has to assemble new parts of a Mercedes-Benz car today. As the assembly process is new, he asks Mr. Winkler (his supervisor) for a mobile device. Mobile clients can connect via wireless protocol to the Martinshof IM-LIS server. His supervisor gives him a mobile device; he selects the appropriate chapter and starts to learn the assembly process directly at his workplace. He follows the instructions step by step and tries to perform the process at the same time.

After a repetition of the process, Mr. Schmidt can accomplish the assembly process alone. Later, he will use the mobile application if he forgets how to do a particular assembly task.

Scenario Highlights Pros and Cons

Pros

- Mobile learning helps workers to learn directly in a real context.

- Workers can feel independent due to their own learning experiences.

- Guided learning process where the description becomes less abstract as it is used directly in a real context.

- As Mr. Schmidt has his own cell phone, he can use his own device (if the device is compatible to the IMLIS requirements).

Cons

- The advisor needs to constantly keep the system updated which could take additional time.

4.4.3 Scenario 3: Mobile Learning in Leisure Time

Background Information

Tanja is a 17 year old, student with a cognitive disability on the borderline level. In addition to her mental problems, she has hearing difficulties. She is interested in mobile cell phones and the functions embedded in a cell phone. Her parents got a new contract from Vodafone for her with a new touch screen device. Her father is a sailor and has a private boat. He can work with computers and understands his daughter's disability.

Scenario #3

Step 1: Tanja wants to accompany her father on the boat next summer. Her father promised her, if she learns the basic safety skills needed for sailing, he would take her on a one-week trip. She had never been on such a trip and is motivated to learn these skills. As Tanja's father knows exactly about the abilities and disabilities of her daughter, he prepares the sailing learning materials via the teacher portal. He has different pictures, films and texts about sailing. Later, Tanja's father helps her to install the IMLIS client on her cell phone.

Step 2: On the tram, Tanja uses her cell phone to learn about these sailing rules. On her mobile telephone materials without audio support are all visualized, and combined with some funny interactions derived from real context. On the weekend Tanja can take the device on a family picnic. There she can start to learn via her cell phone. In less than two weeks and with 12 learning sessions, she can learn what she the sailing skills she needs.

Scenario Highlights Pros and Cons

Pros

- Learning process can occur anytime even in leisure time.

- Social communication can be between father and his daughter.

- Parents support child to become more autonomous from their own understanding of their child.

- Learner is not limited to a specific place of learning.

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Cons

- Learners can be easily distracted from learning process in a non-school area.

- The parents or caregivers may not be acquainted with digital media and this kind of media-based learning.

4.4.4 Scenario 4: Preparation of Digital Learning Materials via IMLIS Teacher Portal

Background Information

Karin is a 35 year old teacher of children with cognitive disabilities. For eight years she's taught: four in a special school and four with another teacher for normal children in an inclusive class.

Currently she teaches fifth grade to children mostly ten and eleven years old. Five students with disabilities are in their class. Two of her students are borderline and three are moderate; each student is different in learning behavior and skills. For the exercises she prepares a daily small sequence of lessons and exercises for each of her five students, as there is not too much textbook, printed or other material available for people with cognitive disabilities. She collects pictures and small exercises that she can easily diversify and adapt. But this work takes a lot of time especially to make copies, arrange and try out the variations.

Scenario #4

Karin wants to teach to the students the topic "Time" as this topic should be reviewed many times with the students with cognitive disability. She had scanned some clock faces that show different times. She had also scanned the face of a digital clock. All these materials she had uploaded on the system some months ago and with the same materials she can arrange new exercises for each student monthly.

Katrin uses IMLIS teacher portal to create and manage lessons and monitor the success of her students. In the system each student has a profile that with updated information according learning behavior from each learning session. First of all, she studies each profile and how each student can succeed in his or her tasks. According to this she makes comments and notes that she saves in her task-field in the teacher portal. In a second step she creates two exercises, one for borderline and one for mild students. In step three she adapts the exercises to each student. The two borderline students are Ann and Franka. She analyses Ann's success and needs and adds specific interactions to the exercise according to the student's needs. Franka needs more support during the workflow so the teacher adds other interactions to the existing exercise. This learning design is customized for Franka.

The teacher prepared a unit to meet the diverse needs the three other moderate students Rose, Selim and Ronald. She created a unit for Rose and then for Ronald using a specific lesson and adding different interactions for each of them. For Selim she had to modify more because he had language problems. She shortened the unit and added several iterations with variations of specific parts. She added the adequate interactions to the unit that should support him in the workflow.

Finally, she recorded and implemented a personal welcome for each student and specific motivational feedback to be presented as audio. When everything is done she tests each learning unit with the preview-function where the system simulates the learning process of the chosen student according to his/her profile.

Scenario Highlights Pros and Cons

Pros

- The system enables effective reuse and arrangements of uploaded materials.

- The system preview-function shows a simulation of how the student with his/her needs will manage to use the lesson.

- If a teacher works over a certain time with the system, the quantity of learning materials will increase enabling the easy creation of diverse lessons and exercises a in short timeframe.

- By the monitored learning behavior of each student in his/her profile the teacher gets detailed knowledge about the development and needs of each student.

- It becomes possible to analyze when and what kind of teaching material will best support the development of a certain student.

Cons

- The system has to be understood in order to use it effectively – takes time to learn how to use it.

- At the beginning, it takes a lot of time to upload and categorize the materials.

- The teacher portal is difficult for teachers with lower computer skills to manage.

- It is not easy to create lessons that can be solved collaboratively with other students.

4.4.5 Scenario 5: Sharing of Learning Materials between Teachers

Background Information

Agnes is a 42 year old teacher for students with cognitive disabilities. She works in an inclusive class with David, a 38 year old teacher. Together they teach 21 children, three students have borderline cognitive disabilities.

Scenario #5

David and Agnes set up the scheduling together. According to this scheduling Agnes states which of the three students with cognitive disabilities can do the normal lesson and which students need additional special exercises in order to follow the lessons. She selects material the learning materials for each of these three students and will upload their material to the teacher portal. Agnes and David create a personal profile for each of the three students; in this way David and Agnes can create the lessons specified for the needs of each student.

Half a year later Agnes enters another class set to teach the same topics that she taught the last class. She is able to reuse the previous materials for another lesson of new students. The system also monitors how the targeted student can deal with the materials. According to student feedback and learning behaviors, a meaningful profile for each learning asset grows. Furthermore other teachers can benefit from this learning material knowledge base. Later, Harald (another teacher) asks Agnes to use her materials in his class. Agnes agreed to offer a public right to use her materials. Harald can search the existing lessons by the preview, and might use this lesson unmodified or change them for his class. He can also create new lessons from previous learning assets.

Scenario Highlights Pros and Cons

Pros

- The system enables the effective reuse and arrangements of uploaded materials so the teachers can easily share the materials.

- The IMLIS categorizes the learning materials automatically based on learning history and behaviors.

- After an initial learning period, less effort in preparation time is required, and then the system reaches a certain amount of potential for to foster high learning performance.

Cons

- At the beginning, it needs a lot of effort to implement a basic collection of learning material.

- It takes a period of time till the system gathers enough precise information for each learning asset.

- Like other communities, these interactive classrooms may have only a few active users who contribute to the system, and most other teachers will just use the prepared materials.

- It doesn't support direct communication between teachers.

4.5 Interview with Experts

To meet the system requirements, and to design an accurate system, we collaborated with experts in the involved fields of this study. We have gathered relevant structured and unstructured information as well as behavioral and situational interviews [Gubrium and Holstein 2001], protocols, discussions and brainstorming [Flick 2002].

The participation of the users in the IMLIS design was a cardinal concern of this project. Besides the system target group, the tutors and teachers were directly involved in the learning process. In order to understand learner requirements and to design according to their needs, the knowledge of the teachers and their experience were important. The teachers involved in our model of didactical and usability designs contribute as learning experts, provide learner support, and act as and publishers of learning content and contribute to the teacher portal.

The first steps defined as working on the didactical requirements that are given by specific content, teaching methodologies and learning process. For these goals, several meetings with experts were organized. The questions (addressed by brainstorming with our researchers) were sent to the invited experts to solicit their first impressions and to help them prepare to meet us. Subsequent meetings focused on certain aspects of the development process and were agreed upon by the participants at the beginning of each meeting.

Our small groups comprised between 2-5 experts. According to our requirements, the experts brought teaching materials that they use in real contexts in schools. Guided by our questions, these materials were analyzed from the referential viewpoint "What does this kind of learning material mean for the requirements of IMLIS?"

After the first sequences of expert meetings, the results were discussed with professors from inclusive education so that the outcome could be scientifically formalized for the concept of the system. This kind of approach was a recursive cycle of defining a set of

requirements and problems that had been analyzed from a variety of viewpoints over time. The outcome created a set of requirements and questions needed to be solved with the help of experts in order to get a precise image of the requirements that could be formalized. With respect to this complex definition process the requirements could be implemented in a generalized way and used in diverse situations and contexts.

4.6   General Technique Aspects

In the beginning of the implementation phase, we analyzed the technical requirements needed in our development process. We also reviewed the technical architectures of current/previous projects in order to find their strengths and weaknesses. For our solution, the contribution tools toward this approach are:

- **Java:** a programming framework to enable the application to be cross-platform.

- **Java ME:** for client application as it can be supported from many mobile devices and it uses appropriate functional arguments.

- **Eclipse IDE:** An open source development platform for programming of client, server and teacher portal.

- **Eclipse ME plug-In:** for implementation of J2ME in Eclipse.

- **Wireless Toolkit:** for implementation of mobile emulators with real screen size, WLAN and touch screen features.

- **MySQL Database:** for storage and retrieval of learning, administration data as well as metadata.

Figure 23 shows the mobile system layers from mobile hardware to mobile applications. The J2ME is located between the two upper layers.
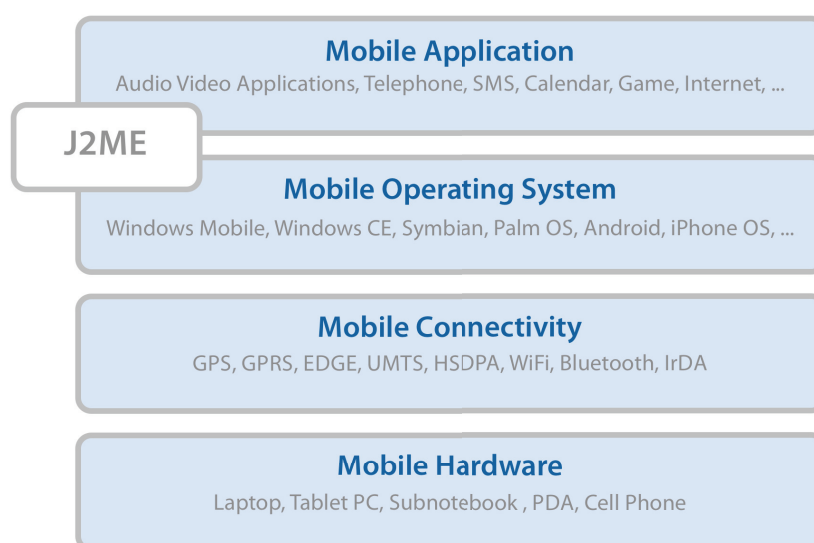
Figure 23: Mobile system layers [Krannich 2010:72].

J2ME stands for Java 2 Micro Edition and it is a runtime environment from java specially designed for mobile devices with storage, screen and processing limitations. J2ME consists of two elements of configurations and profiles[1]. Configurations provide a virtual machine and a set of libraries for programming; and profiles consist of APIs built on the system for the runtime environment and controls the user interface, networks input and output.

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[1] See J2ME documentations at http://java.sun.com/javame

5 Design and Prototypical Implementation of IMLIS

In the previous chapter introduced the requirements and analysis for a conceptual platform which supports people with mental disabilities by the use of mobile technology. We also defined the design process for development of a prototype. This chapter describes the components and implementation of the mentioned approach as a software prototype called "Intelligent Mobile Learning Interaction System" (IMLIS).

5.1 General Concept

5.1.1 Background

The design requirements of IMLIS could be described as general principles predominantly deduced from previous discussions from chapter 4 and partly based on experience gained from observations, workshops and interviews with disability experts.

IMLIS demonstrates not only the advantages and possibilities of mobile technology, but also the functionalities implemented by intelligent models. Instead of repeating the traps of expert systems[1], the research aim is to understand the emotional qualities developed by disability experts, teachers and tutors, when they try to focus on the learners as well as support their individual learning styles. Personalization is an important topic of current learning application discussions. This system contributes to this area of specific learning context for a specific target group.

5.1.2 IMLIS Approach

This project, considers the idea of mobile computing as a learning context which is embedded in everyday working environments for people with mental disabilities. The integration of working and learning in one and the same process is supposed to support the acquisition and reveals tacit knowledge that seems to play a crucial role in this context. The main ideas of this development built in a cooperative process with the target group are described in this chapter. After analyzing the objectives and comparing them to the requirements, we selected a system, which should:

- be a personalized learning system

- support user interaction

- trace user behaviors

- support multimedia

- be a multi-user system

- be suitable for indoor and outdoor learning

- easily edit and update learning material

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[1] Expert systems are programs made by a set of rules which attempt to provide answers for every problem according to the knowledge pool of the system. An expert system consists of two components: knowledge base and inference engine.

IMLIS firstly analyzes and identifies specific requirements, constraints and conditions of the person through interactions. Commonly, the people with mental disabilities have delay in their physical, cognitive and social activities and have less stamina than normal people. They should be able to associate perception with concepts and content. Hence, it was important to divide the learning activities and interactions into smaller, control and manageable workload, repeat learning material over a period of time, using easy language and prepare more visualized material to facilitate the learning process for the target group. IMLIS takes into consideration these requirements.

5.1.3 Target Group

From the beginning of the study, we identified people with disabilities as our target group and decided to study those with mental disabilities. Based on the international classifications and other classifications (mentioned in chapter 3) a short abstract division into three levels was chosen. According to this, our target group can is divided into borderline, mild and moderate. In some cases, tests of the severe group were undertaken. The approaches to the preparation of learning material differed from group to group depending on their level of disability.

After starting to work with the mentally disabled, we observed the importance of involving their teachers and teaching staff (tutors and helpers) in the project. The learning activities of these students are closely coupled with the interactions of their teaching staff which reinforces that the learning context comes from the interaction between student and teacher. Knowing this, the target group was extended to include teachers of the learner target group.

5.1.4 System Architecture

The IMLIS is a client-server based system and emphasizes a dynamic structure for learning content instead of a fixed-static structure. By adapting learning content and activities to the learners and their special abilities, the system is able to prepare an appropriate profile or model for the learners which initiates a personalized learning process in presenting and memorizing the learning content. The system architecture consists of three parts: mobile clients, stationary server, and teacher portal. The client can be any touch-screen mobile device which is connected via a wireless protocol to the server. The server is a standalone stationary device that manages, personalizes and feeds the mobile client with appropriate learning content and interactions. Teacher portal is a gateway for uploading the learning content and activities, as well as a monitoring center for learner behavior and personalization statistics.

The data transmission power in such kinds of client-server systems depends on different factors such as mobile device processor, connectivity and data type. In IMLIS, the data will be pre-computed before utilizing and transferring it from server to client. With the first connection between the server and client, the server asks for the client's needed features and will save the features; later by data pre-computing in server, the stored features of the mobile device will be considered in process.
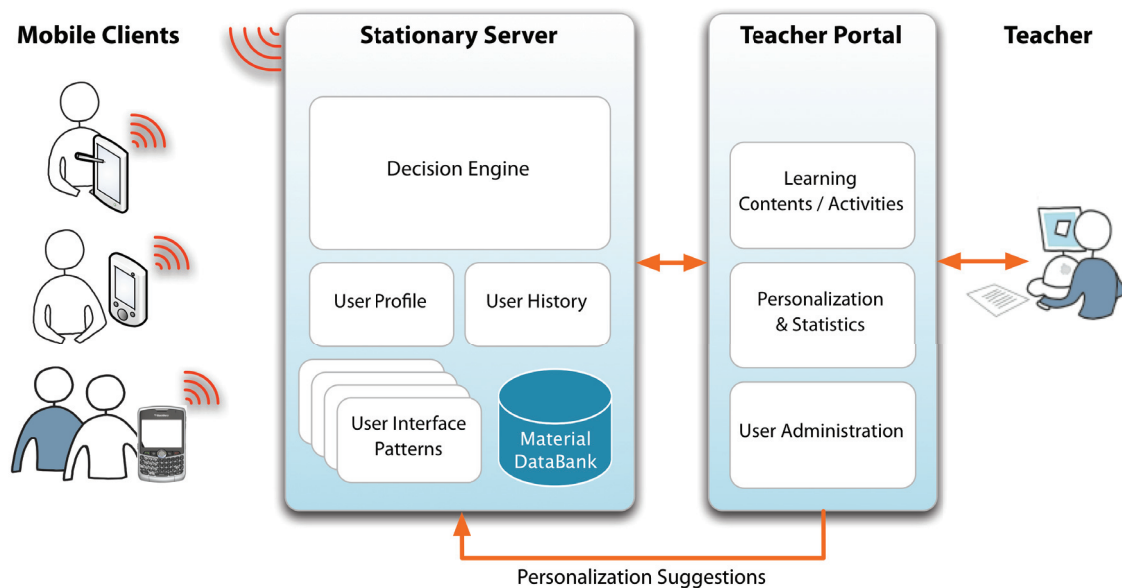
Figure 24: The IMLIS architecture.

Figure 24 depicts the IMLIS architecture. As shown, the system offers the possibility of connection for multiple clients at the same time; continuously the client requests can be processed individually and returned with the same quality to clients. The requests between mobile client and server are based on fixed value URL addresses containing all the needed header information, ports and network status. Communication between mobile client and server is implemented using the HTTP protocol.

The learning process in IMLIS starts with generating a personal profile based on learner strengths and weaknesses. This profile can be generated with the help of tutors or parents using small analytical games, interactions and a short questionnaire, which evaluate the personal level of development. With registration, a username and password for the learner is defined. Selecting a picture instead of a password is an alternative user registration for the seriously mentally disabled. These could include an avatar or taking a picture[1] via camera integrated into a mobile device and a symbol as a password. The learner's profile is not fixed and can be updated during the learning process according to

learner's behaviors and history. By successful profile registration and gathering the analytical information from the server, the decision engine selects the appropriate, personalized learning content and interactions based on criteria from the learner's profile. The direct request of the client for the material is forwarded through the decision engine to the database.

The selected content and interactions from the learning material databank will be matched with the user interface patterns and will be sent to the mobile client. The mobile client devices can be different for the learners mostly according to their physical abilities, level of disability and preferences. When the client receives the learning packet from the server, the learning process starts. During the learning process, the results of tests, quizzes and interactions are processed by the server and saved as log files in the database to be considered in the next process of the decision engine.

Teachers and instructors have the possibility via the teacher portal to upload, define, edit or administer the predefined learning materials, lessons and interactions according to specific metadata. Each learning asset or interaction is assigned metadata and specifications according to their relations to learning abilities. Teacher portal also provides the statistics and messages about the learner's behavior, history and progress via messages and learning curve graphs.

5.1.5 Learning Process in IMLIS

The basic hypothesis is that learning is an action that needs an agreement from the student. Even for people with cognitive disabilities, a self-determined willingness should be established. The presentation of the learning topic or the content should respect the learner's comprehension of reality. This means that the presentation should provide points of relations to the experience of the learner, so that learner can be open to the new topic.

In this way, curiosity will be evoked and the learners would be engaged in their own learning process of trial and error. The teachers should observe students to build a learning environment that empowers learners and tolerate incorrect answers. The system takes this into consideration because it provides motivating feedback lays out the visual progress not learner mistakes. At the beginning of the learning process is the anticipation phase, which contains preparation and motivation as well as the understanding of the process. After this phase, learning starts. The following diagram shows the learning process in IMLIS.

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[1] Taking picture via integrated camera on mobile device is seen as a future plan for this system.
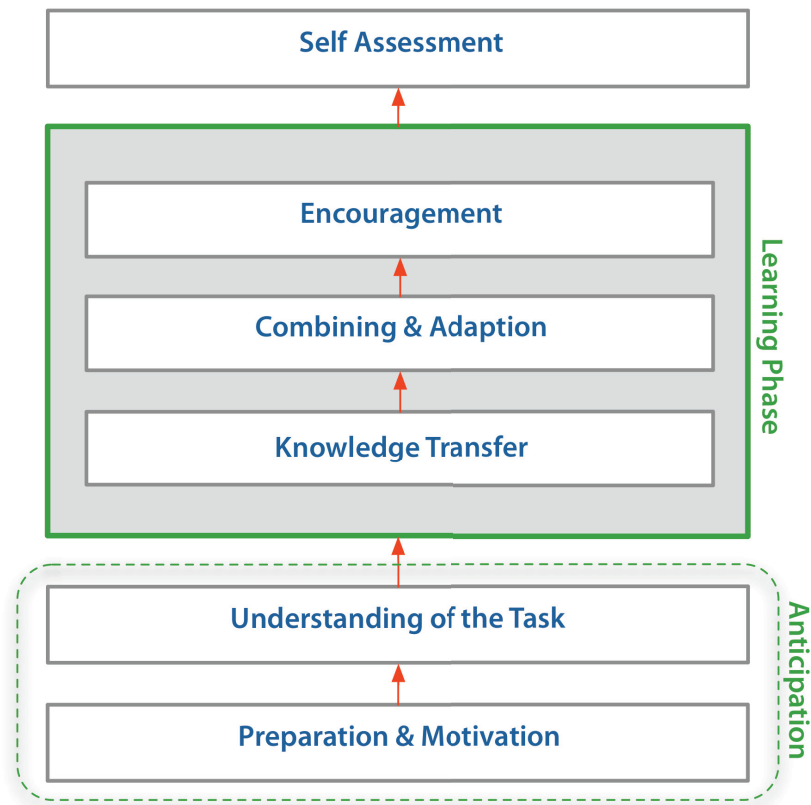
Figure 25: Learning process in IMLIS.

The design of the learning units follows basic steps. At the first stage the student's attention should be induced. This is supported by an anticipatory step which consists of preparation and motivation; with this, the comprehension of the delivered content is enforced. At the second stage, learning with the knowledge transfer begins and continues by the combination and adaptation phase. The knowledge is adapted by new recombination. Meanwhile, the system attends to the actions and hesitations of the users with encouraging interactions and feedback.

In the next step, the knowledge adaptation is finalized by encouragement through interactive feedback from the system. This process is followed by an in-depth test or self-assessment tool designed to foster autonomy and self-reflection. During these processes, information is transformed into knowledge and transmitted back to the learners.

5.2 Data Organization and Content

5.2.1 Organizing Learning Content

Generally in mobile learning scenarios and other learning systems too, one of the most vital parts is the learning content. Content is presented in a context and might influence

different learner feedback and interaction. In IMLIS approach, learning content is extremely sensitive and important for this target group.

The system provides different learning outputs according to the specified user. These outputs are based on user abilities, user history of usage, and the suitable of user interface presentation. For example, if the learner has a slow reaction time, the time for the presentation of the learning material in output is affected by this factor. On the other hand, the feedback gathered in the end of the learning process and applying the feedback results for the next decisions also influences the process. This is like traditional learning when teachers get familiar with students' backgrounds after several sessions and will interact with them according to their individual abilities. IMLIS tries to cover such kind of issues dynamically according to the level of weakness and cognitive disabilities.

In order to cover the educational aspects, the prototype attempts to apply the following aspects of the learning material, based on World Health Organization (WHO) classification, teachers and expert's advise (within the workshops) and our experience in different workshops:

- **Urgency of learning need:** the starting point of creating a model for IMLIS system was to foster autonomous orientation and action in society. For this basic and advanced training modules are targeted that practice every time recognition, sign recognition and symbol processing.

- **Using supportive learning behaviors:** with experts and teachers learning behaviors had been analyzed and implemented in the system. With the continuous processing of user feedback the weaknesses of the individual learning behaviors can be analyzed, the strength can be detected and by positive feedback to the user, the positive behaviors can be fostered.

- **Using stress and attention on special words and phrases:** the design for the feedback is sensible to detect and cover this aspect and change the interactions provided by the system.

- **Using clear, easy comprehensible and self-adaptive interactions:** this was done by a precise formulation of the model, discussed with teachers in workshops and evaluated by small interactive parts of the prototype; and also implemented in small applications that focus one aspect that can be evaluated with the experts. The final prototype was evaluated also by a guideline that listed the tested interactions, so that the combined interactions can be evaluated towards clearness.

- **Categorizing of interactions based on disability:** with experts (in workshops) basic disabilities of the target group had been stated and put into a list. Accord-

ing to this list, the interactions of the model had been mapped. The categories without an adequate interaction had been discussed, which if interactions should be constructed in this version of the prototype or it can be left out.

- **Using simple animation guides and gestures based on the environment (e.g. sympathy's avatar):** for the next version of the application the implementation of an animated guide or avatar as a helper was conceptualized.

- **Audio integration (clear and distinct) for all material:** in the teacher portal several templates are available that have to be combined with the uploaded learning materials. In these templates audio files are needed to complete the process of preparation.

- **Using direct, accurate and unique names for terms, avoiding abstract naming if possible and avoiding subjunctive sentences and using more indicative, concise a simple language:** a person with expertise in simple language (in German: "einfache Sprache") was included in the development of the system. She tested the basic interactions according to simple language and provided a guideline. This guideline will be implemented in the next evaluation of the system in teacher portal to support teachers by the creation of lessons that can be reused by other teachers.

- **Applying invisible checkpoints to control user concentration and attention:** the system monitors the behavior of the user and the feedback to the interactions. Hesitations, false clicks and continuous misinterpretations of tasks are recognized and saved in the log files of each individual.

Using Mobile Learning Standards

In order to support mobile learning standards such as SCORM, CORDRA etc. as well as using the features (mentioned in section 2.6.1) like reusability, accessibility, durability, adaptability and scalability, the learning materials can be packaged in compressed files and uploaded to the system as a package. These packages should be in Zip format and tagged with appropriate metadata for the criteria in the teacher portal.

The precondition for the packages is the compatibility of the presentable learning assets with the mobile version. Also learning packages from other learning management systems can be uploaded to the IMLIS system with respect to mobile's screen format.

5.2.2 Metadata in IMLIS

In personalized mobile learning solutions, like IMLIS, a learning unit can contain a different amount of learning objects in hierarchy levels, and the customization algorithms, which decides on the learning process patterns, metadata plays a very important role to keep the data about learning resources.

One of the most important metadata advantages is quick searches and queries inside the package for both developers and learners. Even introducing the package to search engine's spiders will be done by the metadata feature. In IMLIS, we considered three categories of metadata, which impact the learning process. These three categories are:

- The metadata of the criteria collected from user profile (by user registration).

- Learning materials and interactions metadata, which are assigned to learning content by uploading the materials via teacher portal to the server.

- Context-state metadata used by decision engine during personalization process.
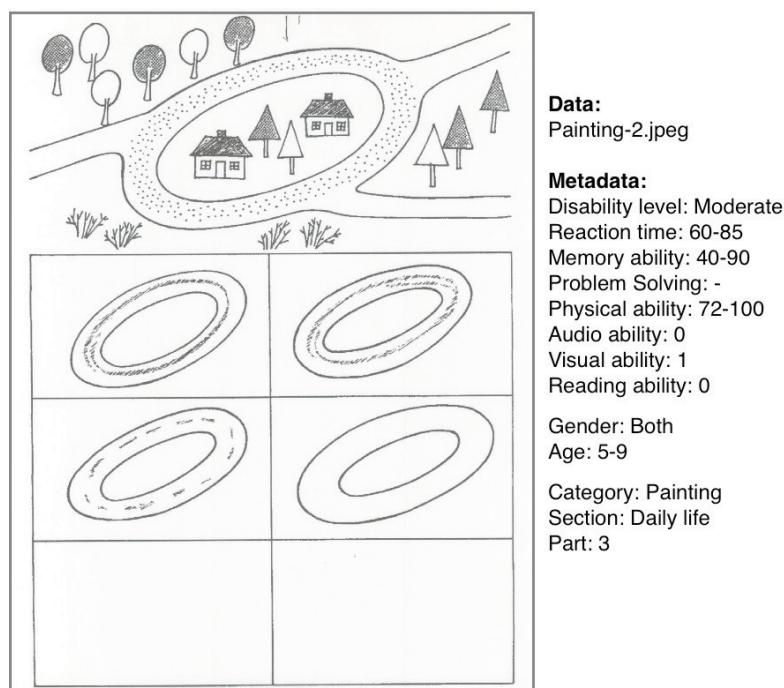
Figure 26: Data and metadata for a sample learning material.

The picture above represents data and metadata for sample learning material in which the image by itself is considered as data and all related information about this picture (such as disability level, reaction time etc.) that shows how, where and when this picture should be used and behaved are considered as metadata.

5.2.3 User Profile

The user profile in IMLIS is a collection of personal data, abilities, and limitations associated to a specific learner. This profile can be considered as the identity of the person. As mentioned in the architecture description, and in order to have the user history and the behavior during learning for authentication and personalization, users have to register for the first time in the system and create the own profile. Users can register alone or with the help of parents or teachers.

For registration, a learner selects the "New User" button on the first page of the client application. By registration different criteria values should be entered into the system, which describe the skills and abilities of the learner. Based on interviews and literature as well as WHO standards, the following criteria have been chosen for profile registration:

- IQ Score (learner intelligence ability level)
- Reaction Time
- Memory Ability
- Problem Solving
- Physical Abilities
- Audio Ability
- Visual Ability
- Reading Ability
    - Symbols and Forms Recognition
    - Syllables Recognition
    - Text Recognition
    - Text Reading
    - Text Understanding

Experts and colleagues involve in this research have discussed and provided different input on the criteria mentioned above. The first criteria IQ score, is usually used in the United States and England, while in Germany and many European countries, the level of disability like borderline, mild, moderate and severe are used. We have considered both national and international methods in the profile registration as well as learning material data entry.

In the section of reading and writing the distinction between "cannot read", "cannot write" and "can read", "can write" do not fit to the situation. The process of understanding the graphical representation of oral language is a process with several steps. A

learner can understand and recognize pictures and the letters of his name, but there is no recognition of distinct letters for example. The general process in training programs for learners with cognitive disabilities can be described with five to six main steps.

It starts with the recognition of objects that are represented with a picture. Then symbols are differentiated. In a next step towards writing and reading syllables of simple words become comprehensible and from the syllabus a word and a line of words; and at least a small sentence can be recognized. When the learner manages to read or write a sentence, the understanding of the meaning has to be developed and finally simple text can be understood and eventually reproduced. According to this description, we implemented the distinction between the five levels of reading-writing skills: symbols and forms recognition, syllables recognition, text recognition, text reading, and text understanding.

After submitting the profile values from the learner's side, if all data met the requirements, the server sends a confirmation, the profile values will be stored in database which completes a successful registration. At this point in the system, the profile will be developed when the system starts by a form where a tutor or other person has to fill in the criteria values. But in a next step (considered as future work), we aim to add an interactive tool that can be used autonomously by the learner with special needs.

With small games and funny stories containing short, specified tasks and the monitored user behavior, the system can sample step by step each criteria which is needed for the learner's profile. The tasks are as simple as possible but specific to produce the needed result to motivate the user. This required complex research in test design and game based evaluation for this target group. For the login page it is easier in next steps. Pictures, avatars, and symbols are considered to foster the easy and autonomous use of the system with respect to target group abilities. To protect the learner's personal privacy, the learner's profile data is protected against unauthorized access.

5.2.4 Interactions and Content Types for Creating Learning Materials

Based on the literature review and state of the art mentioned in chapter two, usually high performance learning happens when the learners are provided with interactions, feedback, and encouragement throughout the learning process. The teachers and instructors via teacher portal can generate and modify different interactions with a set of templates, which request appropriate learning assets (picture, text, audio, etc.) and questions. For providing an interactive learning process to the learners, the following 12 interactions are implemented within the process.

- **Match the image to the audio:** in this interaction, learner should pay attention to the audio announcement and find the relevant image according to the audio.

- **Assign image to appropriate image:** the same way as the previous interaction, but assigning the image to the similar image. The other pictures (wrong answers) will be randomly selected from a data pool or can be defined manually by the instructor in teacher portal.

- **Match the picture to term:** this interaction is the matching of image and the related term.

- **Drag and drop the letters:** this interaction requires the learner to drag the appropriate letters and drop them in the right positions.

- **Find the image related to the sentence:** in this interaction, learner should find the appropriate image to match it to the sentence provided from instructor for this specific image.

- **Arrange syllables:** this interaction requires that learner place and step the word syllables in the right order.

- **Fill in the blank by arranging the letters:** this interaction provides the learner with description for arranging the letters in the right order.

- **Drawing:** within this interaction, the learners would be able to draw in a picture to paint with different colors according to the sample. The sample is provided from teacher via teacher portal.

- **Sort the images:** in this interaction, learners should sort the pictures according to the sample order which is provided on the page.

- **Set the digital clock:** this interaction is like a kind of game for setting a digital clock. An announcement will ask the learner to set the time according to the image shown on screen.

- **Exercise - Match the image to image:** this interaction is a kind of training exercise for the students and allows them to practice before doing other related interactions. Here the learner should match the image to the related image. There is no assessment by the teacher in this interaction.

- **Exercise - Match the image to text:** the same interaction as the pervious one, but matching the images to the appropriate texts.

By analyzing the learner's interaction history, from the learning process, the system can evaluate the learner's ability level on specific interactions and considers an appropriate interaction for next steps of learning according to the percentage reached by learner.

5.3 Decision Engine and Personalization

5.3.1 Decision Engine

In IMLIS, every learning asset is assigned to a key with identifiable tags, priority flags and related metadata. These metadata should be defined by data entry of learning assets based on parameters that are available in analytical information and show the criteria of usage for the specific learning asset. In this system, "Decision Engine" decides about the output-learning package based on the analytical information specified in the profile registration. The user profile appears as an identifiable profile key which is generated automatically for the decision engine. The decision engine can then decide individually for each learner which learning content and activity are suitable for the learner.

For preparing a learning package, the decision engine compares the profile key with the learning assets keys according to available search model and selects some of the learning assets. The selected assets at this stage should be reviewed based on user history log files and user feedback from previous learning sessions. The remaining assets should be sorted by priority and appropriate category, lesson and page. The final selected assets in this phase will be integrated into the adaptive patterns to be packaged as a learning package (LP) and will be sent to the client.

Table 8: Sample profile and learning assets keys, used in IMLIS decision engine.

Key for Profile ID: 374	45	0.75	36	74	95	0	1	1

Learning Assets (LA)	C1: IQ	C2: RT	C3: MA	C4: PS	C5: PA	C6: AA	C7: VA	C8: RA
LA1: intro.jpeg	40-55	0.25-1	20-50	35-85	10-99	Void	1	Void
LA2: main.txt	25-40	0.15-1	20-40	30-80	50-99	Void	1	1
LA3: movie.avi	40-55	Void	20-90	30-80	Void	1	1	Void
.	.	.	.	.	.	.	.	.
LAn	…	…	…	…	…	…	…	…

Sample criteria (C) used in IMLIS. IQ: Intelligence Quotient, **RT**: Reaction Time, **MA**: Memory Ability, **PS**: Problem Solving, **PA**: Physical Abilities, **AA**: Audio Ability, **VA**: Visual Ability and **RA**: Reading Ability

The received learning package will be presented in mobile client for learning process. The profile key (gathered in user registration) can be updated any time based on the result of feedback and learner's behavior history. For the visual component and objects in the learning process, enough care should be taken to ensure that items are clearly visible and marked in user interface, so that the functions are easy to understand.

5.3.2 Personalization in IMLIS

A huge advantage of personalized learning is the discovery of specific needs of a single user. Specifying these helps to reinforce abilities and tries to cover disabilities. Personalization in IMLIS is based on a three-dimensional cubic according to level of knowledge, level of mental ability and the work tasks for the learners. The learning entity will be selected with respect to three dimensions mentioned above.

Figure 27 depicts a comparison between other learning approaches (two dimensional) and IMLIS approach for selecting an entity based on three-dimensional personalization cubic. Four kinds of personalization are applied in IMLIS as follows:

- **User personal profile information:** personalizing the learning process and content according to the user personal profile information which is submitted at the beginning of the process in profile registration.

- **User interactions:** personalizing the interactions according to user history of interactions done by learner. The results of progress in history table will be applied for next decisions.

- **Feedback results:** the previous feedback results gathered during the learning process will affect content presented later. This feedback can also be manually defined by the teacher/instructor using the system.

- **Learning content criteria updates:** the metadata of learning content can be updated based on learner success with this content. By using an inappropriate learning content for a series of learners and getting unsatisfactory results, the system automatically reveals the pitfalls and sends a message to the teacher regarding the irrelevant content, important information needed to change the content level.
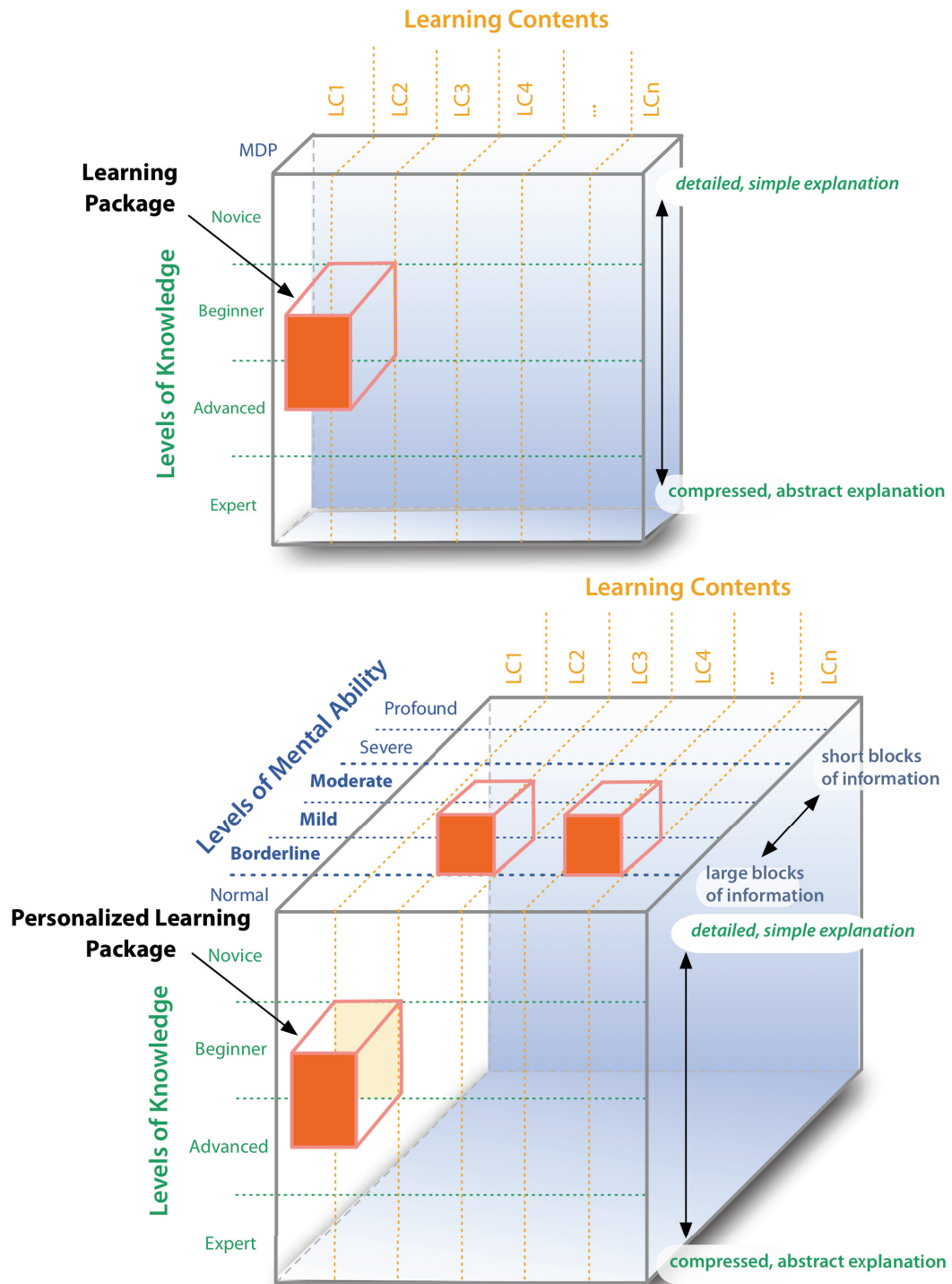
Figure 27: Two-dimensional learning approach in comparison with IMLIS three-dimensional learning strategy, adapted from [Krannich and Zare ICELW et al. 2009].

Based on all learners' behaviors, the system analyzes the learning assets and interactions in order to find weaknesses of the material for the appropriate group of learners and according to these analysis, the system suggests the changes to the teachers/experts and whether the material and workflow should be adapted more to the specific needs of the learners. The decision engine is responsible for personalization and selecting the

relevant content from the database. The following diagram shows the workflow of the personalization process in IMLIS.
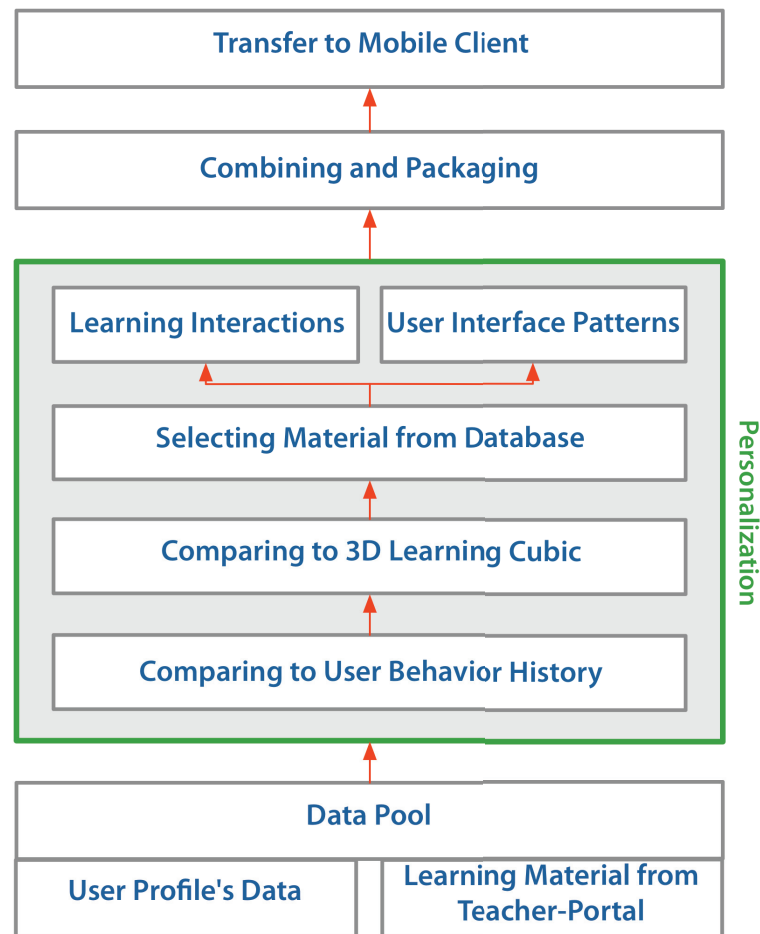
Figure 28: Personalization process in IMLIS.

As shown in Figure 28, the analytical criteria from user profile and the learning material from teacher portal will be stored in a data pool. In the personalization phase, the criteria in data pool will be compared with user behavior history and feedback gathered during previous learning sessions from user. The result of this level will be compared with IMLIS three-dimension learning cubic.

Based on the result at this level, the appropriate learning material for the specific learner will be selected from database. According to selected data, the relevant interaction and user interface patterns will be selected by the system which is ready for combining and packaging. The prepared learning package will be transferred to the mobile client for the learning process.

5.3.3 User History and User Experience

The user history and user experience provides details of user progress, which is gathered during passed learning sessions. IMLIS monitors the learner activities during learning process and tries to provide the new learning materials and activities based on the history of learner behavior. The system recognizes the behavior of the learner over a longer term. By a sequence of learning sessions, the feedback of the learners and their behavior is processed so that an activity profile and learner history is created for each learner and stored in the database. According to these activity profiles, personalization can become more and more precise. This even has an impact on the learner's initial profile created upon the first registration; in this way, the user profile can be updated according to an average of a series of changes in user history results. The user history contains the following information for a specific user:

- The number of previous login sessions.

- The accessed learning materials.

- The completed learning categories.

- The number and kind of interactions used by the learner.

- The successful or unsuccessful results and statistics from each interaction.

- The results and statistics of tests and quizzes.

In the system several models of learner behaviors and training curves are implemented that are mapped in the teacher portal for a specific learner. For every learner in the system, a learning progress curve with peaks and weaknesses is provided. According to personalization model, integrated in the decision engine, the peaks and weaknesses can be analyzed in the system to make clear when a specific learner is cognitive and emotionally strong, and when the learner needs easier lessons or repetition. These kinds of analyses enable a personalization model according to specific time and abilities.

User behavior monitoring

The mobile client not only provides the learning material, but also provides invisible monitoring that analyses the actions of the user according the presented material and in given sequences of time. As an example, a picture is presented and an audio announcement asks the learner to choose the right answer which matches the picture. In this situation, the system monitors the clicks entered in page and analyzes if the user clicks on the correct choice, wrong choice, or somewhere else in the page. Sometimes the user clicks on the picture instead of clicking on the choices (Figure 29).

Figure 29: User clicks on a learning page, monitored by the system.

A set of priorities and flags are adjusted in the system in order to analyze clicks and use the results in the next decisions. These records are stored as statistics and can be mapped on different analytic templates. According to this analysis the system updates the user profile and the metadata aggregated to the used learning material.

5.3.4 Learning Curve

The learning curve in IMLIS refers to the graphical representations of learner's progress during a personalized learning process. This graphical curve is derived from user profiles, user history and user experience during the study. Teachers and tutors are able to monitor and analyze the learner's activity during and after every learning session. This monitoring can be via the learning curves in teacher portal. In workshops with the experts of a school for students with cognitive impairments, we got to know that from an expert view, the support of a student, the characteristic of the student's learning behavior and the rhythmic arrivals of peak points and minimums in a learning process are important to evaluate the potential of individuals. With this knowledge of the potential, the development can be supported, decisions on the way of inclusion in normal classrooms can be done, and next possible learning steps are can be charted.

Generally, the learning curves are not stable. Mood, context, time and social aspects may affect learning. But over a longer term, learning curves can more clearly reveal details about tendencies, opportunities and weaknesses. In this way, the system helps teachers gather personal impressions and support specific decisions to be updated by information from the system. This effort is not only an evaluation that can be done with

grades, but more a diagnosis tool to map the specific learning curve of a specific learner on a known model of specific learning abilities coupled with specific disabilities. By the implementation of specific learning models, which can be drawn on the learning curve, it might be possible to enhance abilities for specific interventions for supporting specific learning motivations. However these aspects might be implemented in a future version of the system.

The learning curve is a graph, resulting from three axes of criteria (concerning user history and behavior) axis (Z), user profile axis (Y) and time -learning sessions- axis (X). For deriving a learning curve in a three-dimension area, we need two equations to make two surfaces. The confluence of these two surfaces will result a curve.

```
Z = Criteria, Y = Profile, X = Log-in sessions
```

The first equation would be the variation in criteria (Z), which has constant affect (K) on user profile (Y).

```
(1) ΔZ = K * ΔY
Z - Z1 = K * (Y - Y1)
Z = K * Y + (Z1 - K * Y1)
```

The second equation can be any variation of profile during a certain time, which means that the profile (Y) is a function of time (X) (learning sessions).

```
(2) Y = AnX^n + An-1X^n-1 + … + A1X + A0
```

From the two mentioned equations, and confluence of two surfaces a learning curve results (Figure 30).
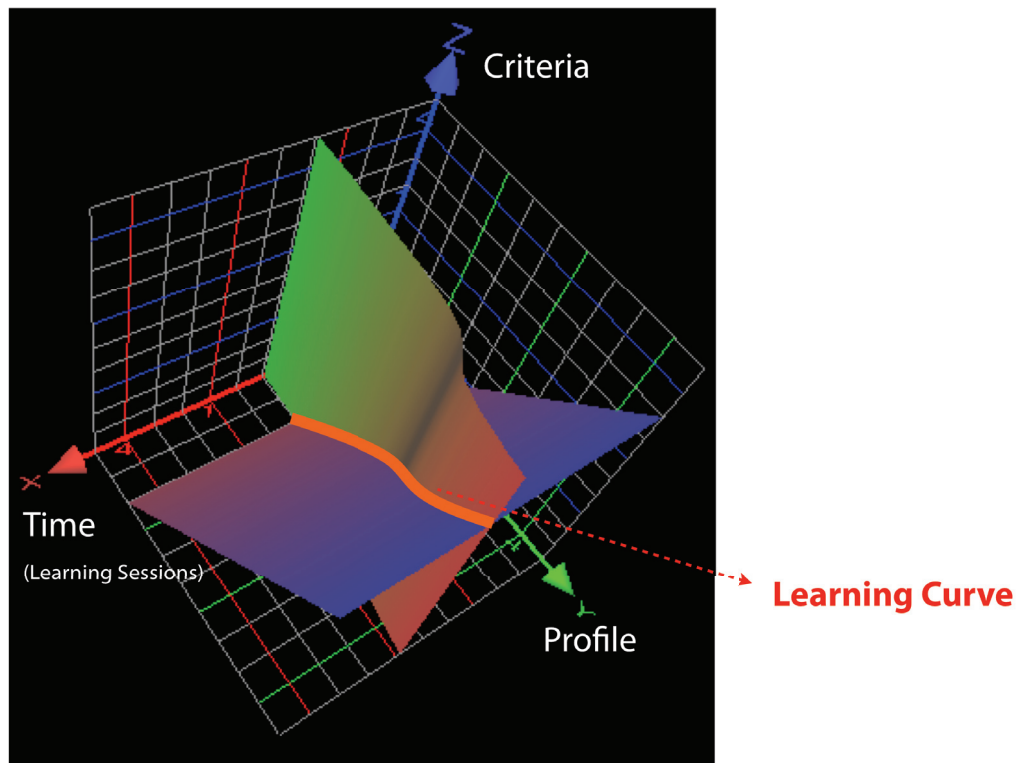
Figure 30: Learning progress curve for a specific learner.

The learning curves can be analyzed in teacher portal for all available learners in the system. The teachers and instructors can monitor the rate of progress and improvements of each individual in performing a learning process.

The need for a statistical overview on the learning behavior and the results of the exercises was demanded by the didactical experts and teachers in special schools[1]. The background is that each student comes to the integrative institution with a statistical analysis of his learning behavior over a larger period. For planning the next steps for a longer perspective updated presentation, the analysis of learning statistics are helpful. In IMLIS, the system monitors how a student solves a problem and a quiz (according to time, etc.) and how many mistakes occur. The learning curve can show if there is development or if there are difficult slumps that can have other reasons and should be supported by additional interventions. Upon the view of teachers this visualization is a helpful tool to organize the personalized lessons with the system that respect the individual student's problems.

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[1] Förderzentren Wahrnehmung und Entwicklung.

5.4 Technical Aspects

5.4.1 Client-Server Technical Aspects

The IMLIS client-server architecture describes a structure in which the mobile client requests an action from IMLIS server. In return, the server replies to the client's requests with relevant actions. The data resources in the server are treated as a learning material pool, which can be accessed from different teacher portal clients.
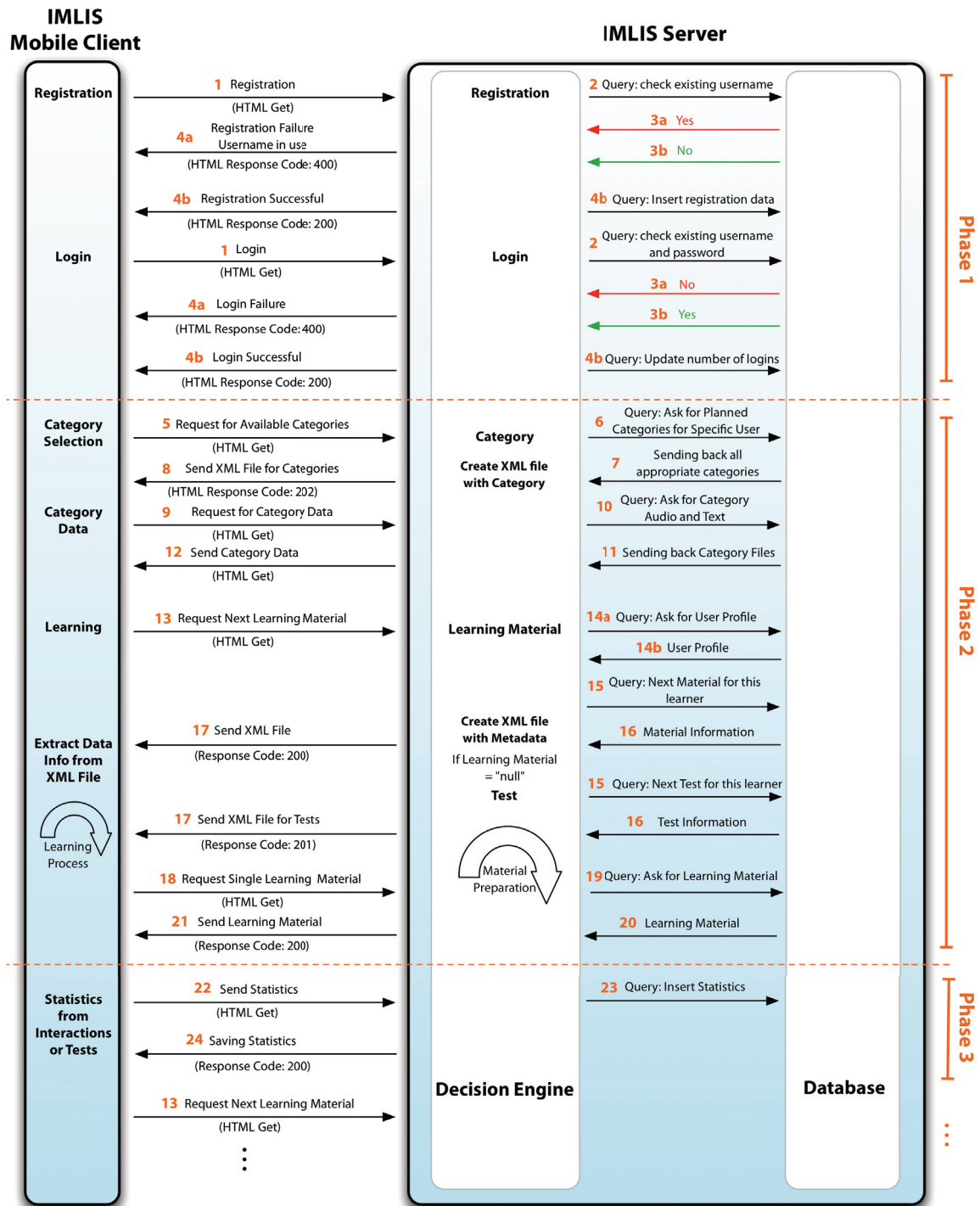
Figure 31: Client-Server transactions in IMLIS.

Figure 31 depicts in three phases the requests and responses between mobile client and IMLIS server. The process starts from mobile client by requesting user registration in system or login. After registration/authentication, mobile client asks for learning material. In this phase, the decision engine sends a query to database based on request from client for the user profile, and then decides on the appropriate learning process. The decision for learning process will be reflected on a XML file and will be sent to mobile client. The mobile client receives the XML file and starts the learning process according to XML file and asks the server for the next materials based on a list written in XML file. This process will be repeated until server answers "null" for learning material left for this session of this specific user. In this status, the tests will be started and a test-XML file will be sent to client for quiz process.

The last phase is sending statistics and history of learning process for this kind of specific learner to the server. The results of statistics and history will be stored in the database for the next usage of the decision engine.

5.4.2 Data Storage and Retrieve

The database used in IMLIS is a fundamental part of the system, which grew out of different discussions and system requirements. The database is MySQL[1] and serves to store data about the learner, and the learning materials and tests, as well as the history processes for each individual that can be called on demands of learning activities.

The database includes both main and marginal data used in the system, which consists of four kinds of information as learning assets, metadata, user history and log files information, and administrative data. Each learning record and criteria in the database has been indexed by certain metadata. The implementation of indexing helps for easy search on the database. The learning resources are stored and provided by a database that operates according specific rules. These rules allow the outcome of the database to increasingly personalize the needs of the learner and become more accurate if the amount of learning materials grows; this builds a more valuable system.

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[1] http://www.mysql.com
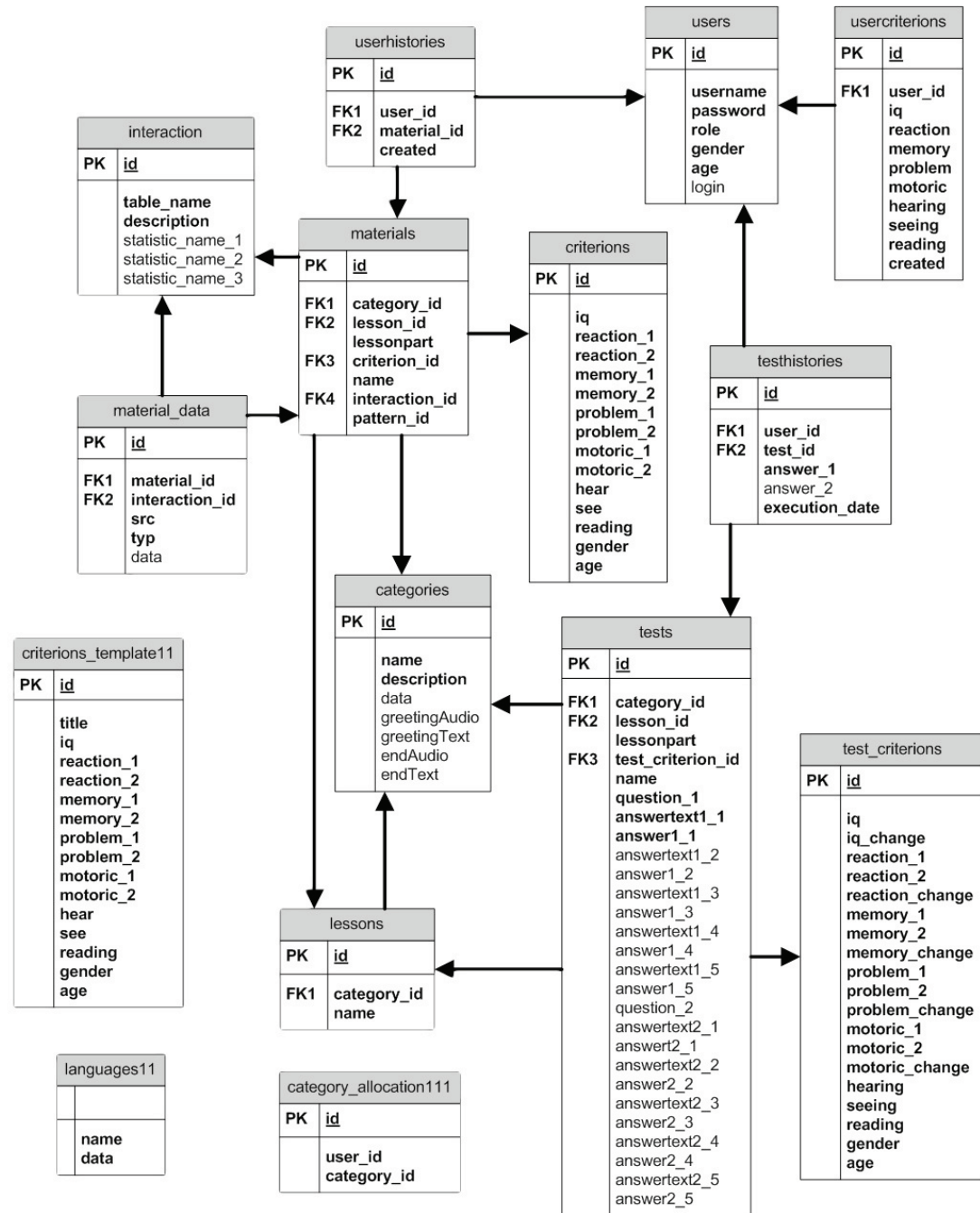
Figure 32: Database architecture in IMLIS.

The depicted diagram (Figure 32) shows the IMLIS database architecture with the related primary keys (PK) and foreign keys (FK). The arrows indicate to which entity the foreign keys belong, thereby showing the arrowhead to the entity that provides the foreign key. The bold printed attributes in the tables are not allowed to be empty. The entities with the name of "materials" and "users" are presented separately on the following diagram.
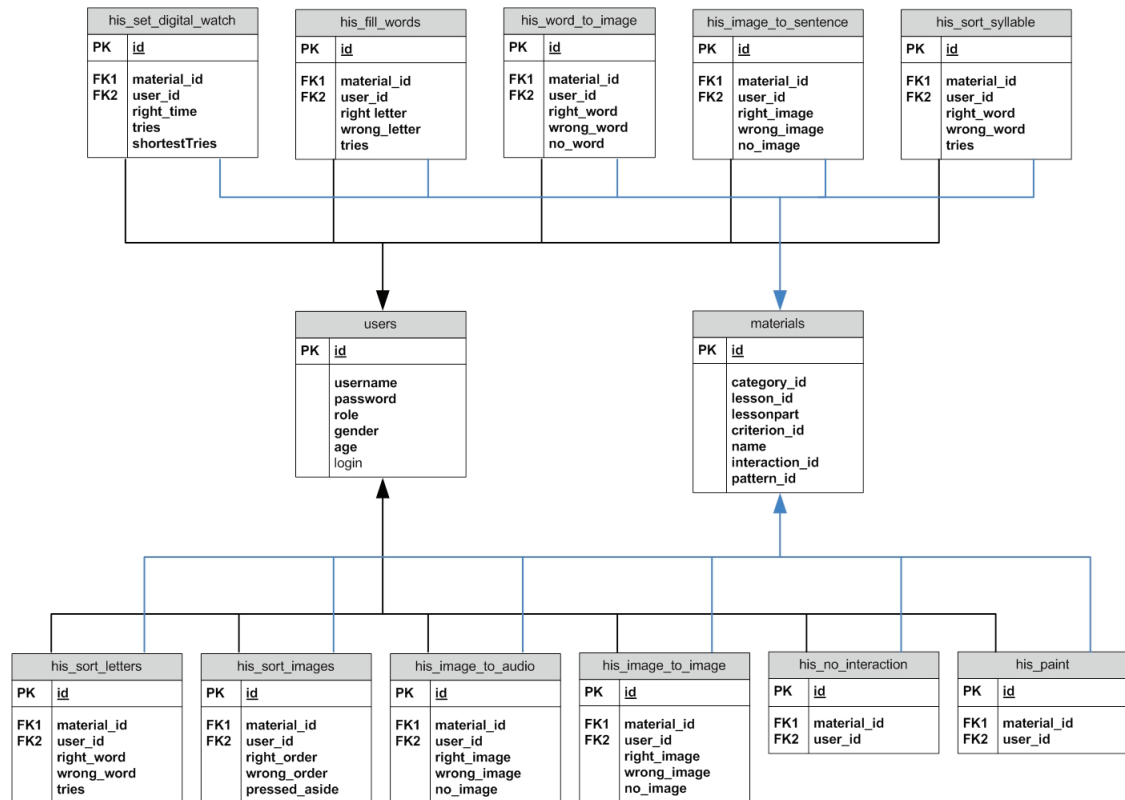
Figure 33: "Users" and "Materials" tables architecture.

The data records in the database can always identified by the IDs and primary keys. To build relationships and connections to the individual tables and log tables, different foreign keys are used. The accuracy in IMLIS is related to the frequency of use and the amount of stored materials. This layout fits more to a community of users, means from a broader group of users who agree to share materials in order that each one will benefit from this communal effort. Definitely submission of learning content with correct metadata by teachers is key to an accurate and practical databank.

5.5 User Interface Design

The user interface of every learning application should come from direct contact with the users of the system as UI plays a considerable role in a learning process. The design of user interface should be based on target group abilities. Moreover, the possible use of individual learning elements should be easy to understand and integrated with interaction, if possible. UI design parameters, which we included in the design considerations for mobile clients are:

- Screen size of mobile devices

- The target group, people with learning disabilities

- Simplicity, to reduce learners irrelevant thinking load and foster orientation

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- Velocity of content loading, implemented with content transforming methods

As buttons and their functionality should be visually self-representative, simple and clear to interpret the nature of the functionality (if possible), we have selected a very simple user interface, which consists of a simple self-expressed "back" and "forward" navigation buttons. In different interactions, special buttons associated to interaction's functionality are used. We tried to prevent overwhelm on learning content and their related tasks to avoid overload on learning pages. Also keeping content as simple as possible to attract learner attention to the object.
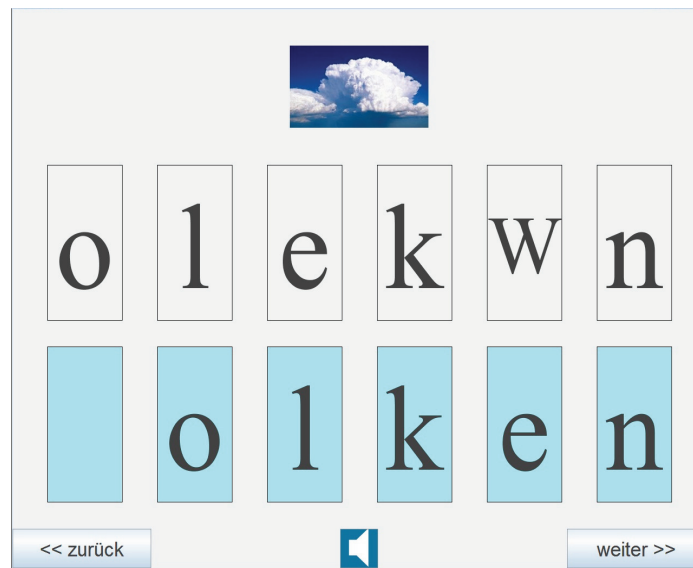
Figure 34: A simple user-interface screenshot from IMLIS mobile client prototype.

In addition to the mentioned UI design, the IMLIS teacher portal gives the possibility to the teachers to select the appropriate layout pattern for the output learning content. The teachers can see the final preview of the output content which will be presented in mobile clients.

Transferring huge blocks of data from server to mobile clients can take time based on data volume. In order to reduce the loading time of learning content on mobile clients, the content should first be edited and resized on the server according to the technical features of mobile device and then sent to the mobile client.

5.6   Prototypical Implementation

The prototype was designed and implemented based on initial system requirements in parallel with workshops as an iterative design. In every workshop, we tried to test and evaluate our prototype with real users and teachers in order to improve its weaknesses. To fulfill the system requirements, the IMLIS prototype includes the following main components:

- Stationary server

- Mobile clients

- Teacher portal

5.6.1   Early Prototypes

Before starting development of the main IMLIS prototype during the literature analysis and workshops, we developed some early prototypes with different methods in order to use them in pre-workshops for our initial self-evaluations.

We started with a java-based small application on cell phones. This application is developed by LMA[1] rapid mobile application platform focusing on work safety as learning content. The process of learning started with a simple presentation of text, pictures and audio without interaction and continued with test and feedback at the end of this process. The results of the learning process for each individual learner could be saved in an online log file and tutors could access it to see the results. With this prototype, and with nearly three learning modules, we conducted the first initial workshops.

Figure 35: First mobile client prototype used in pre-workshops.

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[1] Hot Lava Mobile leading solution for rapid mobile application development. http://www.outstart.com

The second prototype was implemented with the same concept as IMLIS as a web based approach. We tried to implement the first ideas of IMLIS in this approach in order to see the results of an early simple decision engine for personalization. Later this development became the basis for IMLIS and we took over the mobile prototyping approach. The implementation was java based with a mySQL server as database.

Figure 36: Web-based IMLIS prototype.

5.6.2 Mobile Client

The IMLIS appropriate mobile client is a touch screen mobile device with wireless protocol functionality. The mobile device can be any brand which supports java applications. For mobile client visual representation, a Qwerty Device emulator from java wireless toolkit was used. As the sizes of screens are different in mobile devices, techniques for representation of data and user interface are implemented. In this way, with the first connection, a mobile client sends its screen size and the device model features; later the server decides on the appropriate patterns for the target device features.

The client can only be used for the registered users who fulfill the requirements of profile registration. Users can register easily on the first page of the client application. Registered users can log into the learning process with username and password (visual password as pictures are also provided for the users with reading and comprehension difficulties). With a successful user authentication by server, it sends an XML file, which the metadata includes for the representation of layout patterns, and learning con-

tent. The XML file contains all information needed by the client such as lists of learning content and modules as well as the object names, metadata, and the next learning steps for the specific learner. The proposed images to be used in client learning process are advanced edited by the server for the appropriate size according to client screen features. In this way, the data transfer from server to client is easier and faster.

Figure 37: Screenshot of IMLIS mobile client.

The client application is adapted to the needs and abilities of the learner according to their unique possibilities to provide the optimum learning process. As the entire surface of the client devices screen support touch screen functionality, by clicking on the content on the client screen, the content can be zoomed in for better visualization. By clicking on audio and video elements, the media is played. By repeating clicks on audio/video objects, they are re-played. At the end of every interaction and learning process, the mobile client sends learner feedback to the IMLIS server.

5.6.3 Server

The server application is a java-based program executed on a stationary platform. On one hand it coordinates all decisions, connections, and activities between mobile client, and database and on the other it provides services to multiple mobile clients on the network. All client requests are answered by the server application. Depending on requests and demands, the server feeds the client with appropriate responses and materials. As

mentioned in IMLIS architecture (Figure 24), the entire server application consists of a decision engine, user profiles, user history log files, user interface patterns and connection to learning material database.

In IMLIS, the transactions and data preparation should be processed on the server side before transferring them to the clients. This greatest advantage of this processing on the server is that the processing and preparation can be done independently of the mobile clients and their related software platforms. In some cases processing may need resources or functionalities not available on the mobile client. The disadvantage is that learners have to wait for milliseconds (in cases seconds) to get responses from the server. The main functionalities of the server application are:

- Authenticating of users for login to the system.

- Identifying and selecting the appropriate learning materials, interactions and tests for a specific learner.

- Retrieving the learning materials, interactions and tests from the database.

- Tracing and following the user behaviors during the learning process.

- Appling the user interface patterns to the selected learning materials and interactions.

- Identifying and updating user profile criteria.

- Identifying and messaging new suggestions for learning materials metadata changes in teacher portal.

5.6.4 Teacher Portal

Teacher portal is a gateway for teachers and caregivers to facilitate access to the administration of the learning process for learners. The idea behind the teacher portal is a desk for strategically planning the learning resources by learning teachers and administrators. In the design of the teacher portal and the interactive workflow, the teacher's knowledge and their practical experience with learning material preparation is formulized and considered in the design process. The teacher develops management ability by planning what kind of knowledge in which representation is useful for the specific learner. They need to analyze the learner's effort and develop an individualized learning strategy. In this process the teacher is more like a coach and the learners themselves become their own teacher supported and encouraged by their coach. The following diagram shows the learning material construction in the teacher portal.
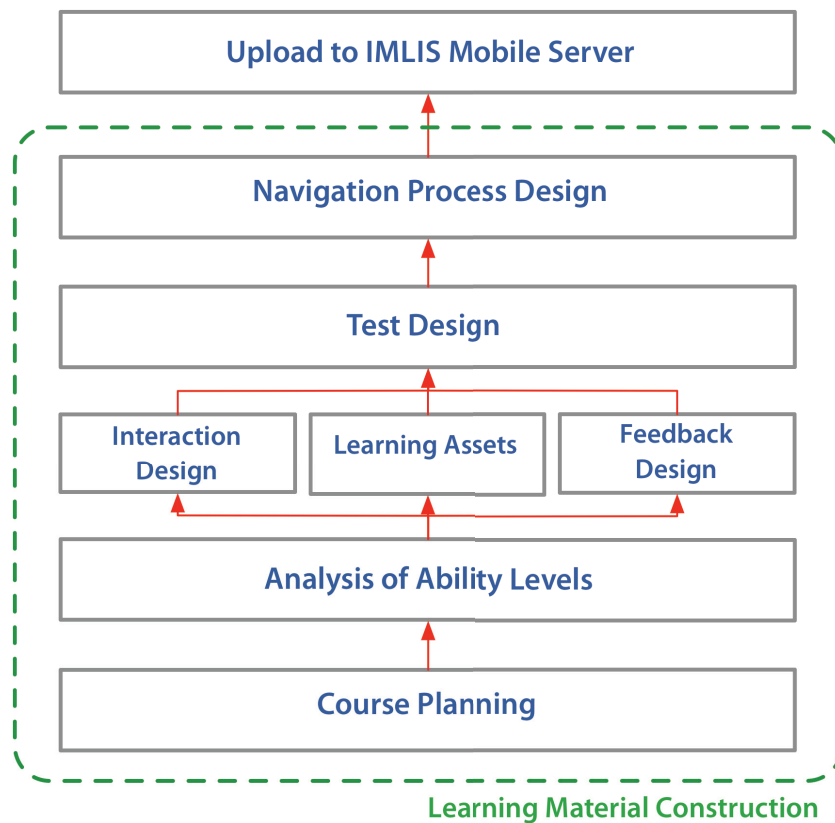
Figure 38: Learning material construction in IMLIS teacher portal.

The learning material construction in teacher portal as shown in figure 38 starts with course planning from teachers and tutors. In the next step, the ability levels of target group should be analyzed in order to assign metadata for learning content based on learner's criteria. The next step consists of interaction design, learning assets and related feedback design for the learning process. The tests and quizzes should be prepared based on the learning process design and content. The last step of construction is assigning a navigation map to the process which shows the path of learning. The result will be sent as learning packages to IMLIS mobile server.

In contact with teachers during this empirical research, some of them described that the optimum way to prepare learning content would be to work with other colleagues to find out how teachers from different teaching approaches create material appropriate for the students of their classes. They found the solution to categorize their material, so that other colleagues can more easily use and combine other materials with their own materials. In some cases they described the material categorizing procedure. The concept of teacher portal enables them to build a specified area for the teacher. Here is a summary of the teacher portal features.

- Uploading, editing and administering learning content.

- Defining interactions for the learning process.

- Constructing, editing and administering learning tests and quizzes.

- Defining user interface layouts for mobile clients.

- Access to all statistical learning process results.

- Analyzing the learner's progress curves and their performance over time.

- Monitoring the individual learner's behaviors.

- Analyzing the curricular personalized content directly from assessments.

- Classifying the learning categories for a specific learner.

- Users administration and disciplinary incidents.

The teacher portal challenges the usual way teachers prepare lessons because it is untraditional. However, this working style will influence the future of a new generation of teachers because it will enable them to reinforce cooperation in education by the ability to work in a growing mobile community. Teacher portal is a cross-platform application for administrating and uploading the learning content and personalization analysis. The teacher portal provides a small tutorial that can be completed and extended by other teachers according to the design of learning units. The following diagram (Figure 39) depicts the teacher portal sitemap architecture.
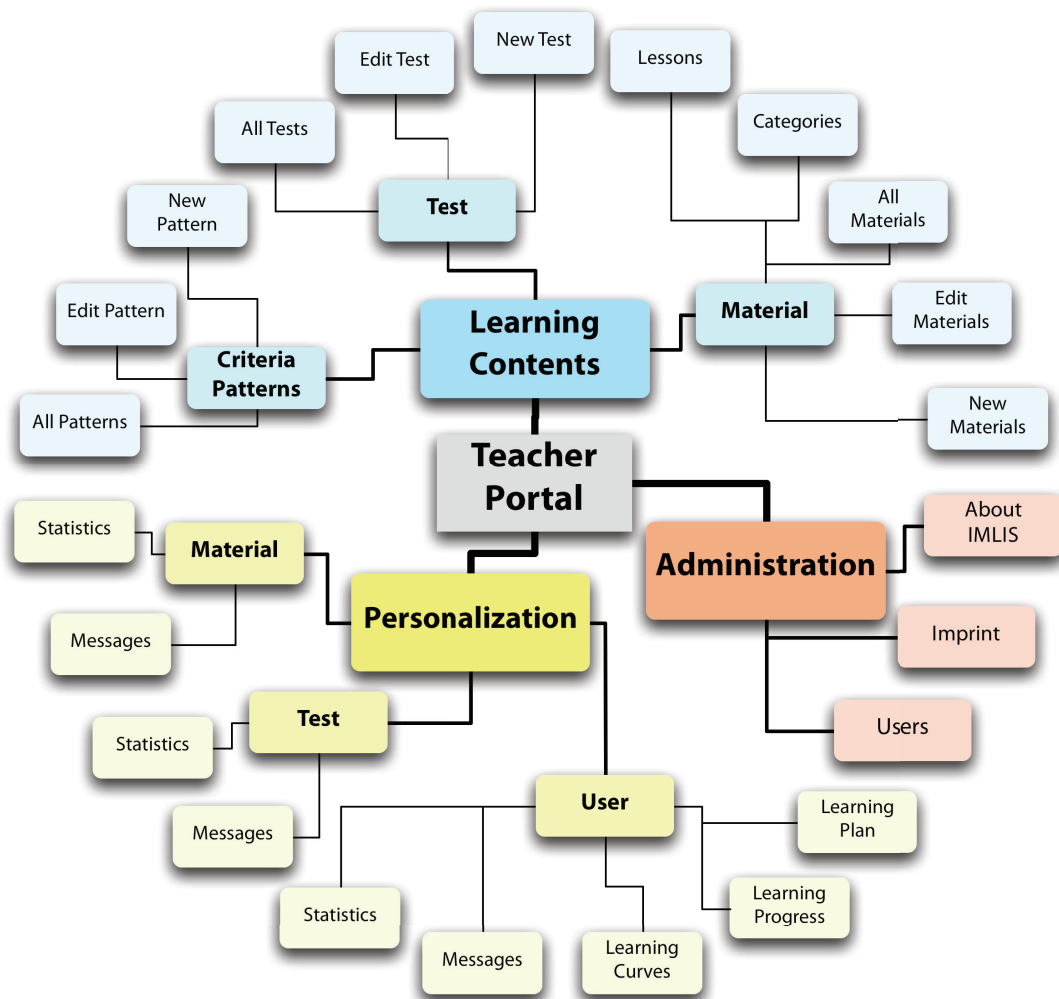
Figure 39: IMLIS teacher portal architecture.

As shown in the picture, the teacher portal has three working stages: 1) learning material, 2) personalization, and 3) administration. These stages are explained in following sections.

5.6.4.1 Learning Content

In the first stage of teacher portal, the teachers and tutors have the possibilities to create and upload, edit, categorize, and administer learning content and interactions; these can be done according to a systematic layout. It is as general as possible to enable links and easy sharing between teachers and their colleagues. Teachers are also able to design learning paths, sequences of material and lessons.

Figure 40: Screenshot of IMLIS teacher portal.

As shown in Figure 40, the learning content tab is divided into three main parts (material, test, and criteria templates) each with sub tabs.

5.6.4.1.1 Learning materials

This section includes the fields for generating a learning package which consists of learning assets, learning interactions, metadata and sequences. For generating a learning package, firstly, a category and lesson should be selected (or created if not available). The order of presentation material and the metadata information such as gender and age of target group, the pedagogical criteria (IQ score, reaction value, the value of memory, problem solving ability) as well as physical abilities, audio, visual and reading abilities should be assigned. The teachers will be able to view, search, update, and edit the learning content and packages in next sub-sections "material editing" and "all materials".

The sub-sections "category" and "lessons" provide the fields for creating new categories and lessons. Also in these tabs, teachers are able to upload text and audio to start and end each category.

5.6.4.1.2 Generating Test

In this section, the teachers can create the tests and quizzes related to the learning packages prepared before. The questions should be assigned with metadata in order to be used for a specific group of learners. The possibilities of viewing all tests and editing are also provided to teachers.

To avoid test overloading in client screens, each learning package is limited to two tests and each with a maximum of five answers. In addition, the teachers and instructors are able to define specific criteria which can be updated with the results of tests created over a certain time. The criteria patterns can be used in the same way for tests.

5.6.4.1.3 Criteria Template

In order to compose learning units for specific learners that can be handled by the system, according to the individual profile, each, learning element to be uploaded to the system should be connected to metadata that fits to the criteria of the decision engine and the criteria that are used by the teachers themselves. This requires a huge effort by teachers for every single element even when a set with similar or same metadata needs to be uploaded.

At a workshop, four teachers developed predefined templates that enabled them to easily and efficiently connect to metadata. After the implementation of the first templates, this functionality was evaluated by other teachers and was accepted. In this way, the teacher can save a set of criteria as a template and can easily recall it. The recalled criteria template is automatically applied to the current learning package.

5.6.4.2   Personalization

This stage provides analysis and administration of the personalization results and statistics to the teachers. Within this process, the teachers can build and monitor their predictive models, users behaviors and apply their recommendations for the learners.
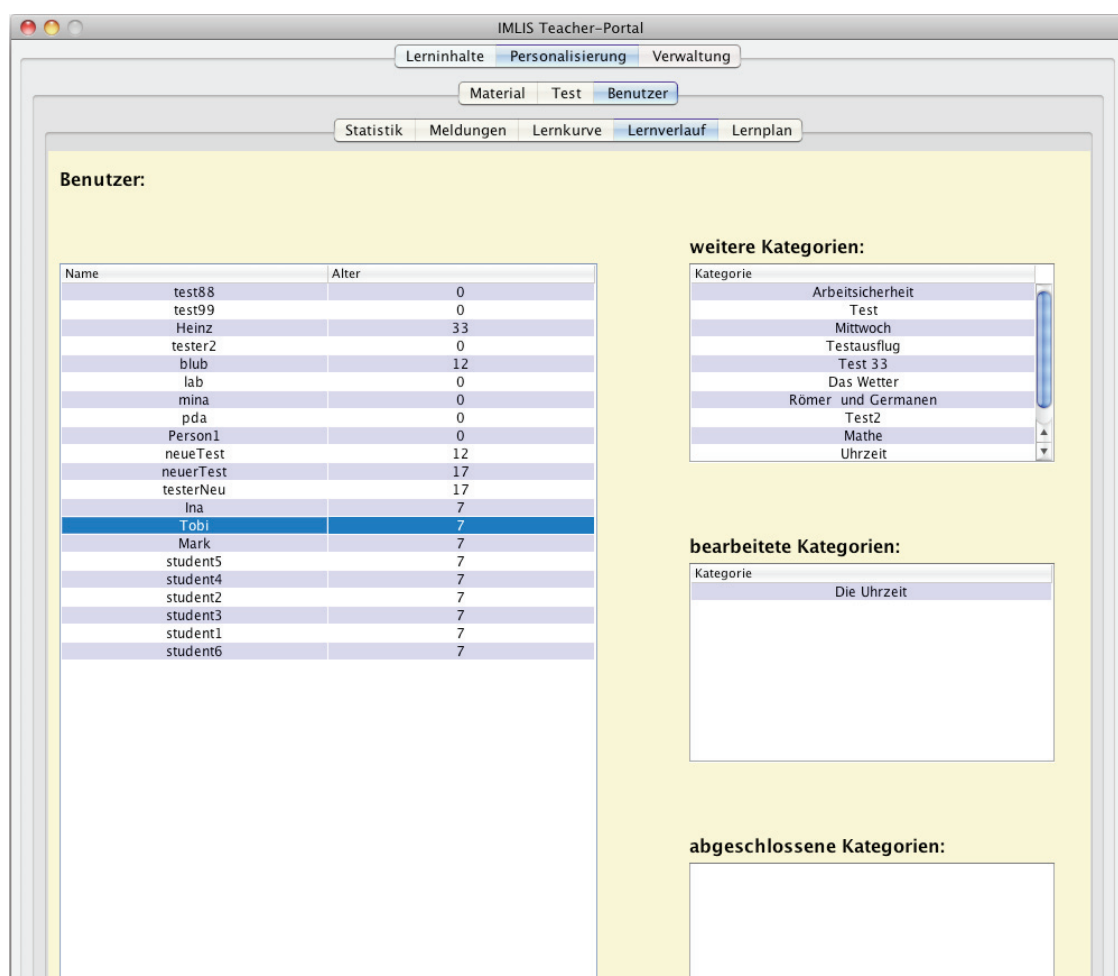
Figure 41: Personalization in teacher portal.

5.6.4.2.1 Learning Material Personalization

This section contains two sub-sections of "Statistics" and "Messages". Here the teachers can monitor the statistics of every single interaction and the feedback related to the interactions. The number of clicks on correct answer, number of clicks on other choices (wrong answers), and number of clicks on blank areas will be captured by the system and from the teacher's side can be stored in the user history profile and displayed to analyze results.

The system automatically watches for the results of learning packages during interacting with the learner and returns messages to the teachers regarding the success, difficulties and failures in completing the packages. For example, if an interaction is designed for a specified target group and from 50 times interacting with learners, 47 times have failed, then the system automatically sends a message to the teacher about the difficulty of this interaction for the defined target group.

5.6.4.2.2 Test Personalization

The same personalization model for learning material is designed for tests. The teachers can monitor the statistics of the tests from the learners during the learning process with percent of successfulness including numbers of right and wrong answers. The system also automatically watches the test results and returns messages about the related test performance. The teacher can click on an editing button to edit or ignore it.

5.6.4.2.3 User Personalization

In this section, teachers can monitor the learner's activities and can also plan for the learning process of each specific learner. The first sub-section provides statistics about each specific learner with the available materials and the number of learning processes performed by the learner. The second sub-section is the messages about the learner's level of activity and informs the teacher if the learner's level should up or downgraded. The third sub-section presents the progress and learning progress curves of each leaner in a 3D graph. The fourth sub-section presents categories information for each learner. The categories include which ones should be worked on in the future, the ones finished and the current ones in process. In the last sub-section, teachers can design a learning plan for each learner. Teachers can define which categories should be presented in priority for a specific learner.

5.6.4.3   Administration

The third stage in teacher portal refers to administration and the policies regarding the users in the system. The sub-sections are visible only to users with authorized rights. The administrators have the right to manage other user profiles.
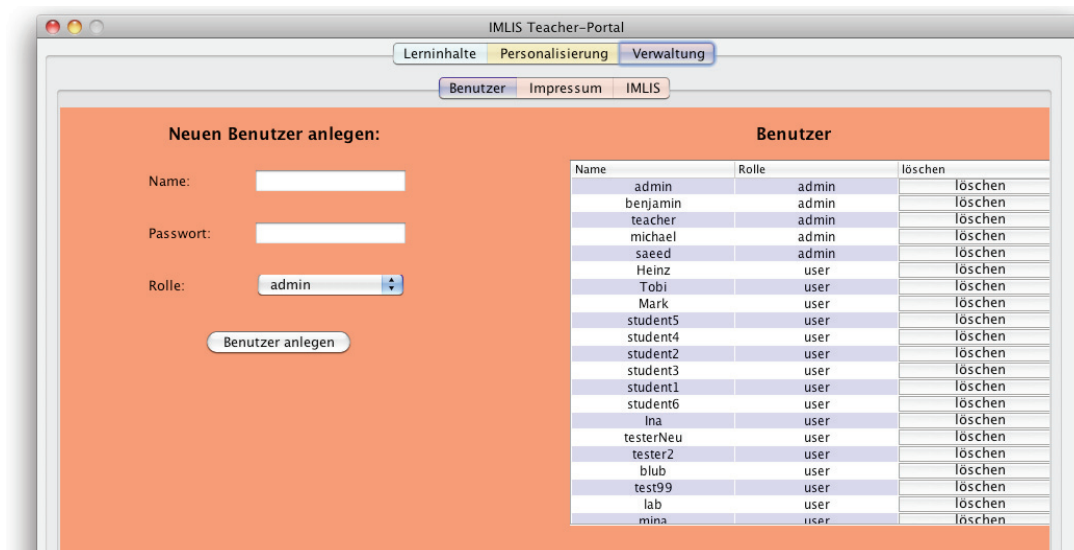
Figure 42: User administration in teacher portal.

This panel provides access for creating teacher portal user accounts, editing and deleting users, and assigning rights for the users. System administrators can perform all needed administrative tasks and roles within IMLIS system.

5.7   Learning Success Assessment

The impact of regular tests and quizzes on the workflow of IMLIS learning units is significant. Embedded in each learning unit, a test or quiz completes the learning effort. Firstly, a playful test or quiz is necessary to gather feedback to update the system profile and survey the learning process, but secondly tests form part of a didactical concept. In our interviews and tests with the target group, we noticed that a motivating test is highly appreciated by learners. In some cases, they repeatedly played a certain test because they enjoyed solving the questions.

In order to use the potential of tests, the teachers in workshops recommended to implement well-designed templates for creating tests. The templates should focus on content as well as skills if possible. The starting aspects are questions about knowledge and in a certain range also questions that reveal comprehension can follow. If the learner shows particular ability for abstract thinking, questions that are designed to challenge the transfer of knowledge to other contexts can be added. On this level, the learner should differentiate between diverse possibilities or should be able to combine different issues in a creative way. These aspects can help to find matching questions. Most importantly, a test should not be too easy or too complicated. It needs to be just challenging enough for the individual learner. With respect to these aspects, a test should not be too long to discourage or interfere with the learner's attention and also it should not to be too short to limit their potential. A well-designed test supports the learning process by adding changes and consolidating attention and building well-balanced tension. Several patterns of a dramaturgy are implemented in the predefined test templates.

5.8   Personalized Content Network

The IMLIS system provides functionalities for creating personalized learning units. With increased participant use, the stored materials grow and the learning process with the accompanying lessons become more and more suitable and accurate to support further learning.

To respect copyright and privacy, each participating teacher can add terms of use or restrictions of use to the system which can limit the use of material to their own class or school. Although a greater number of participants with unlimited restrictions would help create a knowledge base that enables better personalization, even limited restricted uploads mean that together teachers can build a more rich personal base of learning

units. This can facilitate the preparation of the teaching practice not only within the system but also allowing print outs that can be separately used. IMLIS supports the needs of the teachers in a deeper and broader way.
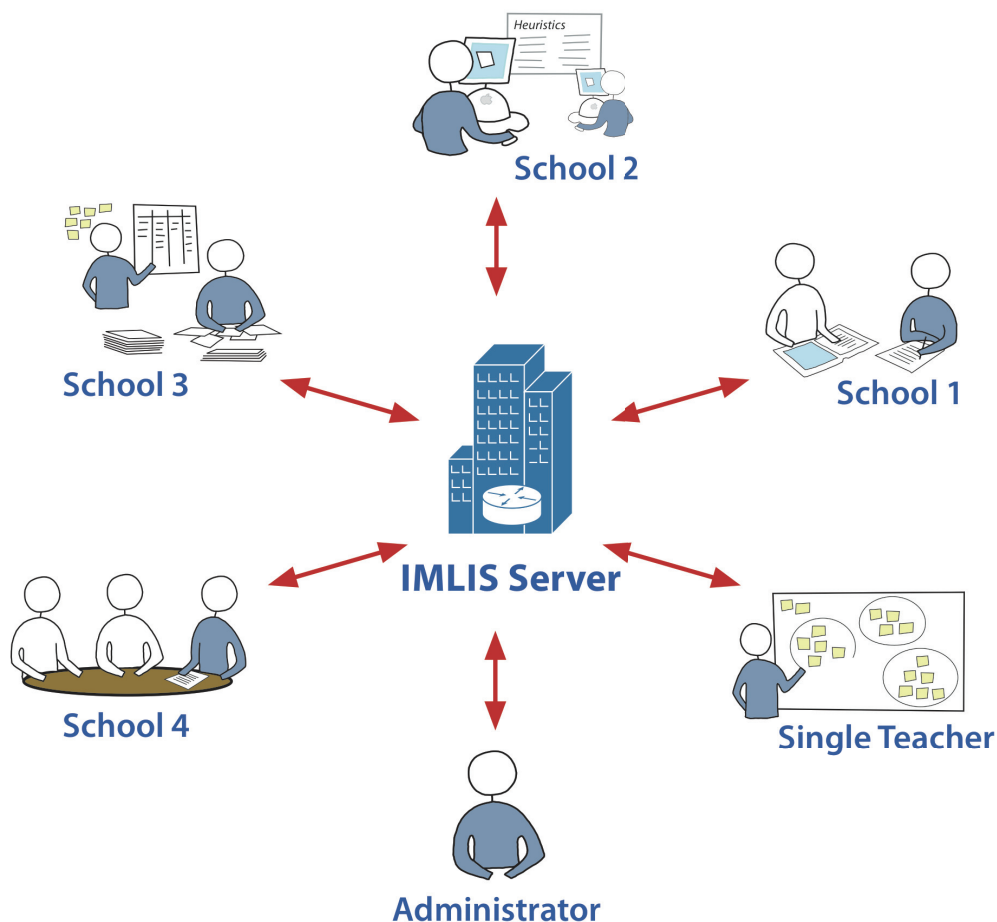
Figure 43: IMLIS personalized content network structure.

The teachers for the students with special needs work in different schools. They plan and teach alongside a teacher for non-disabled students. For their students they plan the lesson according curriculum topics. In lessons, generally several subtopics from different disciplines are included so that several abilities can be trained. In order to support each learner with a disability, the learning material should be adapted to each student's needs. This requires a huge amount of work and preparation.

Some teachers work with schoolbooks for young children to rework the exercise ideas to the style of children of other ages. Other teachers create their own materials and often they try to exchange their materials. Seldom do teachers add tutorials for the specific material for their colleagues. At least there are specialized databases on the web for teacher. Here teachers can research and find materials to adapt to their purposes. In some databases, images can be found and in others practice sheets and homework.

Sometimes two teachers exchange well-prepared material for a whole sequence of lessons. This kind of cooperation can be helpful, according to their personal focus.

To support resource sharing, the school administration can provide a server with a database for sharing learning materials. The use of these materials is often not documented and causes additional work. The benefit of these systems is not well developed, so the effort to participate and contribute to them is problematic. Most teachers in our workshops suggested a community server for sharing materials and knowledge of didactical methods. IMLIS supports this functionality and incorporates idea of learning material that is stored with additional metadata of their usage, context and target group.

For such a system, the teachers believe that they will engage more in IMLIS because this contribution strongly supports their own needs for material preparation. They also indicated that sharing might be a first step towards building an online community to spark the exchange of material in a structured and helpful way. Of course sharing experience and knowledge within a teacher network would provide immeasurable support amongst the disability community.

6 Testing and Analysis of IMLIS based on Workshops and Experts Interviews

This chapter presents the tests, analysis, workshops, feedback and evaluations done during this study. Various tests have been accomplished to discover the strengths, stability, security, problems and weaknesses of this approach. This chapter also presents the results of the workshops conducted during this study.

6.1   Qualitative Research Evaluation Methods as a Matching Approach toward a Model of Personalized Learning

The challenge of this research is to focus on a wide field of mobile learning and learning behavior targeted and analyzed to build implementation models. Qualitative research methods such as qualitative content analyze [Mayring 2000], narrative interviews, problem-centered interviews and expert interviews (including guideline-based interviews[1]) [Flick 2002] participant observations [Mack et al. 2005:13] render possibilities to evaluate human behavior with its motivations and reasons. The questions like how, what and why, focus firstly on the actions and then answers to these questions helped us to develop processes that can be formalized into a model.

According to Alan Cooper, there is a need in current software development projects to implicate the understanding of complex actions [Cooper et al. 2007: P50]. This need can be met by the integration of qualitative methods. Through this methodical approach the personal experience, their opinion, comments and their suggestions for improvements can become fruitful resources for the research. The methods used throughout our approach are participant observation, narrative interview study and expert interviews. Three methods of qualitative research for data collection were adapted to the setting of the evaluation according to the context and the subjects of the evaluation.

Participant observation focuses on an internal perspective to prepare the composition of questions that lead to the foundation of the hypothesis required to propose new areas for mobile learning solutions. This explorative method was used for the evaluation with students and for the workshop with teachers. The participant observation was coupled with narrative interviews. These interviews should reveal motives and support the comprehension of the individual actions; they also provide opportunities to express opinions in order to support reasonable motivation for a specific action. Throughout the observations the attendees were interviewed.

The attendees were encouraged to freely interact in our study. This allowed us to observe and collect their motivations during specific actions or afterward through questioning. Even in workshop group discussions, we kept this approach by using a moderator and two observers. The groups always comprised between two to eight participants so that at least one observer could focus on a maximum of four participants. After the discussion the observers arranged personal narrative interviews for each participant.

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[1] In German: Leitfaden-Interviews

This approach was specifically chosen to reduce stress on the target group. The results of this effort were thoroughly analyzed and became the condition for the ongoing research. With expert interviews during the workshops results were stabilized and analyzed. Here the subjective perspective of different experts used to build a broader interdisciplinary understanding of the complex challenges of this research. The expert was consulted as a representative of a discipline.

We aimed to cover several views for a multiple model with different levels of solutions that enabled us to verify the results by providing a certain diversity that had been the base for our broader model of interactive personalization. We prepared a specific problem that was related to the expert's discipline of as a starting point, but then the contextual meaning and motivation of actions and beliefs were asked in a non-predefined way to support self-interpretation.

The participant observations: handling, processing and the data analysis were centralized. Here the whole context and the presentation were targeted. Because of the complexity of the data, it had to be reduced to meaningful data and generalized. The events and actions of the participant observation and the narrative interviews were recorded by video camera. These recordings were transcribed and analyzed sequentially by the objective hermeneutics method [Oevermann 1987]. The outcome of the qualitative data analysis was centralized which enabled us to generate reference value and the general conditions for typification and promoting the construction of a theory related to the subject.

6.2   Technical and Functional Tests

An overview and impression of the IMLIS was commissioned, in which the goals and motivation were presented. Besides many small tests during the implementation phase, different type of tests were accomplished for IMLIS prototype in order to evaluate the results. These tests determined the results of the prototype and backed up this approach according to the system requirements.

Figure 44: Prototype testing with different types of mobile devices, 2010.

For the testing, the following four mobile devices were selected according to their type, features and abilities. The HTC device is a normal touch screen cell phone for daily usage. The ACER is a common PDA which can be used in schools and workplaces. The PSION device is a robust, waterproof and unbreakable device appropriate for outside usage or in the workplace. The OQO device is a powerful handheld device similar to a miniature personal computer. These devices were selected for our testing because of their features.

HTC   ACER   PSION   OQO

Figure 45: Four selected devices for IMLIS prototype testing.

The IMLIS prototype was tested from two main technical and functional views. From a technical view, the following tests were completed in different types of mobile devices: cell phones, smart phones, PDAs, and small mobile laptops.

- Connection protocols from mobile client to the IMLIS server and the potential of Internet connectivity.

- The presentation of learning materials according to the different mobile screen size.

- IMLIS client application installation in mobile devices.

- Local storage capacity for keeping IMLIS log-files.

- Java and J2ME support by mobile clients.

- Stability and robustness of client devices.

- Battery lifetime.

As IMLIS supports different functions, the following functionality tests were done in different types of mobile devices:

- Interactivity support by clients (if the interactions integrated in IMLIS are supported by the client devices).

- Touch screen function and the alternative function instead of touch screen possibility.

- Zoom function for client screens.

- Data entry via mobile buttons and integrated virtual keyboards.

- Media functionalities for running learning audio and video assets.

The following table shows the results of some important technical and functional tests on four selected devices.

Table 9: Comparison of the results on four client devices.

	HTC - Touch Diamond	ACER - PDA	PSION - ikön Rugged PDA	OQO - Model 01+ & 02
Connection Protocol	Internet UMTS	Internet Wireless	Internet Wireless	Internet Wireless
Touch Screen	Yes	Yes	Yes	Yes
Battery life-time	~ 5 Hours	~ 2 Hours	~ 3 Hours	~ 2 Hours
IMLIS Client App installation / How?	Installed / Without Problem	Installed / With Java Problem	Installed / Without Problem	Installed / Without Problem

Local storage capacity	Yes	Yes	Yes	Yes
Java / J2ME support	Yes	Yes	Yes	Yes
Zoom function	Yes	No	No	Yes
Audio/Video support	Yes	Yes	Yes	Yes

In order to complete our use cases, we implemented the IMLIS client on some mobile devices and tested interactive tasks with a series of user inputs. With this limited but precise test sequence, different aspects were checked. The results helped to refine some performance aspects and gave confirmed that IMLIS is usable in real learning cases with current client devices available in the market. Also, it had to be clearly stated that this test series was neither a complete empirical evaluation nor a comparative survey on the mentioned devices.

6.3   Conducting Workshops

Between December 2007 and May 2010 we completed different workshops which can be divided into three parts: pre-workshops, developmental-workshops and post-workshops. With the formative pre-workshops, we aimed to analyze the basic conditions for the context and user group in order to define the initial requirements of the approach. During a longer term of interrelated formative developmental-workshops the implemented concepts and models were evaluated and analyzed. In summative post-workshops the final prototype version was tested with the students and teachers. So the focus on interactive design and the general model was targeted with respect to the contexts in real situations.

In many cases, testing with teachers was preferred in order to avoid too much stressful testing of the students with cognitive disabilities. The selected tests were discussed with the teachers considering environmental conditions and the abilities of the persons tested to actually perform the tests. Table 10 shows an overview of the main conducted workshops during this study.

Table 10: An overview on conducted workshops during this study.

Workshop	Description
WS 1	**Purpose:** Understanding the restrictions and abilities of people with cognitive and additional disabilities. Gathering concepts of visual learning materials that are currently in use. **Methods:** Observing the students during the learning process. Interviews with students (with help of a tutor). Engaging them with the used materials of the lesson that were observed. **Process:** Taking notes during the lesson. Collecting with the teacher the used materials, and taking small interviews with some students by engaging them with their materials and asking about difficulties. Afterwards they are asked to give a discription of what happened during the lesson. These materials were then analysed with the teacher concerning the learning process. **Results:** The material in use is easy but detailed with several small steps and not all students get the same material. The general material is varied for each student by small changes so that each student can follow the overall lesson with their own personalized material. **Participants:** 9 Learners + 2 Teachers **Location:** Schule an der Marcusallee - Bremen, Germany **Date:** 26.02.2008
WS 2	**Purpose:** Analysis if and how people with cognitive abilities can use mobile devices for self-determind purposes. Stating their learning behaviors in an open context. **Methods:** Videoetnography. Observing the participants during learning while engaged with mobile devices. Small learning units were provided as a possible task, but learners could freely choose themselves as a target. Small interviews with all participants concerning their experience, started by asking them to describe the things they had done and what they archieved. **Process:** Engaging participants with small devices. **Results:** This target group is able and strongly motivated to use mobile technology even when problems arise they know how to help each other and some are able to solve these problems by themselves. **Participants:** 4 Learners + 1 Supervisor **Location:** Sheltered Workshop Martinshof - Bremen, Germany **Date:** 11.03.2008
WS 3	**Purpose:** How people with cognitive disabilities can manage the tasks at their workplace and how further training is organised; how classroom learning is integrated extended and integrated in the setting of sheltered workshop. **Methods:** Observing people at work, interviews with participants and their supervisors.

	Process: Observing the people at different stages in their workplaces, asking about their tasks and tracking how they can perform each step of the tasks. Engaging supervisors with the results of the observational research and discussing with them how they organize the setting and how they adapt the tasks to each person and how they decide which work can be done by whom.
	Results: All tasks and machines are adapted and personalized to the needs, abilities and restrictions of each person/worker.
	Participants: 6 Learners + 1 Supervisor
	Location: Sheltered Workshop Martinshof - Bremen, Germany
	Date: 16.04.2008
WS 4	**Purpose:** Learning from another culture of inclusive classroom. Focusing on personalized teaching practice. Analysing how teachers with a different background deal with abilities, restrictions and needs. Recognizing possible options for a broader model of personalized learning. Analysing how these teachers prepare specialized material for each individual's need.
	Methods: Discussion with a group of teachers. Video clip analyzing.
	Process: Visit a group of teachers and discuss with them their experience and practice and how their school system works.
	Results: Personalization is important. The need of autonomous exercises and training is highly valued and is seen as an opportunity to develop a certain self-determind learning practice.
	Participants: 6 Teachers + 2 Supervisors
	Location: Northwestern University - Chicago, USA
	Date: 11.06.2008
WS 5	**Purpose:** Understanding the usage of mobile device by the target group, analysing cognitive barriers and abilities. How this user can comprehend the specific use of the device, application, and in detail the interaction and screen.
	Methods: Tasks for the participants with paper prototyping. Observing them with video. Interview afterwards and discuss the results with their supervisors.
	Process: With prepared paper screens the participants were asked to fulfill simple and small tasks. First, a series of tasks was created concerning usability of screen design, second, usability testing of a small learning application.
	Results: Everybody had previous experience with mobile devices. Even they had difficulties in imagination. Every participant managed to do the task with the paper screens, but they needed continous individual support (to motivate or to get small advice) to do the task. Everybody was interested in mobile devices. The tasks had to be explained several times to simplify it.

	Participants: 4 Learners + 1 Supervisor **Location:** Sheltered Workshop Martinshof - Bremen, Germany **Date:** 16.07.2008
WS 6	**Purpose:** Testing how people with cognitive disabilities can use a small learning applications on a mobile device without help, and which aspect of the application generates motivation. To estimate importance of the aspect "joy of use" for this target group. **Methods:** Starting with a small presentation about the device and the task the participants were engaged with the devices. Video observance and interviews with the participants. **Process:** After basic instructions, the participants were engaged with the device. The task was explained several times as often as needed. The participants had to deal with the situation on their own. Only if a participant repeatedly tried out an action unsuccessfully did he get support to help solve and perform the specific action. After the test, the participants were interviewed separately about their experience, difficulties and "joy". **Results:** For some participants it was difficult to perform the task; some participants who managed to fulfil the task helped others with difficulties. Because of the "playful nature" of the application most of the participants performed the task several times and were happy, laughed and started talking with each other. They liked the quizz a lot. Surprizingly, even the participants with major difficulties told about the fun they experienced. Some had problems with coordination, but in the end they could manage. **Participants:** 4 Learners + 1 Supervisor **Location:** Sheltered Workshop Martinshof - Bremen, Germany **Date:** 21.07.2008
WS 7	**Purpose:** How students with cognitive disabilities deal with mobile technology. To acquire their cognitive behavior by solving tasks of their school training that demand mostly memory and attention. **Methods:** In the first part the participants were engaged with different types of mobile devices and small tasks. Their handling and feedback in a group discussion was filmed. **Process:** The participants had to solve some small comunication tasks with different mobile devices. Every participant managed to use the devices, but the simple devices seemed to be more difficult for them and they did not like them. The group performed several memory and symbol recognition games that they knew from weekly school training. After the game they met in a group discussion to describe their weekly training, how they deal with it and what they liked about it. Afterwards the teacher was interviewed and provided comments on these discussions. **Results:** They could perform tasks very fast and they liked the interaction very much. The normal devices which are more complex were preferred and they could handle them better. They liked the memory games a lot and were trained to deal with this task. According to the teacher, regular

	memory learning and training other cognitive abilities in a playful way is very important for them. **Participants:** 7 Learners + 2 Teachers **Location:** ZIM, University of Bremen - Bremen, Germany **Date:** 06.10.2008
WS 8	**Purpose:** Analysing accessability and usability of mobile phones for the the target group. Observing the behaviors with different cell phones. **Methods:** Engaging a group of young workers with different cell phones. Asking them to fulfil small communication tasks with different cell phones. Video observance. Interview with experts concerning accessibility of mobile technology for this target group. **Process:** The participants liked to play with the devices. Very soon they knew how to use them. Even the common devices were easier from them to use. They performed the communication tasks with the different devices. The recorded actions were analysed by an expert. **Results:** The target group liked to use mobile devices. Most of them had experience with mobile phones and this technology is very attractive to them. They prefer the common devices not specialized ones and because of this attraction, they were able to overcome handling difficulties. The experts point out that the need for communication with society is symbolized by mobile devices and working with mobile devices can foster self-confidence and cognitive development of the disabled. **Participants:** 5 Learners + 2 Supervisors **Location:** Sheltered Workshop Martinshof - Bremen, Germany **Date:** 08.10.2008
WS 9	**Purpose:** Analyzing the application and the system by teachers for students with cognitive disabilities. Getting feedback to the interactions, the teacher portal and critera (metadata) for the materials. Evaluation of the screen design and analysing the functionalities coupled with user profile. The main viewpoint was the needs of the target group as key-critera to evaluate the system. **Methods:** Presentation of the prototype. Group-discussion and development of ideas on paper, as protocol and video tape. **Process:** Presentation of the different parts of IMLIS, analysing weaknesses, strengths and suggestions for improvements by the teachers. Discusson on the quality and acceptability of the interactions and development of ideas for the refinements with the teachers. Discussion of templates and learning materials, focusing precisely on how the material can behave in learning contexts in combination with criteria (metadata). Fixing the result in a concerted verbalized protocol taped with a video camera. **Results:** The model of administration and execution of uploaded learning material was extended and adapted by multiple user-generated subcategories, teacher-centered design of categories, cases studies for defined contexts and situations where this flexibility in category plays a

	role. It was a general evaluation with benchmarking aspects where functionalities from other software was compared to IMLIS. In a second part it was a creative approach, where further ideas were created. The category gender, useful in certain contexts and the profile (with its automatic update functionalities) should respect the multiple levels of abilities of an individual. *For example one student can be very well developeed in mathematics and can have major problems with reading. This complex status of different abilities should be supported, so that the system offers higher standard for example for mathematical excercies and less complicated lessons for reading. Even the learning curve for different topics and abilities can be different.* **Participants:** 4 Teachers **Location:** Grolland School - Bremen, Germany **Date:** 21.10.2009
WS 10	**Purpose:** Evaluation of the personalized learning materials in common classroom activities (mostly non-digital). Evaluation of teaching methods, didactical models and the associated environment for integrative and inclusive classroom. **Methods:** Inspection of products and processes. Video observations and documentation. Interviews with participants and self-assessment of the participants. **Process:** With teachers analysing several chosen learning cases, stating profile, the material for the learning steps and matching the results. Analysing how a teacher can create digital materials for one specific purpose with some existing software tools. Observing how this student work with their customized material. Interviewing the teacher and student afterwards and taping the results. View the teachers enviroment with additional descriptions. **Results:** A step-by-step description of a personalized workflow for specific students. A description, that can be formalized, about how a teacher can create personalized materials for a specific context for a specific student. **Participants:** 6 Learners + 1 Teacher **Location:** Robinsbalje School - Bremen, Germany **Date:** 03.12.2009
WS 11	**Purpose:** Getting information about the current didactical model of integrative and inclusive didactic at schools in Bremen and their situation. Getting a model for presenting and teaching the main idea of IMLIS to teachers who are targeting to use digital media in context of integration and inclusion. **Methods:** Presentation and discussion documented with a video camera. **Process:** Presenting the system and the concept of IMLIS. Describing the functionality of several use cases. Discussion and detailed analysis with guided questions. Inquiring about the comprehension of the teachers with specific questions and additional interviews.

	Results: IMLIS is a system that is useful for integrative and inclusive contexts and autonomous training activities monitored by tutors. The activating aspects for students were stated. It had been a longer discussion whether and how this system can improve teachers actions related to preparing personalized learning materials. In order to share and reuse the materials, they have to be categorized. IMLIS offers a system for this in its teacher portal, but this has to become more flexible. A certain development of specified usability in the teacher portal is still needed and the combination of templates, criteria and interactions should be analysed in detail. A teacher portal tutorial would be useful. **Participants:** 9 Teachers **Location:** University of Bremen - Bremen, Germany **Date:** 27.01.2010
WS 12	**Purpose:** Review of the IMLIS requirement with teachers for students with cognitive disabilities. **Methods:** Presentation coupled with starting questions for the discussion. Discussion and communal protocol of the results. Documented with a video camera. **Process:** After triggering questions a list of criteria was developed with the participants. With these questions IMLIS was analysed by presenting functionalities and explaining models that are behind the interactive behaviors of the system. This analysis lead to a discussion about the use of mobile learning and media for this target group. It was about how to implement this media and opportunites in one's own teaching practice and classroom. **Results:** After critical feedback a general acceptance to IMLIS was stated. The group found many opportunities for useful extensions of classroom teaching. They also saw potential for fostering media literacy of this target group, given that they do not have adequate applications for this purpose. **Participants:** 7 Teachers **Location:** University of Bremen - Bremen, Germany **Date:** 10.02.2010
WS 13	**Purpose:** Deeper and closer understanding of the implemented IMLIS prototype and the suggested model. Identify social communication aspects in IMLIS and needs for further extensions and add-ons. **Methods:** Group discussion and group work with the following discussion of the results summed up by the group and recorded with a video camera. **Process:** In preparation for this meeting every participant got access to the IMLIS prototype in order to examine the prototype according to their own criteria and view points. At the beginning the questions and impressions and results were gathered and discussed and three main questions were stated. Based on these three questions, the IMLIS system was analysed on the level of model and concept. Whether the concept

	meets the needs and abitlity of the target group and with respect to strengths and weaknesses in the model. The contribution and implementation of IMLIS in social interactions and communication was discussed. Also the role of interactions between learner and teacher, learners and learners, and learners and context were discussed. **Results:** A deeper understanding of the implemented models enables teachers to find their appropriate use cases for their specific classes and student needs. Improvements of the personalization model and suggestions for the teacher portal design become clearer. The need of tutorials for teacher that not only describe the functionlities but also the models was stressed. **Participants:** 4 Teachers **Location:** University of Bremen - Bremen, Germany **Date:** 17.02.2010
WS 14	**Purpose:** Preparation of concrete learning materials and interactions. Usability testing of teacher portal by teachers. Testing the model and implemented workflow of teacher portal in order to make refinements. **Methods:** Performing a practical work session for designing concreate learning materials and interactions for IMLIS in small subgroups. Uploading the results in the system and testing the implemented lessons. Video taped interviews with the participants. **Process:** After an overview of the available materials, they were classified according to criteria. In small groups, lessons were built from the teachers for diverse user profiles and contexts. Afterwards the materials were digitized by the teachers and uploaded to the system. In a next step in small groups the teacher decided on different profiles and tested the lessons according to their criteria stated for the individual needs. Afterwards in small interviews the teachers described their experience by creating, digitizing and uploading the learning materials. **Results:** The preparation and uploading of the learning materials was seen as a possibility to build a base of reusable learning materials. The effort to produce a single lesson for one student is very high. Models of co-creation of materials and exchange should be implemented to migrate existing materials from other applications. The usability of the teacher portal should be refined especially the preview function and visual orientation should be further improved. **Participants:** 5 Teachers **Location:** University of Bremen - Bremen, Germany **Date:** 03.03.2010
WS 15	**Purpose:** Evaluation and analysis of IMLIS outcomes. To correspond the outcomes of the previous evaluations especially to map the overall critics on the model and the learning performance. **Methods:** Group discussion and separate interviews with the teachers. Recording with video camera. **Process:** After a discussion from the general IMLIS concept and the

	gathered results of the previous sessions, a general review on the IMLIS was given and analysed. Possibilities for implementation in schools were discussed along with conditions of use. Afterwards in separate interviews teachers described what was important for them, what they learned from IMLIS and what is their general impression. **Results:** All teachers could work with the system and understood the functionalities. Most of them saw posibilities for themselves to improve their teaching practice with the system. The greatest problem was starting to learn how to use the system. More start-up learning materials may be need of enough to help the teachers to quickly start working with the system. A community of teachers might solve this problem. **Participants:** 4 Teachers **Location:** University of Bremen - Bremen, Germany **Date:** 10.03.2010
WS 16	**Purpose:** Evaluation of IMLIS for teaching contexts with diverse cultural background and in a different school system that have a different educational concept. Stating the potential for adaptation and extention. **Methods:** Presentation, guided tours and discussion. Summing up at the end with the group. Writing a protocol. **Process:** Presentation of IMLIS with a focus on the teacher portal. Discussion of their experience with respect to interactive functionalities and classification by criteria. **Results:** The teachers stated that IMLIS supports many necessary functionalities that might be used in their lessons. Of course, the system should be translated, also the technology infrastructure should be supported by the school. They understood the use and could imagine how it could support learning, knowledge and skill training. **Participants:** 3 Teachers **Location:** Noavaran Institute – Tehran, Iran **Date:** 31.03.2010
WS 17	**Purpose:** How learners with diverse cultural backgrounds and with different school experience can comprehend the IMLIS. **Methods**: Guided presentation and group discussion. Narrative interviews. Taking notes afterwards. **Process:** Testing IMLIS client runned in smart cell phones with students with disabilities. Describing the system and presenting them the IMLIS client. In groups the participants could try out the system with guidance. Afterwards in a group discussion, the participants talked about their experience. **Results:** The participants could understand the system and liked to use a mobile device. They could easily imagine themselves learning with such a system. **Participants:** 4 Learners

	Location: Noavaran Institute – Tehran, Iran
	Date: 03.04.2010
WS 18	**Purpose:** To evaluate the implemented IMLIS mobile client prototype with target group in a specific context. To process a pre-defined scenario for making a video clip to present the IMLIS concept. **Methods:** Testing the prototype with the students. Video recording during the learning process. **Process:** Beginning with introduction of tasks, the students worked with the mobile devices. Afterwards they were asked to describe what they did and they talked about their experience with the client. Both parts were documented with a video camera. **Results:** Immediately the students understood the use of the client and could manage to access the excercises. They liked the system and wanted to regularly use such a learning sytem. **Participants:** 4 Learners + 1 Teacher **Location:** Robinsbalje Schule – Bremen, Germany **Date:** 04.05.2010
WS 19	**Purpose:** To evaluate the quality of personalization and the "joy of use" by the target group. Testing the ability of IMLIS to adapt to this situation and how the system would provide personalization. **Methods:** Testing the IMLIS with the students. Video recording during the learning process. Narrative interviews with the learners and teachers. **Process:** After a short orientation, the students started to learn with mobile device by trial and error. Then the participants got small tasks, some they had to do in a without a mobile client and some with a mobile client. Afterwards they were asked to describe what they did and then talked about their experience with the client. With specialized questions, their emotional engagement was analyzed. **Results:** The students caught on immediately how to operate the system. They liked to use IMLIS and could solve the given tasks. The system provided the lessons that were appropriate to them; therefore, they did not state any difficulties in the interview. They described the level of difficulties as similar to their normal lessons provided by their teacher. All stated that they didn't need help to perform and solve the tasks and the documentation could prove this. A precise implemented profile and precise preparation of the learning material enabled a personalized learning activity to be autonomously managed by this target group. **Participants:** 2 Learners + 2 Teachers **Location:** Schulezentrum an der Julius Brecht Allee - Bremen, Germany **Date:** 18.06.2010

6.3.1 Pre-Workshops

At the beginning of the study and in the analytical phase, we conducted several formative pre-workshops in order to test and getting impression about the mentally disabled. The pre-workshops were accomplished in different stages with both children from schools and adults from sheltered workshops. These workshops provided us with different results and showed us the starting points of study as well as resources. During the workshops, we had the chance to discuss our solution with the teachers and experts. The initial workshops included four workshops with 4 to 8 participants between 12–40 years old done in cooperation with "sheltered workshop Martinshof" and the "vocational training school in Bremen[1]".

The first workshops focused on the role of digital media in their everyday life. We wanted to understand their first impression and how they use and what they know about mobile devices. The participants were initially given an introduction about the mobile technology, use of digital media and such kind of information. During the workshops we continuously monitored participant attitude and feedback to our experiments.

Figure 46: Memory game activity in a workshop, ZIM - University of Bremen, 2008.

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[1] Allgemeine Berufsschule in Bremen, http://www.abs-bremen.de

Later in the workshops, we tried to ask them about their learning activities and how they adapted to new technologies. We introduced them to different possibilities of mobile devices. At the beginning, they were totally interested in fun activities with devices such as photo shooting via integrated cameras on devices, SMS sending, and games. Then we presented them with different quizzes on mobile devices and asked them to break up into groups and try out the quizzes. In the last workshops we introduced different mobile phones to get feedback on their interaction with these mobile devices.

6.3.2 Developmental Workshops

After analytical pre-workshops parallel with the literature review in the first phase of the study, we started the second phase of workshops parallel with the development approach. The aim of these parallel workshops was to keep the requirement updated according to the mentally disabled needs and also to implement the feedback directly in the prototype. In this phase, we conducted seven workshops with different kinds of participants.

As our approach was a learner-centered design, we started with a paper prototyping workshop. We tried to encourage users to participate in the design process to include their own perspectives. In this workshop we gave printed-paper screens of mobile devices to the participant as well as a simple learning scenario and we asked them to design the user interface for the related scenario. At the beginning, it was hard for them to do it, but after a complementary explanation, they did it in different ways. Mid-way through the design, we gave them a brief explanation and feedback on what they were doing. One of them had problems writing, we helped him write. The most challenging parameter in design for them was the navigation design although we gave them some numeric labels to use for ordering the pages. Following this activity, the participants presented their results to the others.

Figure 47: Paper prototyping workshop in Martinshof, 2008.

After the paper prototyping activity, we gave them real PDAs with the same scenario implemented as a simple learning program. As they had thought about this scenario before, they could easily go through the learning process and finish it. The next series of workshops was conducted over a three-month period in four sessions each of about two hour long with three breaks in the middle. The aim of these workshops was to get the impressions and feedback from users regarding general mobile learning. We focused on real learning mobile programs to monitor their activities during the learning process.

We started with very simple learning interactions on PDAs. For the learning programs, we used the "Hot Lava Mobile authoring tool" from OutStart Company[1]. The programs provided different topics of learning like work security instructions at the workplace, the instruction of right using of monitor, fun mathematical exercises and brain jogging training. In the prepared programs, an avatar or an animation guide was provided for them.

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[1] Hot Lava Mobile, http://www.outstart.com

Figure 48: An IMLIS developmental workshop in Martinshof, 2008.

The last developmental workshops were conducted with tests on IMLIS prototype showing different views of usability, design and content. We have introduced our participants to IMLIS prototype on different mobile devices. As this stage of the prototype supported touch screen functionality, many problems for using different mobile devices appeared. At the time of these workshops the new generation of touch screen mobiles hadn't yet reached the market (at least not common). The results and feedback of these workshops, narrative interview with participant, monitoring them during learning, and talks with teachers, helped us to advance the development of our prototype.

6.3.3 Post-Workshops

The summative post workshops were the last series of workshops in this study and the final version of IMLIS prototype tested. We tried to look for answers to the following general questions after accomplishing these workshops.

- How many system requirements present are covered by the result?

- How can the usability of the IMLIS prototype with respect to a broader understanding of usability that includes the limitations of the mentally disabled be accomplished?

- How can IMLIS system motivate learners?

- How can teachers use the system for their needs in school?

Teachers and students, not involved in the development of the system evaluated it in real context. They got only an overall description and devices with access to the IMLIS system. Small tasks for teachers and students were prepared and they were asked to perform them. To reinforce former achievements, the following issues were analyzed:

- Usability of the teacher portal and intelligibility of workflow and design in teacher portal for uploading and organizing learning material.

- Usability of the mobile client application.

- Intelligibility of the provided lessons for the students.

- If the concept of personalization can be recognized in the system by both students and teachers.

- The need for supporting the students to use the system.

- The migration of learning material from traditional learning into IMLIS system.

- If the teachers accept this system.

- If the students accept this system.

For each of these issues one or more small tasks were used and participant's behavior was monitored by video camera. In some cases, the recorded sequence was played for the test person who was asked to comment on video. In addition, two test scenarios developed by teachers and were tested by the students. In a real context the students had to solve exercises with IMLIS that they would have done in their traditional daily training. In this way, the two learning situations were compared and analyzed from different points of view.

6.4 Workshops Results

Conducting workshops helped us to carry out both the practical and theoretical sides of the study. After finishing the workshops, we were able to evaluate the approach and identify the advantages and disadvantages of the solution. The pre-workshops made the initial impressions of mobile learning clear. With the knowledge and experience in pre-workshops, we could start our work and continue it in parallel with developmental workshops. The developmental workshops helped us avoid distraction from our goal and the post-workshops helped us to see the result of our approach in real context. After each workshop, the students and experts were questioned. Answering these questions clarified issues concerning the educational and critical points which could be useful for further processing of the system.

General questions

- Did you have any experience with digital media as well as mobile devices before?

- How did you find IMLIS?

- Did you get any extra motivation by this system?

- What were your expectations?

System questions

- Could you accomplish the user profile registration?

- What would be the most appropriate for the classification of learning materials and assigning metadata?

- How was the usability with mobile devices?

- Could you understand the lessons?

- Could you understand the navigation?

The overall results of outcomes from these questions made a clear overview of the system. We recognized that nearly all knew something about mobile devices. Most of the learners have seen advertisements and knew about mobile device brands. For them a mobile device symbolizes "a gateway to the world". A lot of them had their own cell phone and they knew how to use them. In most cases they required a mobile telephone to organize emergency help, if needed. Some could work with other functions of cell phones like SMS, mp3 player and camera.

The small quizzes were not complicated for most of them. On the contrary, they liked to take the quiz, although some of them had to do the quiz several times in order to understand how it worked. In some cases, we could give enough attention to the groups that had difficulties to successfully complete the quiz. Easily they learned to use the simple functions of new mobiles, and they helped each other to use the mobiles in the proper way. They expressed that they learned to use many functions of their cell phone by observing other classmates and colleagues.

Based on the principles mentioned in section 3.6, and our experience in different workshops with the mentally disabled, we studied their special learning behaviors and distinguished the following four important parameters. These four parameters have a direct influence on the performance of cognitive processes. Therefore, a learning application should precisely consider these four in order to enable adequate support:

- **Attention**

  This parameter is the absorption of information in a learning process. The lack of attention is regarded as a huge problem for the mentally disabled. Often they can hardly focus their attention to the important parts of a task and can be easily disturbed and distracted from what they are doing. In this approach, we tried to recognize when the learner is distracted, and tried to re-introduce the learner to the learning process.

- **Recall**

  It refers to a call for stored information to bring it back to mind. The percentage of this factor differs too much with the mentally disabled. The improvement of this factor can be defined somehow as a success in a learning process.

- **Memory**

  People with mental disabilities always have problems in reproducing information. It is not the problem to save the information, but to retrieve the information. The process should contain an imperative and structured workload.

- **Speech**

  Based on the literature review and experience mentioned in state of the art, experts proved that it gets easier to keep something in mind when you can name it. IMLIS tries to support the learning process in a way that requests the learner to name or repeat the objects and events over different periods of time.

We observed participants who attended tests within different workshops; they played a weekly memory game at school that trained their ability of recall, memory and communication. Their teachers and advisers emphasized the importance of encouragement, which seems to be immensely important for those who have problems in learning.

According to our experience during the tests, people with mental disabilities often get disappointed and exhausted because of their limitations in reaching their goals. The learning program should be so designed that motivates them to go forward and not to give up mid-way. Every small mistake should be corrected with appropriate feedback (usually positive and in a motivating way) and every favorable outcome and success should be "appreciated" by the system. In many cases a small effort or advance should be considered as a success.

As our approach formed with the participation of experts and learners directly in the design process, our participants were always informed about their role and impact in the system design. Their comments were continuously validated, and many were taken into consideration in the implementation of the IMLIS prototype. The assessments of the validations were generally positive and encouraged us in different development phases. In different workshops we noticed that learning by mobile devices sparks independence and self-reliance which helps learners to perform the tasks without help. Self-learning reinforces the learner's autonomy over a period of time.

The early versions of teacher portal received much criticism from the teachers in different workshops. They all thought that the system required a huge workload for content preparation due to the need to enter metadata for each object. Later by adding the default metadata pattern possibility, teachers were more satisfied with the system. Teachers also criticized the absence of learner gender and age in the learning content representation. So the differentiations between male and female as well as age option were added to the system criteria.

6.4.1 Tests in Workshops

For the enhancements of concept and the system performance, several workshops with teachers from inclusion and didactical research were arranged. Each workshop focused on specific goals and questions. Generally the focus of these workshops was on the discussion of the concepts, so often the practical workflow was shown by a demonstration or guided examination of the prototype, guided by questions. The prototype functionality was analyzed to reveal if it fit into the didactical needs of the learners. For the evaluation of the IMLIS functionalities, a presentation and testing model was developed. This model should be applicable to the workshops and their participants both students and teachers.

6.4.1.1 The Model

The workflow has three primary stages, 1) anticipation of the main idea by a presentation of the system, 2) try out with a real prepared exercise, and 3) gathering the experience by a discussion and statements (these statements can be externalized to oral, written or by a drawing). According to the context and the participants the three stages are differently realized. For the first stage, presentation of the idea, several slides and materials were developed. A list with the concepts was accomplished and many diagrams and figures were prepared. Diagrams visualize didactical reasons and aims for specific parts of the system concepts. Furthermore, in case study diagrams the workflow of a learning process by a learner was shown.

For the second stage, by trial and error several use cases according target groups were implemented. These practical actions of the participants were continuously monitored. With a teacher or tutor the difficulties and supporting advice was recognized. In the third stage, video monitored discussions, were analyzed and used for complementary developments of the prototype. For participants with severe physical disabilities, we provided a way that they could draw their experience, and then a helper questioned the details of their drawing in order to gather comments. These evaluations aimed to get feedback by using interactive mock-ups in order to construct and refine the underlying model. The assumption of these multi-leveled evaluations created a model for the implementation of the software.

6.4.1.2 Test with Learners

Within the workshops, IMLIS was tested with the learners for system evaluations. The presentation of the idea behind the system development was purposely omitted for the learners. Usually a teacher presented how the system as well as mobile client worked. Both before and afterwards, users engaged in talks about their experiences with the device and learning materials. The practical use of the system was designed according a real use cases that were selected for a certain context and for certain participants.

Figure 49: The IMLIS testing workshop in Rabinsbalje School - Bremen, 2010.

The evaluations gave useful information for the design of the concept, the implementation phase, and the didactical usability in real contexts. From these activities, the needs of the target group and their real learning behavior could be precisely specified.

In a workshop, teacher demonstrate to the students (in borderline level) how they go through the learning process with IMLIS client application. The students were very engaged and motivated. In few seconds they learned how to use the device, to teach each other how to use it and enjoyed using it. For them it was easy to understand the lessons. They liked the idea to use the system even in classrooms for learning and games. The exercises from what they did on paper simply transfer to a mobile device.

Figure 50: IMLIS testing workshop in School an der Julius-Brecht-Allee - Bremen, 2010.

In another workshop, two students from a group of 9 mentally disabled joined tests on IMLIS. The two students were twelve year old boys in the borderline level. Klaus was a small restless boy who uses a computer at home for games and is also interested in mobile devices. The second boy, Murat was quieter, from a migrant background and physically much bigger than his classmates.

The two boys were asked to sit in a separate room next to the classroom and to fulfill three tasks. First, they were asked to start the system and log into their profile predefined by the teacher. Next they were to try out a lesson. In the beginning they had to decide on a topic. According to the topic, they had the choice of two to three lessons. In the lesson they had to connect a name of an object to a graphical representation. The relation of signs to pictures was put in several playful tasks. Both started and managed to login and decide on a lesson. Murat mentioned that this was very easy for him, as he had often seen how his brother logged in to a computer game.

After a while, it became obvious that he occasionally needed a person to remind him to stay focused. Nevertheless, he accomplished the lesson in 15 minutes, which was faster than expected by the teacher. He reported that he liked the mobile technology so much and he did not experience any difficulty.

Klaus hesitated in the beginning but then he quickly started his chosen lesson. He very precisely checked what should be done. The whole time he stayed quiet and focused. It seems that he worked slowly and patiently though out the exercise observing and following what the system asked him to do. Step by step he solved the task but it took him a little bit longer than Murat. He stated that he liked this game, even more than computer games that he knows.

The second task was a lesson prepared by their teacher, which they did in class a week before. Both boys hadn't studied enough the week before. This time we wanted to know if they recognized the lesson and if they would learn more now. They should see the pictures of a clock and then they should find the right sentences. For Klaus it appeared as an enjoyable task that he liked a lot and successfully solved in ten minutes. Then he repeated this exact lesson again and enjoyed that he could manage to complete the lesson. For Murat it was much harder. He couldn't easily find the appropriate sentences, and only with help it was possible to motivate him to keep trying. At least he managed the task and seemed to be satisfied but also a little bit tired.

The third task was to use the mobile device with the software in any context in their leisure time. In order to simulate this Klaus and Murat were allowed to play on a self-defined task in the school yard. Klaus walked with the mobile device around in the yard while he played his favorite lessons on clocks, which he had already solved before. Murat decided on another lesson on weather that works with a lot of pictures. As Murat has problems with language, the system adapted to his language abilities and did not offer him full words but syllabus that he should arrange in the right order. He worked on his task while he played on the swing. Both boys appeared quite satisfied after their mobile learning experiences and claimed this time spent was leisure time it was not exhausting for them.

Generally, the system and its functionalities were easily understood and they managed to cope with the lesson and understand the related tasks. For Murat the system could adapt to his problems. Above all, he could succeed at the assigned tasks.

6.4.1.3 Test with Teachers (Teacher Training)

Over nearly three months every week for two hours we conducted teacher training workshops in which eight teachers from different schools for children with special needs analyzed the concept of IMLIS system and created scenarios with example lessons for their students.

After presenting the basic concept of IMLIS, the teachers were asked to describe example lesson cases. By grouping cases the teachers mapped out their teaching practice on the virtual facilities of the IMLIS system. Through this process on one hand the concept of IMLIS became less abstract and revealed it concrete options, on other hand the teacher found a way to make explicit their teaching experience and to build references on a more abstract level. These references remained individualized to avoid generalized roles nevertheless, these individual references enabled each teacher to decide on a topic that could provide a useful example and chose the related content to build such lessons.

For the teacher's evaluation, the presentation of the concept and idea was important as we sought to evaluate how teachers would adapt this system to their teaching style. For the teachers, a combination of diverse activities was important. Alternate ways of learning needed to be provided. This included a blend of manual activities, sensory activities using touch, sight, hearing and movement. The following aspects were discussed in detail with the teachers.

- Autonomous exercise, easy to organize with a mobile device.
- In a combination of active manual movements, it can connect thinking and abstraction to a real action with the sense of touch.
- Providing contexts during learning activity.
- Binding social awareness through autonomous activities.
- Bringing organizational aspects to learning activities and helping them to develop a more self-determined learning process.
- Creating personalized learner profile.

The above mentioned points initiated brainstorming which led to scenarios for two topics of small lessons for three different levels of disability defined with multiple concepts of use. The learning units were grouped according to targets according abilities and subtopics according individualities of learners. This work resulted in a map that unified diverse use cases. From this wide variety of possibilities, twelve example sub-cases were delivered as abstractions to visualize the options. In these cases, different learning methods with different media units showcased the options of personalization. These

concrete materials and learn scenarios were implemented in the IMLIS system in order to be examined in post-workshops with learners.

With this manageable visualization, the sub concepts like personalization became comprehensible and ideas for possible use cases arose. But this visualization also served as a tool to discuss teaching methods and styles that had been implicit especially where the teacher found a possibility to share their knowledge and experience with each other, as they found a common language to communicate.

Figure 51: Learning material and interaction brainstorming in teacher training workshops, University of Bremen, 2010.

Each teacher is responsible to give regular reports on the learning behavior of each disabled student and his/her development. This always requires considerable time. In order to remember properly, they have to regularly gather the results of the learning process. The idea of a learning curve became more obvious here although there have been many discussions on how exact learning curves according to multiple intelligence can be.

The discussion with the teachers reveals that proper selection of material is not easy, especially if each unit needs to fit to different contexts and combinations. The use and adjusting of personal learning models can be improved to support analytical purposes. Also the creation of learning units can be enhanced. As a secondary question teachers

should discuss copyright and communal use of material. Several workshops and tests indicated there are still challenges regarding how a teacher adapts him/herself to this system and how they learn to use it.

6.4.2 Feedback from Experts and Teachers in Workshops

An important aspect of every workshop is getting feedback from attendees, thus, after every workshop, we directly or indirectly gathered feedback from students and trainers. In some cases, we conducted small interviews, simply asked their opinions or tried to deduct their views from their behavior. We recorded user feedback on the assignments. Sometimes the results confirmed out expectations, whereas other times we received unexpected feedback from user perceptions. For example, the need of learning content exchange coupled with the need of sharing didactical experiences provided unexpected feedback from teachers.

In order to get critical feedback and more detail on remaining problems throughout system usage, we defined a setting for anonymous interviewers. Anonymous interviewer refers to persons not directly involved in the system development and not connected as a user. Questions as a guideline for the interview were stated, that should encourage the test-person to talk about the problems in a useful way. By this mapping of problems and weaknesses urgent tasks for system development could be identified and repaired.

6.4.2.1   Teacher's Mental Attitude Concerning IMLIS Teacher Portal

Whenever the idea of a teacher portal is presented, most teachers were interested, encouraged and interested in how to use it. After an introduction to teacher portal screens, teachers began to doubt the usefulness of the system. Teacher doubt may have resulted because:

- Some teachers are still unfamiliar with digital media or at least they do not feel comfortable using it.

- They believe that they have to spend more time on the process of learning material transformation from traditional learning to digital media learning.

- Sometimes they face different digital media applications which tend to confuse them.

- The teachers are not sure that technology infrastructure would enable or support such systems. They worry about insufficient digital media hardware in schools.

- Some teachers relayed concerns about copyright issues on digital media.

To motivate them to use the IMLIS, we involved them in practical uses which can bridge this divide. They can try mobile devices themselves guided or motivated by an expert only when they become open and do some experiments according to their use

cases. In this effective action they learn the potential of the teacher portal. At least in discussions they stated that this system provides a more detailed and effective preparation of learning materials. The chance to reuse material makes it even more interesting for them. Although a tool like teacher portal can clearly facilitate their work over a period of time, some teachers remain conservative and disinterested in changing their established teaching style.

6.4.2.2   Feedback and Criticism from Teachers and Experts

After each workshop, we asked from the teachers[1] and experts to state their general impression regarding the system, the performance and whether they can use it in their daily work with learners. These feedback are translated from German to English and listed below[2]:

- Mrs. Smith, School Director

> *"For me it is interesting that the system adapts by learning through the interaction. I like that you have to create a profile by supplying basic information and the students can receive individual tasks and exercises in different levels according to their profile.*
>
> *In general I liked the whole discussion today, for example the suggestion that there has to be a distinction between younger and older students. It will be really interesting to see how the students will respond to a presentation of this system. Often for young people it is different than from an adult perspective."*

- Mrs. Meyer, Teacher

> *"Well I like it as well, it is very interesting to understand what can be done with this system. I especially like that this system seems to be self-explanatory and can be used autonomously by the student and the system offers functionalities for checking outcomes - self-evaluation.*
>
> *I am look forward to what will be possible with this system."*

- Mr. Fridrich, Teacher

> *"The co-modeling of the software with a person who comes from the teaching practice with students from this target group should be fostered. The concept, the aim and practical use case should be defined closely with the teachers, or in a language that is more comprehensible.*

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[1] The used names are not real and changed due to keeping the privacy.

[2] As the workshops were done in German language, the citation feedback is translated into English. Most of the original audio/videos are available in attached DVD.

The difference to a database that can be used for exchanging learning material should be more obvious. For specific topics, there are already applications that guide students step by step through the lesson in an intelligent way. What is the difference to IMLIS?

IMLIS, as I could understand is an application that can manage learning material in an intelligent way and that is not specialized to specific topics. There seems to be an immense demand with a huge amount of work! I think there should be a copyright solution, because the outcome of the use of such an application will be better if a community of teachers could share materials."

- Mrs. Müller, Teacher

"I liked it very much, that this kind of system was started, but for me it is important that this approach is not only about minimizing the size so that the device with the application can be carried in a trouser pocket. It should be observed where it targets for this application exists, for example work assignment and job instructions that can be handed down. It was really good to see the example where it was possible to read the barcode of an object and to verify whether I chose the right material.

I would appreciate if the approach would carry on in this direction. Established processes should be reduced to an easy level, so that I can assign an action to someone and it can be done without annoying questions and check-ups.

Furthermore, I would suggest that attention be paid to what is for younger and what is suitable for older students."

- Mrs. Brown, Teacher

"I think it is a really helpful project for our teachers of students with special needs. Of course the implementation or upload of learning materials should be continued. The specific opportunity of this system is that we get a detailed view on the abilities of a student.

I think that it might be not easy to create or find learning materials for students with multiple disabilities, so I think that it will take time to implement these materials. For students with small learning disabilities it is a really good challenge and for this group we have enough learning materials to be implemented (uploaded).

I am convinced that it can be used for guided activities and for training units. For me, the personalization is the most important aspect. The expe-

rience how this system adapts to individual needs is interesting. For the implementation of additional learning, material time and effort are necessary."

- Mrs. Clark, Teacher

"Today I understood what this system is all about and how it works. For me it is important, that every time a student will finish the work with an exercise, another exercise from the next level will be provided to him or her.

The preparation of the learning material will be done by the teachers, so that there will be a differentiated offer, implemented in the program that allows variations. This important aspect refers to the diversity of our students! I suppose that this media can motivate and support our students."

- Mr. Bergman, IT administrator in school for people with special needs

"I got the impression that the system provides a lot of possibilities that can also be extended for different needs and contexts in classroom. For the setting in current schools we should discuss if this system should focus more mobile devices or a broader variety with stationary computers that will fit more to the current situation of technical equipment in schools.

In general, we can state that the teachers and experts could use and understand the system. In practical use they could comprehend what can be done with the system and what are the potential and requirements in use. Because of their practical involvement, they agreed that a learning system should be developed closed to teachers and their experiences. Nevertheless an adult perspective cannot be replaced the tests with students.

A second focus of their feedback aims the content upload functionalities of teacher portal and preparing learning material. Some state opportunities for managing content and some state that for practical use additional questions like copyright for exchanged material or even used images should be solved. Some stress on the need of creating material that should be conceptualized simple and time saving. Most of them agreed for use cases in their daily teaching practice because they see that IMLIS has the potential to be adapted to the classroom teaching.

6.5   Usability Tests

In order to understand how users can access the system and to gather information on the system usability, a combination method from "Thinking-Aloud" [Nielsen-1 1993:195] and "Informal Walkthrough" [Nielsen and Mack 1994:125] methods were used. This combination is adapted to the specific context of teachers and learners. An important part of the system development was a sequence of usability tests [Rubin and Chisnell 2008] with teachers. In a first discussion for a broader teacher group, an overview on the IMLIS was provided and according to a prepared list, the expectations were gathered.

In order to involve them and to design a participatory development process, the usability tests were combined with discussions. As we aimed to learn what they think throughout the tests, we built small groups each with two teachers asked them to work together, and to perform the tests in a collaborative process. The paired teachers started the tests with arguments and discussions during the test. These discussions were recorded with their actions on the screen. These recordings were a good source for the refinement of the system. Often in the discussions the teachers gave us hints and solutions for the tasks of the next usability tests. To create the groups, we tried to select the teachers in a way that a person with more critical expectations of digital media works with a person with more positive expectations of digital media. We observed that the interaction between the teacher who was more critical and the teacher who was more positive in relation to technology, positively affected the quality of the feedback.

In the usability tests, the teachers first took the role of their students and tried to deal with mobile client basic functionalities on different devices to evaluate the screen design and UI templates. Then they tried the teacher portal for administrating and creating learning materials. In this stage, the focus was on teacher portal functionalities and efficiency of user interactions. Later they performed usability tests on learning lessons and the integrated tests within the system. Here they also focused on navigation and comprehensibility of the interactions.

For the evaluation workshop with the disabled students, we faced a problem that users often verbalized what came to their mind and every emotion that they felt, but they were not normally used to formulating their thinking process. We discussed this problem with the teachers and disability experts. First, we thought of using pictures to foster this mental effort and get feedback from drawings and talking about the drawings. But the teachers suggested selecting a smaller group that is able to verbalize thinking, mainly moderate learners with stronger language skills. With teacher help, small groups of students that knew each other were formed. This arrangement was to reduce emotional stress so that users felt comfortable to speak.

For the test, a workshop with different steps was developed. In the first step, the system was explained for them in an emotional atmosphere. The mobile devices were shown to them and the learners could share their own knowledge, expectations and emotional meaning concerning mobile devices. In the second steps, the learners were divided into small groups each with two participants and assigned roles. One learner had to use the software to solve a small problem and the other was asked to figure out what kind of problem the other student tried to solve. The first student was to verbalize what he thought and the second student was allowed to ask whenever he could not understand what the first person said. By this setting the first student got motivated to keep verbalizing meanwhile the other student asked what he was thinking and doing.

During this process the testing student was recorded with a video camera. Afterwards we asked them to draw with our help what they understood and how the system works. The overall group and the support person commented on these drawings. Through these actions we got indications which interactions worked, and what was unclear. In the next step, with a teacher, we further analyzed the video recordings from the student during the software test in order to relate these outcomes to the indications. By the process of usability test and refinement, it became obvious that from these actions we could reduce usability problems. The usability tests with school teachers and students forwarded us the following results:

- A sequence of small tasks is manageable for the learners based on their stamina and motivation.

- The system supports "joy of use".

- The system navigation is comprehensible and the user does not get lost.

- Teachers still have problems understanding the teacher portal, especially on metadata administration.

- The adaptation of the system and personalization to the learner's behavior supports them to keep learning in a better way.

- The system still needs a better UI design.

- The implemented interaction templates are understandable and could be extended more.

- The audio announcement during the learning process was useful and kept the students from being distracted from the environment.

In the usability tests, not only teachers but also school and IT administrators attended the workshops and compared this system to the e-learning systems that they already use in school.

7 Discussions, Conclusion and Future Work

This thesis has described the conceptual framework and architecture of IMLIS approach with all its advantages and challenges. The focus of this research was to build a sufficient, adaptive and extendible model implemented on system architecture designed to analyze personalized learning via mobile technology. The research features practical use cases and iterative tests of the complete model.

This chapter sums up the dissertation and provides some conclusions and major findings from the results of this study as well as merits for future research arising from this research. It also highlights the strengths of IMLIS and includes criticism of the study.

7.1 Results and Discussions

7.1.1 Discussion and Assessments

This thesis has presented the analysis and requirements for the implementation of an intelligent mobile learning interaction system (IMLIS). The basic aim was defined for a model of personalized mobile learning for the mentally disabled, coupled with the development of a prototype. The analysis of a decision engine for learning process personalization, learning content preparation by teachers, and transformation from traditional learning to a mobile learning approach were examined.

IMLIS can personalize the learning content and interactions according to the learner needs. This system can take the role of a flexible companion that included in the daily life of a mentally disabled person. As a kind of tutor, it guides the learning experience of the person. By an embedded situated help system, the users are encouraged to face new tasks with higher degrees of complexity based on their abilities. Prospectively, this virtual supported reliability could foster their autonomy and independence from advisers.

IMLIS prototype has been successfully implemented on different mobile devices to support personalization for promoting the learning abilities. Several workshops and experiments conducted by our researchers indicate that this system provides an efficient and effective personalized learning method for the mentally disabled. These real context interactions with users and their teachers also brought forth the challenges facing this learning system.

Mobile Learning

Mobile devices are valued objects of everyday life especially for young people. In the workshops with the mentally disabled, it was very clear that for most mobile users a device represents connectivity to society. Seeing the device as something "cool" or as a symbol representing membership to society strongly enhanced user motivation to learn with a mobile device.

The mobile learning system offers the possibility for contextual learning as it is mentioned in literature "learning across context" (section 2.3.3). This contextual learning enables it to reduce abstraction and provides a direct connection from theoretical knowledge to real situations and context. As an example, in our post-workshops, the students learned a lesson concerning weather via mobile devices. Indicators from this use of mobile technology outdoors improved the learning results. From this experience,

support for the hypothesis that "this situated and contextual learning offers possible use cases for guided learning also in work places."

Initial mobile learning projects attempted to focus on use cases developed in specific communities of young people. An example is Flocabulary, where vocabularies are combined with Hip-hop music[1]. This combination motivates most young people and support recall of the provided content. Thus, the well-known idea "making use of the use of media" is forwarded through this technology application. Other projects experiment with cartoon stories and storyline concepts across a game-like an application. Mobile learning should be situated in mobile cultures of communities that use mobile devices, as mobility is increasingly becoming part of culture.

Mobile learning also can support and facilitate the work process and in a way guide to comprehension and reduce the mental complexity. For learning in the workplace, the viability of knowledge is important. In this context, and in a learner-centered design approach, learners with their needs participate in the design of the application and the structure of the learning modules. An important aspect is the adaptive abilities of the software. IMLIS supports the learning process by adapting to the specific problems inherent in the process. The criteria of this adaptation is on one hand developed by the ability of the user to become his own active agent in his learning process; on the other hand, for a self-determined process, the application should give orientation that makes the process meaningful to the learner. Adaptation is immensely important for mentally disabled learners because they often experience problems with orientation and navigation (according to discussions on chapter 3). This kind of mobile learning systems encourages "learning by doing and for doing". Knowledge and learning activities should be integrated into real work situations; this often means using scenarios that enable real contexts and supporting users to solve the exercises.

For mobile learning a further aspect of a current trend is noteworthy. This suggests that media content becomes increasingly fragmented, and reduced in size in order to be recombined and re-contextualized. These small units of content can be used for short intervals of learning activities. During the learning process the particular elements demand a connection to other elements of knowledge, for example to be combined with exercises. This fragmented kind of structure asks for a relation between the steps of the learning process so that in the recombination of several steps a broader understanding can be reached. So the design of the progression of the elements becomes a topic of the didactical model. In the design guideline, building small, clear and well-structured units with motivating aspects needed to be established.

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[1] Flocabulary: Hip-Hop music in classroom. http://www.flocabulary.com

In e-learning, knowledge is distributed into small modules which can be adapted to user needs and reused in different contexts (in such cases, e-/m-learning standards like SCORM can be used). These units should support the presentation of knowledge, the instantaneous application of knowledge and make it memorable. The goal in e-learning is for these units to be used according to the needs on one's own learning path. In this way e-learning can bridge formal and informal learning. The media should motivate and focus the learner attention because it can extend the user's field of experience. Mobile learning in particular can foster this notion.

To sum up, mobile learning develops new concepts of learning in contexts with respect to individual needs of their real life. Physical, mental, emotional, cognitive and cultural aspects each aspect differently influences these needs. The power of mobile learning allows the learner to participate in an entire cycle of work processes that can be learned in real contexts or contexts that match the learner needs.

Why mobile learning for the mentally disabled?

During several presentations and talks on IMLIS model in scientific conferences and discussions with system developers, questions about and the reasons for choosing mobile technology for the mentally disabled were posed. According to the observation during the workshop series in this study, the following indicators lead to this choice of research focus:

- **The mobility of contexts**: which enables exercises whenever cognitive performance and emotional engagement is strongest. A device that can be started immediately on demand nearly anywhere provides the possibility for learners to use it wherever and whenever they need support.

- **Accessibility to mobile technology:** Today most students with cognitive disabilities have a mobile phone which can be regularly used for emergencies and to organize their daily support.

- **Attractiveness:** The mobile device has an appealing image for this target group. Their interest in the "new and perhaps cool toy" increases their willingness to solve difficulties experienced during use.

- **Media literacy of a technology as part of their life:** While students already know how to use mobile devices because they are part of their everyday life, however, the use of mobile devices for learning purposes tends to increase their understanding of this technology. During the workshops the participants became increasingly curious about the technology behind their devices. In a setting where there is increased interest, learner understanding can be enhanced and the use of mobile media in daily life can be developed.

- **School bag tool:** Mobile devices can easily be integrated into their school bag taken everywhere. This adaptability allows greater use in a variety of contexts. Smaller size, decreased weight and lower costs make user access to these devices increasingly possible.

IMLIS Model

As a mobile learning system, IMLIS can be used any time and in any location according to learner needs. Based on chapter 3 discussions (section 3.6), for the mentally disabled, self-regulation and self-organization is often difficult. At the beginning, IMLIS acts more like an assistant and over a longer period of use in learning sessions, it begins to support and evoke development of the self-regulation. Through the learner's own interactions and "self-regulation" the device begins to make learners more autonomous. An advanced learner can decide to create his own learning timetable, if the teacher agrees by "checking the teacher portal". This means that learners can control how often they want to study a specific lesson or practice a specific exercise.

The tests tend to become increasingly self-evaluating by offering a simple visualization during the learning process. Through these functionalities learning autonomy is fostered and the self-assessment and skills of self-regulation can be developed. Physical mobility that is based on the mobile device's physical qualities supports also mental, cognitive and social aspects of mobility. Mobile learning also enables specific social community within a specific culture.

The model of learning process in IMLIS can be extended to a learning context where students and people with cognitive impairments can independently solve their tasks by interacting in a community. However, the first step focuses on guided problem solving of given tasks through observing a predefined process. Although choices are implemented whenever they are possible, the major learner decisions involve situated learning anytime, anywhere. The version of the use cases and the implemented model do not support independent project work, but this possibility may be included in future versions. The immediate contribution is a model of a system that supports personalization on different levels.

The creation of a successful application based on this new kind of didactical approach, used scenarios built in collaboration with the teaching staff to guide learners with the application in different contexts. Especially for learners with mental disabilities, this becomes more prominent and highlighted. During this study, a teacher-training curriculum was conducted for designing scenarios and content for real work contexts in schools.

Personalization in IMLIS

This study focused on three aspects: 1) A contribution to the empowerment of the mentally disabled, 2) Findings on understanding the media specification of mobile technologies, and 3) The combination of the mobile technologies with the needs of the disabled based on personalization. The personalization model in this study has three stages:

- **The first stage** is a profile and ongoing monitoring of the learner activities, whereby the system adapts itself to learner behavior and current ability level. This adaptation is modeled according traditional learning whereby teachers focus on adapting and supporting learners. In this case, personalization serves as an empowering assistant or support system.

- **The second stage** is where IMLIS identifies the incorrect content metadata in the system and suggests appropriate metadata and usage level. For example if learners are asked the same question 30 times and 95% of the total results are incorrect, this indicates that the question is not tagged with appropriate metadata. Therefore, the system sends an automatic message to teachers via teacher portal to improve the metadata and usage level.

- **The third stage** offers teacher interventions and learning process planning in teacher portal; learners receive lessons and content that challenge them according to their own profile which is developed and completed by the sequential use of the system. The 3D learning progress curve helps teachers to recognize the weaknesses and potential abilities required to strengthen the learning process.

The monitored learner behaviors can be analyzed according to different learning patterns. The system can use different patterns and will recognize which one is suitable for a specific learner to promote better performance. The successful learning patterns can be reused and enhanced for subsequent learning sessions. In addition, via teacher portal, different possibilities can be added to the criteria of a learner's profile, such as race or gender.

The interaction feedback and motivating audio files can be selected from a list of predefined templates or can be manually added by the teacher. This choice may be considered similar to the well known exchange of mobile phone ring tones. In addition, teacher portal supports visualization preview from the content which allows teachers to directly see the output-learning page according to content preparation. This can help them better orient students and prepare learning processes.

Personalization, an important aspect of IMLIS, appears to serve as a formalized mentor that provides learning strategies to the user and in this way personalization can also be considered a contribution to the Feurstein model (discussed in section 3.6.1) concerning cognitive development.

Accessibility

Beside these results mentioned, the system contributes to a broader concept of inclusive design and usability of mobile devices. The focus of this study is the interaction model for personalization. For a learning system that can support learners with cognitive disabilities, other system development aspects should be covered. These aspects are screen design, simple language and accessibility (barrier-free[1]). For accessibility well-defined guidelines exists. Aware of accessibility concerns, the study included teacher insight into the meaning associated within their school context and how learning could be combined with inclusion. This study concentrates primarily on personalization and simple language in its design.

The aspects of screen design and barrier-free design can be considered an extension of a next level for the personalization model. This is an area for further research, as the structure of the IMLIS system with templates for interaction and behaviors can be tailored to specific cases of design requirements with specific activations of barrier-free design. This forms the basis for personalized layout and design. Disabled people may have multiple disabilities; therefore the supporting design will vary according to individual needs. With respect the wide variety of possible user needs, an overall barrier-free design may not be able to effectively serve a multitude of needs.

7.1.2 Challenges and Criticism

At first, the system seems limited and abstract. The broad potential of this tool directed great efforts to build the system by adding extensions. The system seems manageable to understand as many concepts unify several levels of diverse needs and functionalities. This abstraction is difficult to discuss with teachers. While it was possible to discuss the concept through use cases, representation in a language for teachers would be more useful.

Teachers need to be able to easily recognize possibilities to implement the tools into their practical teaching. During this study we encountered numerous challenges. For the real implementation of this system in schools, the process needs to be consolidated into these actions:

- Limited functionalities of the current generation of mobile devices

    o Example: The limitation in screen size and precise handling for people with disabilities, or limitations of the processor.

- Complexity in learning situations of the mentally disabled.

---

[1] In German: Barrierefreiheit

- o Example: At the moment the system is modeled according selected use cases. But the interactions between different classmates with diverse needs and levels in an inclusive classroom and the diversity of cognitive impairments and developmental difficulties coupled with physical disabilities and emotional needs demands for the adaptation to an increased complexity in a variety of learning situations with respect to other kinds of learning without digital media (games with physical movements, and by using touch).

- Difficulties in UI implementation with respect to the needs of the mentally disabled.

    - o Example: The UI is still not precisely designed to the specific needs of learners with cognitive disabilities. For a broader use in schools a separate development of a personalized barrier-free screen design is needed.

- Limitation in different mobile devices for testing of prototype as well as using in workshops.

    - o Example: The lack of unique standards for mobile operating systems and embedded software.

- Presenting the use of the system through easy to comprehend examples with real materials and students. This might be accomplished through the use of commented case study videos with real students.

    - o Example: A well-developed help system with tutorials would be needed. e.g. a collection of sample use cases with typical learning tasks and completed with case study video sequences.

- Building a web-based community of teachers that support each other by regularly generating and uploading learning units.

    - o Example: During the workshops, approximately 80 percent of teachers were in favor of more intensive web based cooperation.

Information management developed specific methods and systems for classification of information. Systematic approaches often use taxonomy which demands precise regulations and conventions. In social software projects categories are developed by the use of a community, *folksonomy,* a product of a social process where the meaning is created by use. In the IMLIS precise and exact information is needed to reach a high performance personalized learning system. From one hand a personal profile should be generated based on different criteria, and on the other hand each element of the learning material has to be tagged with meta-information. Although the system monitors the learner his-

tory and behaviors to update the learner personal profile and meta-information, but it also takes time for such kind of personalization.

Based on discussions with teachers in workshops, in Germany students with mental disabilities are individually tested when they begin school. Each student's written profile based on categories and information according psychological and disability standards could be the basis for the IMLIS profile to be created by a teacher or tutor or alternatively a small test from the system could generate profile information.

In teacher portal, the learning content can be uploaded and tagged with criteria concerning three main levels of development, restrictions, and cognitive disabilities. Teachers may detail information concerning categories, or add their own criteria. This functionality supports teacher needs to precisely define personal requirements according to which kind of disability or appropriate element to be used. Often teachers start by distinguishing between three levels of mental disabilities (mild, moderate, and severe) and then they add more detailed information.

Categorizing students presents challenges because teachers tend to hesitate entering detailed information and sometimes sensitive criteria about their students. Defining the criteria for a learner as well as learning materials metadata takes considerable time and workload and generally teachers prefer not to define detailed criteria in advance. They attempt to keep distance from such detail. The need for detail can be considered as a limitation of the IMLIS approach. However, teachers strongly support the need for formalized criteria to be respected by disability experts. This consistency makes it easier for people to share learning material and experience. In addition, it can generate standardization and harmony amongst teachers. Contrary to this point, teachers have difficulties to integrate this task of uploading material in their everyday workflow. Often such extra work is difficult and educators have few resources to accomplish material preparation during their paid work hours in schools or educational organizations.

Contradiction to constructive learning

Constructive learning favors problem oriented and self-determined actions within an open environment. Often learning activities for the mentally disabled use clear and guided training units. The basic arrangement starts with a training oriented design that evolves towards an open environment for growing autonomy.

During discussions with teachers from special education for the mentally disabled, the teaching methods according the needs of a learner in inclusive didactical environment were discussed. The current situation in Bremen schools is more or less based on concepts of integration, which aim to adapt to inclusive models. Teachers stated that there

is often a situation that overcharges the capacity of the learner. For this, certain guidance should be enabled to foster stamina in facing difficulties.

For the mentally disabled, autonomy is initiated through more self-determined exercises. This step is seen by most of the teachers as a step that fosters self-confidence. Guidance implemented in a learning system is continuously blurred by the increasing autonomy of the user; this is according to implemented rules that provide orientation. This includes supporting arrangements for each individual according to their own needs predefined by the teacher. In further developments of IMLIS, growing autonomy is targeted especially by extension of social network functionalities; in this way the potential for autonomous actions for communication purposes can be fostered.

Data Privacy

During a learning process, each learner has to divulge considerable personal data. Only with this data can the system build continuously updating individual profiles. Even though most institutions have already gathered detailed information concerning a specific student. The concept of inclusion implies to recognize the needs of a student according to current context and not a profile. Furthermore, the teacher has to work with profile data to arrange the learning materials in teacher portal according the needs of each student. The need for privacy and the need to work with profiles may be contradictory. In order to deal with these contractions, IMLIS asks the user or the tutor to use symbolic names that can be easily recognized as the user because they are related to a nickname (some traditional institutions already use these kinds of visual images: nicknames like tiger, rose or dolphin). The tutors and teachers have to very precisely and confidentially deal with symbolic user names to protect individual privacy and learner data.

Certainly, the teacher needs to know the symbolic names of each of his students, but the teacher also has to build a class environment that protects students with cognitive disabilities from revealing their virtual identity. In discussions with school leaders, it was recommended that teacher and tutors attend tutorials on gaining access to the system. In such kind of systems, teachers, tutors and administrators should agree to sign an agreement for the protection of data and to guarantee user privacy.

Digital media compared to instructor lead teaching

Good personal relationships between a teacher and the student can strongly motivate learners. Social interactions in groups and the relationships to other learners can also have a major influence on fostering learning. While social aspects and cultural modernization influence the development of digital media and contribute to virtual communities and communication tools and a mobile culture, face-to-face communication can not (and should not) be replaced by digital media. Human compassion and empathy together, contribute to community and learning. Rather, the combination of diverse media, including digital media and real social interaction can provide a modern environment that foster learning and solutions to problems.

Of course the social network aspects of digital media can enhance communication especially if networks combine with real social interaction. For some people, digital devices allow them to participate in society. Beyond this participation, digital tools support actions that need continuous training and repetition. For these actions, digital tools offer possible support that may be considered better than help from a person. In a context of digital media with social interaction, the technology can support education that targets individual development.

If autonomy is the goal, accomplishing the assigned tasks independently on the learning device may be the best way to achieve the desired outcome. The potential of digital media is to train some basic cognitive abilities and to provide communication tools that become meaningful in a real social context. In this way, learning systems are a helpful extension of real classroom learning that cannot replace basic social relationships and learning social communication but these devices can foster communication when combined within a community.

Although the system needs to be further developed to create learning activities and units for a single use case, it appears to become increasingly effective with regular use and updates of learning content throughout learning sessions; especially if a broader community of teachers regularly uploads learning materials. In this way, a personalized content network and a social community (mentioned in section 5.8) were created between teachers, which was an unexpected result from IMLIS approach.

7.1.3 Consequents and Generalizations for Personalized Mobile Learning Approaches

The methods of learning shifted from traditional learning to learning via digital media devices in the last decade and still this shift is moving toward mobile technology. This technology offers new and advanced opportunities for both learners and teachers to access information when needed. In the interim, additional features like interactions, personalization and adaptation are added to learning processes.

Coming generations of learners will surely interact more with mobile technology. The IMLIS is intended to provide an independent learning process for the target group on mobile devices to support each learner with specific and personalized content to learn independently. This independence can also apply to workers who learn directly in the workplace.

By a complex process, a mobile learning system for the mentally disabled was built that enables personalized learning that is managed by teachers for their learners. In order to meet the needs of the teachers and students, a system that provides a standard of learning media embedded in a workflow that follows a appropriate learning method. Also the analysis of the learning practice and behaviors were a major part of this research effort. Through a recursive chain of workshops and implementation activities matching models were developed.

This process focused on the development of specific lessons for specific students. This practice requires models that enable the system to provide personalized material. Based on this, personalization became and the primary focus of the study. The prototype of the IMLIS had to be constructed in a way that it is also enables interactions that supports and evokes perception for implicit practices in order to externalize and generalize these perceptions. According to the diversity of the individual practices, the system needed to provide interactions that could also be personalized. Next, the implemented model of personalization with its functionalities evolved into a system that constantly refines the personalization of a specific learner by self-evaluation and self-monitoring. The broad contribution of this research is a model of wider scope of personalization coupled with a process model for the design of a concept for specific personalization according to a given context.

7.2 Conclusion

IMLIS presents a model of personalized mobile learning for the mentally disabled. This model is still under development. It enables specific quality of interactions and meeting the needs of inclusive education. Also the opportunities of mobile technology present a major challenge for the further development of inclusive teaching scenarios based on a combination of mobile media and real classrooms.

The development consists of several iterative steps evaluated with tests and feedback. In the basic system, a database with decision engine connected to templates, patterns and the learning data were designed and mobile client was built. The evaluation process started with a first range of learning content. The evaluation was designed in order to foster autonomous and work access in the real work contexts. The main focus of the evaluation is in which way the system adapts to the needs of learners, the functionalities, and the usability. The contribution of the overall research during the development of IMLIS is presented in five aspects:

- **Technology**

  An approach to learning process based on mobile technology was implemented and evaluated. Mobile clients were connected to a decision engine supported by a learning material database and integrated in a mobile server. This enabled a specific learning setting consisting of mobile learning modules that support learning activities.

- **Personalized Learning**

  With an extendible model of the complex learning interaction and material feeding during the learning, the process adapted to the current profile of the learner which resulted in personalized reactions from the system for the individuals. This concept enabled subsequent implementations in diverse contexts for target groups.

- **Development of different digital learning material interactions**

  Different types of personalized interactions in 12 categories were designed and evaluated with help of experts and teachers in several recursive sessions and workshops. The migration of interactions from traditional learning to interactions via digital media was discussed and tested.

- **Learning management that foster the curricular work of teachers for the mentally disabled**

   The process of creating personalized learning material by teachers that fit to the need of curricular, context and individual profile of a specific learner, was analyzed. Specific steps and factors were conceptualized and put into the design of IMLIS teacher portal. Teachers and instructors were able to manage and monitor the learner's activities via teacher portal and plan for their learning process based on personalization strategies.

- **Mobile learning for autonomous routine practice**

   In several evaluations of small tasks, the learner autonomy during the learning process was examined in real situations. The feedback settings were developed so that with a mistaken profile the system could adapt autonomously to the actual specification of the learner.

The domain of research was defined based on personalized learning and the need of active connection to real contexts for learners with mental disabilities involved in an inclusive school environment. The research concentrated on material suitable to the needs of a specific learner, therefore, a specific learner profile and each element of the learning material needed to be identified.

Field research and discussions with teachers informed the selection of the main personal criteria. Because of the share volume of possible combinations between defined criteria, a model for patterns of learning units were developed. In a recursive feedback process, this model was defined. And it became clear that an interactive prototype for the system should be conceptualized to provide models of interactions and system behaviors. With the help of teachers, these interactions and behaviors were adjusted and modified to accommodate the ongoing learning process whereby the prototype housed the media and selected teaching practices suitable for the specific target group. Through guided use cases with this system, teachers were able to describe and compare their process related to preparing lessons for a specific learner with the implemented behavior of the system. In extension, developers can use this context to find clues for generalization of highly personalized and diverse processes.

This generalization is not only important to model the system, but also useful in communicating and exchanging learning materials amongst the teachers. During group discussions in workshops, disability practitioners could review teaching practices and reflect on their own methodology support other teachers. At the beginning of the study, the system focused on the personalization of the learning material, but towards the end of the research it became apparent that one of the most important findings could be con-

sidered the intelligent system adaptation to the teachers' practice contributing to greater support for their work.

At one point in the learning sessions, the system not only provided personalized learning material for the learners, but it also indicated the learning behavior and learners success which was monitored and reported back to the teacher. These findings suggest that IMLIS has the potential to offer a sustainable learning process with respect to the abilities of individuals.

It is expected that in the coming years, with the growth of mobile technology, new changes will arrive to revolutionize mobile learning. Such changes may address some of the challenges mentioned in this study. Proposed future improvements to mobile devices would not only serve learners, but would also support teachers and instructors in their need to easily publish and manage learning content via mobile devices.

This thesis discussed research from, literature reviews, case studies, reverse engineering and personal achievements related to a personalized mobile learning system. The full version prototype software and the video recordings from workshops are available in the attached DVD.

7.3   Future Work

A considerable amount of time was dedicated to technical research and information gathering for IMLIS development, applying personalized learning, modeling the interactions with the mentally disabled, and writing the results for this thesis. However, there continue to be unanswered questions and unresolved problems regarding this topic that require further work.

With convergence, mobile devices merging together and provide improved capabilities. In future, these more powerful generations of devices will provide better opportunities for learning process with their superior functionalities. The strength of IMLIS is in its personalization function. It adapts itself according to the learner behaviors. This potential can be extended in future with the help of new personalization algorithms.

Sometimes learners manage problem unexpectedly fast and quickly become an expert able to help other classmates to accomplish their own goals. This person might create a visual or audio-visual help-description of his accomplished task. Improving the communicative functionalities and social self-determined mobile activities will be a challenge for future. Thus the target group might form communities that can explore their world together. In different contexts, further research could focus on consistency of learning content for mobile screens. Mobile learning has an extremely large scope and able to address different areas with various target groups.

To better classify learning material criteria, and uploading via teacher portal, and in order to refine this system in future, some research with teachers and experts was accomplished. The daily routine of teachers was analyzed. It may be understood that a system, which can provide facilitation in the field of uploading learning content, should simulate the task of uploading and composing a lesson for a certain person with a specific profile. So the elements do not get direct information, they are linked to a personal profile and an element gets tagged. Through use and reuse in other lesson an element gathers taxonomic information that is a product of a social process. This kind of a workflow for constructing a learning folksonomy should be worked out and developed in the future.

The aspect of giving the learner's ownership or leadership in the process of personalization can be fostered and the system can support the work in teacher portal by personalization. For this aim, a kind of profile will be developed that knows which kind of material for a similar target group will be needed from each teacher. The profile also can recognize the adjustment of the screen and workflow of specific favorites of a teacher. The teachers get the opportunity to adjust the functionalities according to their own needs.

The teacher portal can be further developed to a specified desktop for designing and organizing learning units and learn processes. A library with styles of exercise and guides enable to design complex adaptable lessons. The criteria on personal profile of the learners and the meta-information of the learning material can be extended in multiple layers with other sub-criteria, that enables to decide when and under which conditions these criteria should be used. In specified area with additional specified options, the teacher can analyze the learning profile of each learner in order to evaluate the problems, find out at which time the learning abilities are stronger and when learner needs breaks and extra support.

The teacher can add new high-leveled interactions tagged with metadata according to criteria for advanced learners. From the other side, the advanced learner can decide for taking leadership of his learning process and can arrange his own approach. Afterwards the system interprets immediately the learner's behavior and feedback and adapts itself to the new approach. The annotations and evaluations of the conducted workshops made clear, which aspects should deserve particular attention and reviewed. At least the advanced learner can take responsibility for other learners by adding helpful information to the existing materials. Learners can gather this information via voice recording annotations or pictures captured by integrated camera in mobile devices.

Appendices

Appendix A: World Health Organization ICF and ICD-10 Tables

Appendix B: IMLIS Highlighted Parts of Source Codes

Appendix C: Screenshots from IMLIS Prototype

Appendix D: List of Publications on IMLIS

Appendix E: Project Material DVD

Appendix A: World Health Organization ICF and ICD-10 Tables

Below is a list of ICF components, domains and qualifier codes from world health organization (WHO) that helped us for the prototype development.

ICF Codes

Table 1: The ICF Components and Domains (World Health Organization, 2001).

ICF Components	ICF Domains/Chapters (First Level Codes)
Body Function (b)	**b1** Mental Function
	b2 Sensory Functions and Pain
	b3 Voice and Speech Functions
	b4 Functions of the Cardiovascular, Hematological, Immunological and Respiratory Systems
	b5 Functions of the Digestive, Metabolic and Endocrine Systems
	b6 Genitourinary and Reproductive Functions
	b7 Neuromusculoskeletal and Movement-Related Functions
	b8 Functions of the Skin and Related Structures
Body Structures (s)	**s1** Structure of the Nervous System
	s2 The Eye, Ear and Related Structures
	s3 Structures Involved in Voice and Speech
	s4 Structure of Cardiovascular, Immunological and Respiratory Systems
	s5 Structures Related to the Digestive, Metabolism and Endocrine Systems
	s6 Structure Related to the Genitourinary and Reproductive System
	s7 Structures Related to Movement

	s8 Skin and Related Structures
Activities and Participation (d)	**d1** Learning and Applying Knowledge
	d2 General Tasks and Demands
	d3 Communication
	d4 Mobility
	d5 Self-Care
	d6 Domestic Life
	d7 Interpersonal Interactions and Relationships
	d8 Major Life Areas
	d9 Community, Social and Civic
Environmental Factors (e)	**e1** Products and Technology
	e2 Natural Environment and Human-Made Changes to Environment
	e3 Support and Relationships
	e4 Attitudes
	e5 Services, Systems and Policies

Table 2: The ICF Qualifiers (World Health Organization, 2001).

Components	**First qualifier**	**Second qualifier**	**Third qualifier**
Body Functions (b)	Generic qualifier used to indicate the extent or magnitude of an impairment	None	None
Body Structures (s)	Generic qualifier used to indicate the extent or magnitude of an impairment	2nd qualifier used to indicate the nature of the change in the respective body structure	3rd qualifier used to indicate the location of the structural impairment
Activities and Participation (d)	Performance (Generic qualifier) used to indicate the level	Capacity (Generic qualifier) used to indicate the level of	None

	of performance in the person's current environment	ability in the standardized environment	
Environmental Factors (e)	Generic qualifier, with negative and positive scales, to denote extent of barriers and facilitators respectively	None	None

Generic qualifier

0   No problem

1   Mild problem

2   Moderate problem

3   Severe problem

4   Complete problem

8   Not specified

9   Not applicable

First qualifier for environmental factors

.0 No barrier + 0 No facilitator

.1 Mild barrier + 1 Mild facilitator

.2 Moderate barrier + 2 Moderate facilitator

.3 Severe barrier + 3 Substantial facilitator

.4 Complete barrier + 4 Complete facilitator

.8 Barrier, not specified + 8 Facilitator, not specified

.9 Not applicable + 9 Not applicable

Table 3: International Statistical Classification of Diseases and Related Health Problems 10th Revision

Chapter	Blocks	Title
I	A00-B99	Certain infectious and parasitic diseases
II	C00-D48	Neoplasms
III	D50-D89	Diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism
IV	E00-E90	Endocrine, nutritional and metabolic diseases
V	F00-F99	Mental and behavioural disorders
VI	G00-G99	Diseases of the nervous system
VII	H00-H59	Diseases of the eye and adnexa
VIII	H60-H95	Diseases of the ear and mastoid process
IX	I00-I99	Diseases of the circulatory system
X	J00-J99	Diseases of the respiratory system
XI	K00-K93	Diseases of the digestive system
XII	L00-L99	Diseases of the skin and subcutaneous tissue
XIII	M00-M99	Diseases of the musculoskeletal system and connective tissue
XIV	N00-N99	Diseases of the genitourinary system
XV	O00-O99	Pregnancy, childbirth and the puerperium
XVI	P00-P96	Certain conditions originating in the perinatal period
XVII	Q00-Q99	Congenital malformations, deformations and chromosomal abnormalities
XVIII	R00-R99	Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified
XIX	S00-T98	Injury, poisoning and certain other consequences of external causes
XX	V01-Y98	External causes of morbidity and mortality
XXI	Z00-Z99	Factors influencing health status and contact with health services

Appendix B: IMLIS Highlighted Parts of Source Codes

B1 IMLIS Client Source Code

B1.1 Mobile Client

Main Classes

Class	Description
Package *Canvas*	Includes the interfaces for representation of interactions or presentation of materials
Client.java	This is the main class for all processes of the client. The additional classes are needed for the specific visualization or to assist the processes of the main class.
DisplayCanvas.java	Display of images, videos, and simulations
ImageToAudioCanvas.java	Interaction to find an image for the appropriate audio announcement
SetDigitalWatchCanvas.java	Interaction for setting a digital clock
SortLettersCanvas.java	Interaction for sorting of the alphabet letters
WordToImageCanvas.java	Interaction to find a word to a picture
Package *Main*	This is a package for sub classes that enables parsing XML-files and for the access of the data that is provided by these XML-files.
CategoryModule.java	Provides information about a category that is selectable
CategoryObject.java	This class has the individual modules of information for the categories
PatternModule.java	Provides information for the visualization of a pattern section
PatternObject.java	Consists on all modules of pattern that builds this spe-

	cific pattern.
XMLModule.java	Contains information about an object which should be displayed
XMLObject.java	This object includes all information according the specific material that should be presented depending the XML- modules.
QuestionObject.java	Contains all information about a test
CategoryCanvas.java	Display the selected categories

Answering the tests:

- Creating of the requested URL

```java
/**
    * Beantwortung eines Tests
    */
   public void answerTest() {

    //Erzeugen der URL mit ID des Tests und den gegebenen Antworten
    String url =
URL+URLEncode("antwort?name="+sUsername+"&pass="+sPassword+"&id="+sQuestionsID
);
    for(int i = 1; i < nNrOfQuestions+1; i++)
    {
        url += "&quest"+i+"="+((ChoiceGroup)questChoiceVEC.elementAt(i-
1)).getSelectedIndex();

    }
```

- Transmision of URL to the server application

```java
    try {
        HttpConnection hc = (HttpConnection) Connector.open(url);
        hc.setRequestMethod(HttpConnection.GET);

        InputStream is = hc.openDataInputStream();
        int length = (int) hc.getLength();
        byte[] data = new byte[length];
        int total = 0;

        while( total < length)
        {
            total += is.read(data, total, length-total);
        }
        is.close();

        testForm.deleteAll();
        testForm.removeCommand(submit);
        testForm.addCommand(exit);
        testForm.addCommand(reverseE);

        //Anzeige ob Test komplett bzw. zum Teil Richtig oder garnicht
richtig beantwortet wurde
```

```java
        //Wenn Test zum ersten Mal gemacht wurde und alles richtig ist
erhält man eine Anzeige,
        //das man aufgewertet wurde bezüglich seiner angegebenen Attribute
        if(hc.getResponseCode() == 500)
        {
            testForm.append(sTestWrong);
        }

        if(hc.getResponseCode() == 501)
        {
            testForm.append(sTestHalfRight);
        }

        if(hc.getResponseCode() == 502)
        {
            testForm.append(sTestRight);
        }

        if(hc.getResponseCode() == 503)
        {
            testForm.append(sTestRight);
            testForm.append(sImproved);
        }

        hc.close();
    } catch (IOException e) {
        e.printStackTrace();
    }

}
```

The demand of the next material was sucessful and thefore an XML file with meta-information concerning next material is transffered.

- Receiving the XML file – transmission completed

```java
//Empfang einer XML-Datei
        InputStream is = hc.openDataInputStream();
        int length = (int) hc.getLength();
        byte[] data = new byte[length];
        int total = 0;
        while( total < length)
        {
            total += is.read(data, total, length-total);
        }

        is.close();
```

- Data parsing in an XML object

```java
//Parsen der XML-Datei in ein XMLObjekt
        ByteArrayInputStream bais = new ByteArrayInputStream(data);

        XMLObject xmlObject = xmlParsen(bais);
        bais.close();

        sActualInteraction = xmlObject.getInteraction();
```

- Reading of related pattern-files and parsing it in a pattern object

```
//Einlesen der entsprechenden Pattern-XML und parsen in ein Pattern-Objekt
            int nPattern = xmlObject.getPatternID();
            InputStream isPat = Cli-
ent.class.getResourceAsStream("/Pattern"+nPattern+".xml");
            int lengthPat = 0;
            byte[] dataPat = new byte[128];
            StringBuffer sBufferPat = new StringBuffer();
            while( (lengthPat= isPat.read(dataPat))!= -1)
            {
                sBufferPat.append(new String(dataPat,0,lengthPat));
            }
            isPat.close();
            ByteArrayInputStream baisPat = new ByteArrayInput-
Stream(sBufferPat.toString().getBytes());
            patternObject = patternParsen(baisPat);

            baisPat.close();
```

- Demanding of a specific file out of the XML object. For images, in addition the size is needed as extra information.

```
//Anfrage an die Server-Applikation nach den einzelnen Dateien aus dem XMLOb-
jekt
            int count = xmlObject.getModulVector().size();
            XMLModule xmlmodul;
            String filename;
            for(int i = 0; i < count; i++)
            {

                xmlmodul      = xmlObject.getModule(i);
                sInteraction = xmlObject.getInteraction();
                sType        = xmlmodul.getContent();
                filename      = xmlmodul.getFilename();
                nMaterialID  = xmlObject.getMaterialID();

                if(sType.equals("image") || sType.equals("searchImage") ||
(sType.length() > 4 && sType.substring(0, 5).equals("image")))
                {
                    if(sInteraction.equals(sINTERACTION[1]))
                    {
                        nWidth = (int)(((double)canvas.getWidth()/100.0)*40.0);
                        nHeight =
(int)(((double)canvas.getHeight()/100.0)*40.0);
                    }

                    if(sInteraction.equals(sINTERACTION[2]))
                    {
                        nWidth  = (int)(((double)nWIDTH/100)*30.0);
                        nHeight = (int)(((double)nHEIGHT/100)*30.0);
                    }

                    if(sInteraction.equals(sINTERACTION[3]))
                    {
                        nWidth  = (int)(((double)nWIDTH/100)*40.0);
                        nHeight = (int)(((double)nHEIGHT/100)*40.0);
                    }

                    if(sInteraction.equals(sINTERACTION[4]))
                    {
                        nWidth  = (int)(((double)nWIDTH/100)*20.0);
                        nHeight = (int)(((double)nHEIGHT/100)*20.0);
                    }
```

```java
            if(sInteraction.equals(sINTERACTION[5]))
            {
                nWidth  = (int)(((double)nWIDTH/100)*30.0);
                nHeight = (int)(((double)nHEIGHT/100)*30.0);
            }

            if(sInteraction.equals(sINTERACTION[6]))
            {
                nWidth  = (int)(((double)nWIDTH/100)*25.0);
                nHeight = (int)(((double)nHEIGHT/100)*25.0);
            }

            if(sInteraction.equals(sINTERACTION[7]))
            {
                nWidth  = (int)(((double)nWIDTH/100)*25.0);
                nHeight = (int)(((double)nHEIGHT/100)*25.0);
            }
            if(sInteraction.equals(sINTERACTION[8]))
            {
                nWidth  = (int)(((double)nWIDTH/100)*90.0);
                nHeight = nHEIGHT;
            }
            if(sInteraction.equals(sINTERACTION[9]))
            {
                nWidth  = (int)(((double)nWIDTH/100)*20.0);
                nHeight = (int)(((double)nHEIGHT/100)*30.0);
            }
            if(sInteraction.equals(sINTERACTION[10]))
            {
                nWidth  = (int)(((double)nWIDTH/100)*30.0);
                nHeight = (int)(((double)nHEIGHT/100)*30.0);
            }
            if(sInteraction.equals(sINTERACTION[11]))
            {
                nWidth  = (int)(((double)nWIDTH/100)*30.0);
                nHeight = (int)(((double)nHEIGHT/100)*80.0);
            }
            if(sInteraction.equals(sINTERACTION[12]))
            {
                nWidth  = (int)(((double)nWIDTH/100)*30.0);
                nHeight = (int)(((double)nHEIGHT/100)*80.0);
            }

            xmlmodul.setData(sendQuery(filename, nMaterialID,
nWidth,nHeight));
            }
            else
            {
                xmlmodul.setData(sendQuery(filename, nMaterialID, 0,0));
            }
        }
```

- Catching of method for visual representation of the materials

```java
//anzeigen der Materialien
        activeXMLObject = xmlObject;
        showScreen(xmlObject);
    }
```

- Methods of direct demands for a file from the server application, considered as Byte-Array

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```java
/*** Anfrage nach einer Datei bei der Serverapplikation und Angabe in welcher
Größe es benötigt wird.
     * @param source Name der anzufordernden Datei
     * @param nWidth Breite
     * @param nHeight Höhe
     * @return angefragte Datei als byte[]
     */
    public static byte[] sendQuery(String source, int nID,  int nWidth, int
nHeight)
     {

        byte[] data = null;
        try {
            //Erzeugung der Anfrage-URL und Anfrage bei der Server-Applikation
            String url =
URL+URLEncode("anfrage?"+source+"&"+nID+"&"+nWidth+"&"+nHeight);

            HttpConnection hc = (HttpConnection) Connector.open(url);
            hc.setRequestMethod(HttpConnection.GET);

            //Speichern der empfangenen Datei in einem ByteArray
            DataInputStream is = hc.openDataInputStream();
            int length = (int) hc.getLength();
            data = new byte[length];
            int total = 0;
//          while( total < length)
//          {
//              total += is.read(data, total, length-total);
//          }
            is.readFully(data);
            is.close();
            hc.close();

        } catch (IOException e) {
            e.printStackTrace();
        }
        return data;

    }
```

B1.2 Stationary Client

Main Classes

Class	Description
Package Panel	Includes the elements for the representation of interactions and materials on screen. The titles of the classes should be self-explanatory or obvious.
DisplayPanel.java	This class directs the representation of the specific interaction on screen. Depending on the interaction the related panels will be shown or if it's a material an adequate layout pattern is used.
Package *Main*	Contains most of helper classes for parsing XML files and use the resulting content.
GUI.java	This class is the core of the application. It is accordant to the class Client.java of the ME version. For this reason the naming of the equivalent methods with equivalent functions are the same. But in the OQO version some ME specific variations of the programm parts are stronger in execution.
CategoryModule.java	Provides information about a category that is selectable
CategoryObject.java	Contains the individual modules of information for the categories
PatternHandler.java	This class proceeds the parsing of the XML-file.
PatternModule.java	Provides information for the visualization of a pattern section
PatternObject.java	Consists on all modules of pattern that builds this specific pattern.
XMLHandler.java	This class parses the XML-file with the information according the material.
XMLModule.java	Contains information about an object which should be displayed
XMLObject.java	This object includes all information according the specific material that should be presented depending the

	XML- modules.
QuestionHandler.java	This class parses the XML-file with the information about questions.
QuestionObject.java	Contains all information about a test
CategoryHandler.java	This class parses the XML-file with the information about the categories.

Recieving of the available categories:

```java
// Alles Ok, jetzt kommen die Kategorien
        if(hc.getResponseCode() == 202)
        {
            categoryChoose = true;
            forwardBTN.setText("weiter >>");
            registerBTN.setVisible(false);

            login = false;
```

- Receiving of the category XML files

```java
InputStream is = hc.getInputStream();

            int length = (int) hc.getContentLength();
            byte[] data = new byte[length];
            int total = 0;
            while( total < length)
            {
                total += is.read(data, total, length-total);
            }
            is.close();
```

- Parsing of the XML files into a category-object

```java
//Parsen des XML-Files in ein CategoryObjekt
            ByteArrayInputStream bais = new ByteArrayInputStream(data);

            SAXParserFactory factory = SAXParserFactory.newInstance();
            SAXParser parser = factory.newSAXParser();
            CategoryHandler handler = new CategoryHandler(this);
            parser.parse(bais, handler);
            CategoryObject categoryObject = handler.getCategoryObject();

            bais.close();
```

- Requests of the related category pictures

```java
int nBtnWidth = (int) (((double)nWIDTH/100)*30);
            int nBtnHeight = (int) (((double)(nHEIGHT-
(nHEIGHT/100*10))/100)*30);

            for(int i = 0; i < categoryObject.getCatModules().size(); i++)
```

```
                {
                        categoryOb-
ject.getCatModules().get(i).setImage(sendQuery("category", Inte-
ger.parseInt(categoryObject.getCatModules().get(i).getID()), nBtnWidth,
nBtnHeight));
                        Sys-
tem.out.println(categoryObject.getCatModules().get(i).getGreeting());
                }
```

- Catching of the methods to showing categories in output screen

```
//Anzeige eines Kategorie-Screens
                showCategoryScreen(categoryObject);
        }
```

B2   IMLIS Server Source Codes

Main Classes

Class	Description
Server.java	This class is used to start the server application
Material.java User.java	Both clases creates either objects for the user or objects for the material. This objects carries either information about the user or the material.
ServerHandler.java	This class gets the request of the client, process this request and send the requested and for the context appropriate data back to client.

Managing different requests of diverse clients:

- Extraction of username and password as well as ineteractions

```java
//Statistik verarbeiten
      if(sQuery.equals(STATISTIC))
      {
          url = url.substring(url.indexOf("=")+1);

          String username = url.substring(0, url.indexOf("&"));
          url = url.substring(url.indexOf("=")+1);

          String password = url.substring(0, url.indexOf("&"));
          url = url.substring(url.indexOf("=")+1);

          String sInteraction = url.substring(0, url.indexOf("&"));

          url = url.substring(url.indexOf("=")+1);
```

- Depending on the extraction of the related needed statistical interaction, values will be stored in the appropriate table of the database.

```java
if(sInteraction.equals(sINTERACTION[1]))
        {
            int nMatID = Integer.parseInt(url.substring(0,url.indexOf("&")));
            url = url.substring(url.indexOf("=")+1);

            int nRight = Integer.parseInt(url.substring(0,url.indexOf("&")));
            url = url.substring(url.indexOf("=")+1);

            int nWrong = Integer.parseInt(url.substring(0,url.indexOf("&")));
            url = url.substring(url.indexOf("=")+1);

            int nNo = Integer.parseInt(url.substring(0, url.length()));
```

```java
            try {
                stmt = con.createStatement();
                rs = stmt.executeQuery("SELECT id FROM users WHERE username =
'"+username+"'");
                rs.next();
                int nUserID = rs.getInt("id");
                rs.close();

                stmt2 = con.createStatement();
                stmt2.executeUpdate("INSERT INTO his_image_to_audio (mate-
rial_id, user_id, right_image, wrong_image, no_image) VALUES ("+nMatID+",
"+nUserID+", "+nRight+", "+nWrong+", "+nNo+")");

                sResponse = "Statistik übertragen";
                httpExchange.sendResponseHeaders(200,sResponse.length());

                OutputStream os = httpExchange.getResponseBody();
                os.write(sResponse.getBytes());
                os.close();
            } catch (SQLException e) {
                // TODO Auto-generated catch block
                e.printStackTrace();
            } catch (IOException e) {
                // TODO Auto-generated catch block
                e.printStackTrace();
            }
        }
        else if(sInteraction.equals(sINTERACTION[2]))
        {
            int nMatID = Integer.parseInt(url.substring(0,url.indexOf("&")));
            url = url.substring(url.indexOf("=")+1);

            int nRight = Integer.parseInt(url.substring(0,url.indexOf("&")));
            url = url.substring(url.indexOf("=")+1);

            int nWrong = Integer.parseInt(url.substring(0,url.indexOf("&")));
            url = url.substring(url.indexOf("=")+1);

            int nNo = Integer.parseInt(url.substring(0, url.length()));

            try {
                stmt = con.createStatement();
                rs = stmt.executeQuery("SELECT id FROM users WHERE username =
'"+username+"'");
                rs.next();
                int nUserID = rs.getInt("id");
                rs.close();

                stmt2 = con.createStatement();
                stmt2.executeUpdate("INSERT INTO his_image_to_image (mate-
rial_id, user_id, right_image, wrong_image, no_image) VALUES ("+nMatID+",
"+nUserID+", "+nRight+", "+nWrong+", "+nNo+")");

                sResponse = "Statistik übertragen";
                httpExchange.sendResponseHeaders(200,sResponse.length());

                OutputStream os = httpExchange.getResponseBody();
                os.write(sResponse.getBytes());
                os.close();
            } catch (SQLException e) {
                // TODO Auto-generated catch block
                e.printStackTrace();
            } catch (IOException e) {
                // TODO Auto-generated catch block
                e.printStackTrace();
            }
        }
```

```java
            else if(sInteraction.equals(sINTERACTION[3]))
            {
                int nMatID = Integer.parseInt(url.substring(0,url.indexOf("&")));
                url = url.substring(url.indexOf("=")+1);

                int nRight = Integer.parseInt(url.substring(0,url.indexOf("&")));
                url = url.substring(url.indexOf("=")+1);

                int nWrong = Integer.parseInt(url.substring(0,url.indexOf("&")));
                url = url.substring(url.indexOf("=")+1);

                int nNo = Integer.parseInt(url.substring(0, url.length()));

                try {
                    stmt = con.createStatement();
                    rs = stmt.executeQuery("SELECT id FROM users WHERE username =
'"+username+"'");
                    rs.next();
                    int nUserID = rs.getInt("id");
                    rs.close();

                    stmt2 = con.createStatement();
                    stmt2.executeUpdate("INSERT INTO his_word_to_image (mate-
rial_id, user_id, right_word, wrong_word, no_word) VALUES ("+nMatID+",
"+nUserID+", "+nRight+", "+nWrong+", "+nNo+")");

                    sResponse = "Statistik übertragen";
                    httpExchange.sendResponseHeaders(200,sResponse.length());

                    OutputStream os = httpExchange.getResponseBody();
                    os.write(sResponse.getBytes());
                    os.close();
                } catch (SQLException e) {
                    // TODO Auto-generated catch block
                    e.printStackTrace();
                } catch (IOException e) {
                    // TODO Auto-generated catch block
                    e.printStackTrace();
                }
            }
            else if(sInteraction.equals(sINTERACTION[4]))
            {
                int nMatID = Integer.parseInt(url.substring(0,url.indexOf("&")));
                url = url.substring(url.indexOf("=")+1);

                int nRight = Integer.parseInt(url.substring(0,url.indexOf("&")));
                url = url.substring(url.indexOf("=")+1);

                int nWrong = Integer.parseInt(url.substring(0,url.indexOf("&")));
                url = url.substring(url.indexOf("=")+1);

                int nTries = Integer.parseInt(url.substring(0, url.length()));

                try {
                    stmt = con.createStatement();
                    rs = stmt.executeQuery("SELECT id FROM users WHERE username =
'"+username+"'");
                    rs.next();
                    int nUserID = rs.getInt("id");
                    rs.close();

                    stmt2 = con.createStatement();
                    stmt2.executeUpdate("INSERT INTO his_fill_words (material_id,
user_id, right_letter, wrong_letter, tries) VALUES ("+nMatID+", "+nUserID+",
"+nRight+", "+nWrong+", "+nTries+")");

                    sResponse = "Statistik übertragen";
```

```java
                httpExchange.sendResponseHeaders(200,sResponse.length());

                OutputStream os = httpExchange.getResponseBody();
                os.write(sResponse.getBytes());
                os.close();
            } catch (SQLException e) {
                // TODO Auto-generated catch block
                e.printStackTrace();
            } catch (IOException e) {
                // TODO Auto-generated catch block
                e.printStackTrace();
            }
        }
        else if(sInteraction.equals(sINTERACTION[5]))
        {
            int nMatID = Integer.parseInt(url.substring(0,url.indexOf("&")));
            url = url.substring(url.indexOf("=")+1);

            int nRight = Integer.parseInt(url.substring(0,url.indexOf("&")));
            url = url.substring(url.indexOf("=")+1);

            int nWrong = Integer.parseInt(url.substring(0,url.indexOf("&")));
            url = url.substring(url.indexOf("=")+1);

            int nNo = Integer.parseInt(url.substring(0, url.length()));

            try {
                stmt = con.createStatement();
                rs = stmt.executeQuery("SELECT id FROM users WHERE username =
'"+username+"'");
                rs.next();
                int nUserID = rs.getInt("id");
                rs.close();

                stmt2 = con.createStatement();
                stmt2.executeUpdate("INSERT INTO his_image_to_sentence (mate-
rial_id, user_id, right_image, wrong_image, no_image) VALUES ("+nMatID+",
"+nUserID+", "+nRight+", "+nWrong+", "+nNo+")");

                sResponse = "Statistik übertragen";
                httpExchange.sendResponseHeaders(200,sResponse.length());

                OutputStream os = httpExchange.getResponseBody();
                os.write(sResponse.getBytes());
                os.close();
            } catch (SQLException e) {
                // TODO Auto-generated catch block
                e.printStackTrace();
            } catch (IOException e) {
                // TODO Auto-generated catch block
                e.printStackTrace();
            }
        }
        else if(sInteraction.equals(sINTERACTION[6]))
        {
            int nMatID = Integer.parseInt(url.substring(0,url.indexOf("&")));
            url = url.substring(url.indexOf("=")+1);

            int nRight = Integer.parseInt(url.substring(0,url.indexOf("&")));
            url = url.substring(url.indexOf("=")+1);

            int nWrong = Integer.parseInt(url.substring(0,url.indexOf("&")));
            url = url.substring(url.indexOf("=")+1);

            int nTries = Integer.parseInt(url.substring(0, url.length()));

            try {
```

```java
                stmt = con.createStatement();
                rs = stmt.executeQuery("SELECT id FROM users WHERE username =
'"+username+"'");
                rs.next();
                int nUserID = rs.getInt("id");
                rs.close();

                stmt2 = con.createStatement();
                stmt2.executeUpdate("INSERT INTO his_sort_syllable (mate-
rial_id, user_id, right_word, wrong_word, tries) VALUES ("+nMatID+",
"+nUserID+", "+nRight+", "+nWrong+", "+nTries+")");

                sResponse = "Statistik übertragen";
                httpExchange.sendResponseHeaders(200,sResponse.length());

                OutputStream os = httpExchange.getResponseBody();
                os.write(sResponse.getBytes());
                os.close();
            } catch (SQLException e) {
                // TODO Auto-generated catch block
                e.printStackTrace();
            } catch (IOException e) {
                // TODO Auto-generated catch block
                e.printStackTrace();
            }
        }
        else if(sInteraction.equals(sINTERACTION[7]))
        {
            int nMatID = Integer.parseInt(url.substring(0,url.indexOf("&")));
            url = url.substring(url.indexOf("=")+1);

            int nRight = Integer.parseInt(url.substring(0,url.indexOf("&")));
            url = url.substring(url.indexOf("=")+1);

            int nWrong = Integer.parseInt(url.substring(0,url.indexOf("&")));
            url = url.substring(url.indexOf("=")+1);

            int nTries = Integer.parseInt(url.substring(0, url.length()));

            try {
                stmt = con.createStatement();
                rs = stmt.executeQuery("SELECT id FROM users WHERE username =
'"+username+"'");
                rs.next();
                int nUserID = rs.getInt("id");
                rs.close();

                stmt2 = con.createStatement();
                stmt2.executeUpdate("INSERT INTO his_sort_letters (mate-
rial_id, user_id, right_word, wrong_word, tries) VALUES ("+nMatID+",
"+nUserID+", "+nRight+", "+nWrong+", "+nTries+")");

                sResponse = "Statistik übertragen";
                httpExchange.sendResponseHeaders(200,sResponse.length());

                OutputStream os = httpExchange.getResponseBody();
                os.write(sResponse.getBytes());
                os.close();
            } catch (SQLException e) {
                // TODO Auto-generated catch block
                e.printStackTrace();
            } catch (IOException e) {
                // TODO Auto-generated catch block
                e.printStackTrace();
            }
        }
        // Interaction[8] = malen
```

```java
            else if(sInteraction.equals(sINTERACTION[9]))
            {
                int nMatID = Integer.parseInt(url.substring(0,url.indexOf("&")));
                url = url.substring(url.indexOf("=")+1);

                int nRight = Integer.parseInt(url.substring(0,url.indexOf("&")));
                url = url.substring(url.indexOf("=")+1);

                int nWrong = Integer.parseInt(url.substring(0,url.indexOf("&")));
                url = url.substring(url.indexOf("=")+1);

                int nTries = Integer.parseInt(url.substring(0, url.length()));

                try {
                    stmt = con.createStatement();
                    rs = stmt.executeQuery("SELECT id FROM users WHERE username =
'"+username+"'");
                    rs.next();
                    int nUserID = rs.getInt("id");
                    rs.close();

                    stmt2 = con.createStatement();
                stmt2.executeUpdate("INSERT INTO his_sort_images (material_id,
user_id, right_word, wrong_word, tries) VALUES ("+nMatID+", "+nUserID+",
"+nRight+", "+nWrong+", "+nTries+")");

                    sResponse = "Statistik übertragen";
                    httpExchange.sendResponseHeaders(200,sResponse.length());

                    OutputStream os = httpExchange.getResponseBody();
                    os.write(sResponse.getBytes());
                    os.close();
                } catch (SQLException e) {
                    // TODO Auto-generated catch block
                    e.printStackTrace();
                } catch (IOException e) {
                    // TODO Auto-generated catch block
                    e.printStackTrace();
                }
            }
            else if(sInteraction.equals(sINTERACTION[10]))
            {
                int nMatID = Integer.parseInt(url.substring(0,url.indexOf("&")));
                url = url.substring(url.indexOf("=")+1);

                int nRight = Integer.parseInt(url.substring(0,url.indexOf("&")));
                url = url.substring(url.indexOf("=")+1);

                int nTries = Integer.parseInt(url.substring(0,url.indexOf("&")));
                url = url.substring(url.indexOf("=")+1);

                int nShortestTries = Integer.parseInt(url.substring(0,
url.length()));

                try {
                    stmt = con.createStatement();
                    rs = stmt.executeQuery("SELECT id FROM users WHERE username =
'"+username+"'");
                    rs.next();
                    int nUserID = rs.getInt("id");
                    rs.close();

                    stmt2 = con.createStatement();
                    stmt2.executeUpdate("INSERT INTO his_set_digital_watch (mate-
rial_id, user_id, right_time, tries, shortestTries) VALUES ("+nMatID+",
"+nUserID+", "+nRight+", "+nTries+", "+nShortestTries+")");
```

```
                    sResponse = "Statistik übertragen";
                    httpExchange.sendResponseHeaders(200,sResponse.length());

                    OutputStream os = httpExchange.getResponseBody();
                    os.write(sResponse.getBytes());
                    os.close();
                } catch (SQLException e) {
                    // TODO Auto-generated catch block
                    e.printStackTrace();
                } catch (IOException e) {
                    // TODO Auto-generated catch block
                    e.printStackTrace();
                }
            }
        }
```

Processing of a request for intialzation of a category:

- Extraction of username and password and related category ID from the URL

```
//Benutzername und Passwort aus Anfrage-URL extrahieren
        url = url.substring(url.indexOf("="));
        String username = url.substring(url.indexOf("=")+1,
url.indexOf("&"));

        url = url.substring(url.indexOf("&"));
        url = url.substring(url.indexOf("="));
        String password = url.substring(url.indexOf("=")+1,
url.indexOf("&"));

        url = url.substring(url.indexOf("&"));
        url = url.substring(url.indexOf("="));

        String sCategoryID= url.substring(url.indexOf("=")+1, url.length());
```

- Creating and transferring of an XML file with meta-information concerning the next materials

```
rs = stmt.executeQuery("SELECT * FROM users,usercriterions WHERE user-
name='"+username+"' AND password='"+password+"' AND users.id = usercriteri-
ons.user_id");
            if(rs.next())
            {
                User user = new User(rs.getString("username"),
rs.getString("password"), rs.getInt("id"), rs.getInt("iq"),
rs.getInt("reaction"), rs.getInt("memory"), rs.getInt("problem"),
rs.getInt("motoric"), rs.getInt("hear"), rs.getInt("see"),
rs.getInt("reading"), rs.getInt("gender"), rs.getInt("age")  );
                xmlErzeugen(getNextMaterial(user, -1, sCategoryID), user,
httpExchange, true, sCategoryID);
            }
```

Processing of a request for a specific file:

- Extraction of file name, material ID, hight and width from the URL

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```
//Dateinamen sowie Hoehen- und Breitenangaben aus Anfrage-URL extrahieren
        String filename = url.substring(url.indexOf("?")+1,
url.indexOf("&"));
        url = url.substring(url.indexOf("&")+1);
        nMaterialID = Integer.parseInt(url.substring(0, url.indexOf("&")));
        url = url.substring(url.indexOf("&")+1);
        nWidth = Integer.parseInt(url.substring(0, url.indexOf("&")));
        url = url.substring(url.indexOf("&")+1);

        nHeight = Integer.parseInt(url.substring(0, url.length()));
```

- File transfer by calling the related methods

```
if(filename.equals("category"))
        {
            sendCatData(nMaterialID, httpExchange);
        }
        else
        {
            //senden der Datei durchführen
            sendData(new File(filename), httpExchange);
        }
```

Processing of the requests for registration:

- Extraction of the considered values from the URL

```
//Benutzername, Passwort und weitere Parameter aus Anfrage-URL extrahieren
        url = url.substring(url.indexOf("=")+1);
        String sUsername = url.substring(0, url.indexOf("&"));

        url = url.substring(url.indexOf("=")+1);
        String sPassword = url.substring(0, url.indexOf("&"));

        url = url.substring(url.indexOf("=")+1);
        String sIq = url.substring(0, url.indexOf("&"));

        url = url.substring(url.indexOf("=")+1);
        String sReaction = url.substring(0, url.indexOf("&"));

        url = url.substring(url.indexOf("=")+1);
        String sBrain = url.substring(0, url.indexOf("&"));

        url = url.substring(url.indexOf("=")+1);
        String sProblem = url.substring(0, url.indexOf("&"));

        url = url.substring(url.indexOf("=")+1);
        String sMotoric = url.substring(0, url.indexOf("&"));

        url = url.substring(url.indexOf("=")+1);
        String sHear = url.substring(0, url.indexOf("&"));

        url = url.substring(url.indexOf("=")+1);
        String sSee = url.substring(0, url.indexOf("&"));

        url = url.substring(url.indexOf("=")+1);
        String sRead = url.substring(0, url.indexOf("&"));

        url = url.substring(url.indexOf("=")+1);
```

```java
        String sGender = url.substring(0, url.indexOf("&"));

        url = url.substring(url.indexOf("=")+1);

        String sAge = url.substring(0, url.length());
```

- Verifiying if the user is already available and if "Yes", informing the client

```java
rs = stmt.executeQuery("SELECT * FROM users WHERE username =
'"+sUsername+"'");
            if(rs.next())
            {
                sResponse = "Benutzername schon vergeben!!!";
                nResponseCode = 400;

            }
```

- Creating of a new user by transferring of considered values in the database and feedback to the clients

```java
{
                stmt.executeUpdate("INSERT INTO users (username, password,
role, gender, age) VALUES ('"+sUsername+"', '"+sPassword+"', 'user',
'"+sGender+"', '"+sAge+"')");
                rs = stmt.executeQuery("SELECT id FROM users WHERE username =
'"+sUsername+"'");
                rs.next();
                int nId = rs.getInt("id");
                stmt.executeUpdate("INSERT INTO usercriterions (user_id, iq,
reaction, memory, problem, motoric, hear, see, reading, created) VALUES
('"+nId+"', '"+sIq+"', '"+sReaction+"', '"+sBrain+"', '"+sProblem+"',
'"+sMotoric+"', '"+sHear+"', '"+sSee+"', '"+sRead+"', '0' )");
                sResponse = "Registrierung erfolgreich";
                nResponseCode = 200;
            }

        } catch (SQLException e1) {
            System.out.println("SQL-Fehler");
            e1.printStackTrace();
        }


        try {
            httpEx-
change.sendResponseHeaders(nResponseCode,sResponse.length());

            OutputStream os = httpExchange.getResponseBody();
            os.write(sResponse.getBytes());

            os.close();
```

B3 IMLIS Teacher-Portal Source Codes

Main Classes

Classes	Description
Center.java	The main class of the teacher portal for the main functions.
CategoriePanel.java	Create and delete categories
EditMaterialPanel.java	Material editiing
EditTestPanel.java	Tests editting
ImlisPanel.java	Information about the program
ImpressumPanel.java	Contact information
LearningCurvePanel.java	Displaing learning curves
LearningProcessPanel.java	Displaing learning process
LecturePanel.java	Create and delete lessons
MaterialPanel.java	Presentation of materials
MessageMatPanel.java	Messages for materials
MessageTestPanel.java	Messages for the tests
MessageUserPanel.java	Messages for system users
NewMaterialPanel.java	Creating new materials
NewTemplatePanel.java	Creating new criteria patterns
NewTestPanel.java	Creating new tests
PreviewPanel.java	Preview on created learning materials
StatMatPanel.java	Statistics of the materials
StatTestPanel.java	Statistics for the tests
StatUserPanel.java	Statistics for the system users
TemplatePanel.java	Create and delete criteria patterns
TestPanel.java	Presentation of all tests
UserPanel.java	Presentation of all system users
PatternHandler.java **PatternModule.java**	Classes for parsing XML files (the pattern file)

PatternObject.java	
JTableButtonMouseLis- **tener.java** **JTableButtonRenderer.java** **TestObject.java**	Helper classes
All the classes in the Pack- **ages Languages**	These classes are needed to parse the specific language-file and to allocate the information to the adequate panels on screen.

Initialize and set up of each panel of teacher portal:

```java
//Initialisierung der einzelnen Panel
    newMatPanel  = new NewMaterialPanel(nPanelWidth, nPanelHeight, lan-
guageObject);
    editMatPanel = new EditMaterialPanel(nPanelWidth, nPanelHeight, lan-
guageObject);
    matPanel     = new MaterialPanel(nPanelWidth, nPanelHeight, languageOb-
ject);
    newCatPanel  = new CategoriePanel(nPanelWidth, nPanelHeight, lan-
guageObject);
    newLecPanel  = new LecturePanel(nPanelWidth, nPanelHeight, languageOb-
ject);

    newTestPanel  = new NewTestPanel(nPanelWidth, nPanelHeight, languageOb-
ject);
    editTestPanel = new EditTestPanel(nPanelWidth, nPanelHeight, lan-
guageObject);
    testPanel     = new TestPanel(nPanelWidth, nPanelHeight, languageOb-
ject);

    newTemplatePanel  = new NewTemplatePanel(nPanelWidth, nPanelHeight,
languageObject);
    editTemplatePanel = new EditTemplatePanel(nPanelWidth, nPanelHeight,
languageObject);
    templatePanel     = new TemplatePanel(nPanelWidth, nPanelHeight, lan-
guageObject);

    statTestPanel    = new StatTestPanel(nPanelWidth, nPanelHeight, lan-
guageObject);
    messageTestPanel = new MessageTestPanel(nPanelWidth, nPanelHeight, lan-
guageObject);

    statMatPanel    = new StatMatPanel(nPanelWidth, nPanelHeight, lan-
guageObject);
    messageMatPanel = new MessageMatPanel(nPanelWidth, nPanelHeight, lan-
guageObject);

    statUserPanel    = new StatUserPanel(nPanelWidth, nPanelHeight, lan-
guageObject);
    messageUserPanel = new MessageUserPanel(nPanelWidth, nPanelHeight, lan-
guageObject);
    learningCurvePanel = new LearningCurvePanel(nPanelWidth, nPanelHeight,
languageObject);
    learningProcessPanel = new LearningProcessPanel(nPanelWidth, nPanel-
```

```java
Height, languageObject);
        learningPlanPanel = new LearningPlanPanel(nPanelWidth, nPanelHeight,
languageObject);

        userPanel      = new UserPanel(nPanelWidth, nPanelHeight);
        imlisPanel     = new ImlisPanel(nPanelWidth, nPanelHeight);
        impressumPanel   = new ImpressumPanel(nPanelWidth, nPanelHeight);

        materialModul = languageObject.getMaterialModul();

        matTAB.addTab(materialModul.getNeuesMaterial().getName(), newMatPanel);
        matTAB.addTab(materialModul.getMaterialBearbeiten().getName(), edit-
MatPanel);
        matTAB.setEnabledAt(1, false);
        matTAB.addTab(materialModul.getAlleMaterialien().getName(), matPanel);
        matTAB.addTab(materialModul.getKategorieTab().getName(), newCatPanel);
        matTAB.addTab(materialModul.getLektionenTab().getName(), newLecPanel);

        testTAB.addTab("Neuer Test", newTestPanel);
        testTAB.addTab("Test bearbeiten", editTestPanel);
        testTAB.setEnabledAt(1, false);
        testTAB.addTab("Alle Tests", testPanel);

        templateTAB.addTab("Neue Vorlage", newTemplatePanel);
        templateTAB.addTab("Vorlage bearbeiten", editTemplatePanel);
        templateTAB.setEnabledAt(1, false);
        templateTAB.addTab("Alle Vorlagen", templatePanel);

        verwaltTAB.addTab("Benutzer", userPanel);
        //verwaltTAB.addTab("Rechte", null);
        verwaltTAB.addTab("Impressum", impressumPanel);
        verwaltTAB.addTab("Über IMLIS", imlisPanel);

        matPersTAB.addTab("Statistik", statMatPanel);
        matPersTAB.addTab("Meldungen", messageMatPanel);

        testPersTAB.addTab("Statistik", statTestPanel);
        testPersTAB.addTab("Meldungen", messageTestPanel);

        userPersTAB.addTab("Statistik", statUserPanel);
        userPersTAB.addTab("Meldungen", messageUserPanel);
        userPersTAB.addTab("Lernkurve", learningCurvePanel);
        userPersTAB.addTab("Lernverlauf", learningProcessPanel);
        userPersTAB.addTab("Lernplan", learningPlanPanel);

        //Setzen der Listener bei Veränderungen der Register
        tabbedPane.addChangeListener(this);
        matTAB.addChangeListener(this);
        testTAB.addChangeListener(this);
        templateTAB.addChangeListener(this);
        verwaltTAB.addChangeListener(this);

        matTAB.setSize(nWidth-7, nHeight-40);
        testTAB.setSize(nWidth-7, nHeight-40);
        templateTAB.setSize(nWidth-7, nHeight-40);
        verwaltTAB.setSize(nWidth-7, nHeight-40);

        sMaterial = languageObject.getMaterialModul().getName();
        sTest      = languageObject.getTestModul().getName();
        sKritVorlage = languageObject.getKritVorlageModul().getName();
        sVerwaltung  = languageObject.getVerwaltungsModul().getName();
        sLerninhalt = "Lerninhalte";
        sPersonalisiert = "Personalisierung";

        learnTAB.addTab(sMaterial, matTAB);
        learnTAB.addTab(sTest, testTAB);
        learnTAB.addTab(sKritVorlage, templateTAB);
```

```java
        personTAB.addTab(sMaterial, matPersTAB);
        personTAB.addTab(sTest, testPersTAB);
        personTAB.addTab("Benutzer", userPersTAB);

        tabbedPane.setSize(nWidth-7, nHeight-40);
        tabbedPane.addTab(sLerninhalt, learnTAB);
        tabbedPane.addTab(sPersonalisiert, personTAB);

        tabbedPane.addTab(sVerwaltung, verwaltTAB);
```

Generating a language object for the selected language:

```java
public LanguageObject getLanguage()
    {
    LanguageHandler handler = null;
    try {
        String filename = (String)languageBOX.getSelectedItem();
        stmt2  = con.createStatement();
        rs2 = stmt2.executeQuery("SELECT data FROM languages WHERE name =
'"+filename+"'");
        if(rs2.next())
        {
            InputStream is = rs2.getBinaryStream("data");
            ByteArrayOutputStream baos = new ByteArrayOutputStream();

            int length = 0;
            byte[] buff = new byte[16384];

            while( 0 < (length = is.read(buff)))
            {
                baos.write( buff, 0, length);
            }
            baos.close();

            File languageFile = new File(filename);
            FileOutputStream fos = new FileOutputStream(languageFile);
            fos.write(baos.toByteArray());

            fos.close();
            is.close();

            SAXParserFactory factory = SAXParserFactory.newInstance();
            SAXParser parser = factory.newSAXParser();
            handler = new LanguageHandler();
            parser.parse(languageFile, handler);
        }
    } catch (ParserConfigurationException e) {
        // TODO Auto-generated catch block
        e.printStackTrace();
    } catch (SAXException e) {
        // TODO Auto-generated catch block
        e.printStackTrace();
    } catch (IOException e) {
        // TODO Auto-generated catch block
        e.printStackTrace();
    } catch (SQLException e) {
        // TODO Auto-generated catch block
        e.printStackTrace();
    }
    return handler.getLanguageObject(); }
```
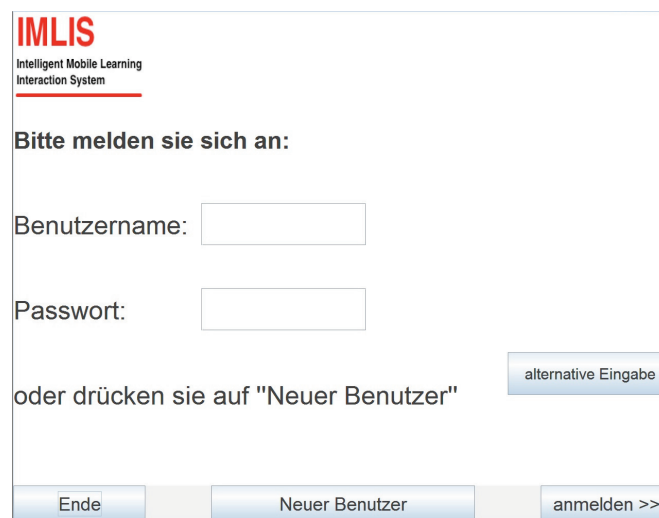
Appendix C: Screenshots from IMLIS Prototype

Client Screenshots
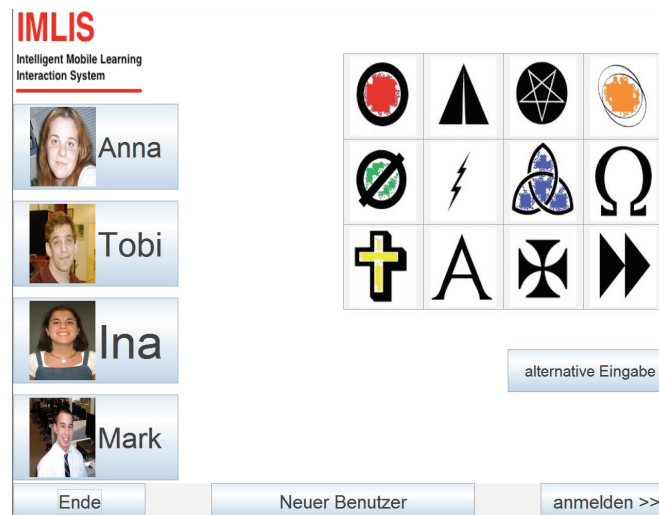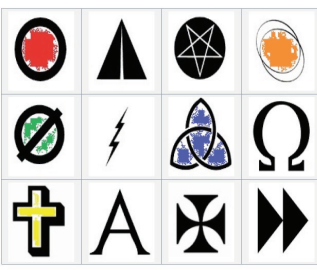
Normal login-in page

Specialized alternative login-in page

Chapter selection by learner
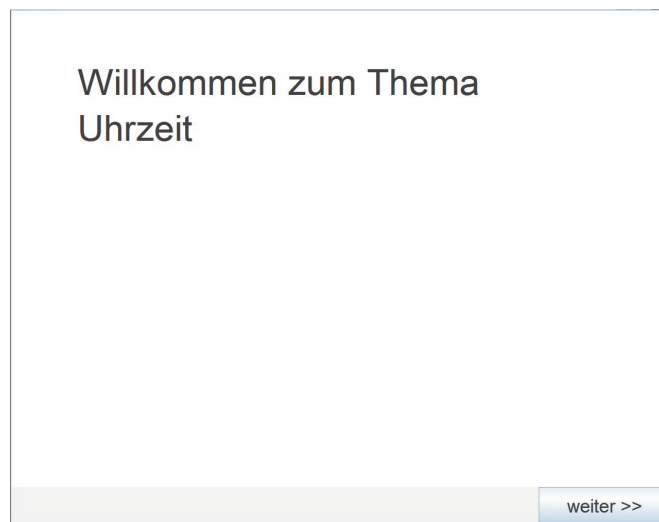
Welcome Text and Audio

Interaction: Drawing (level: multi)
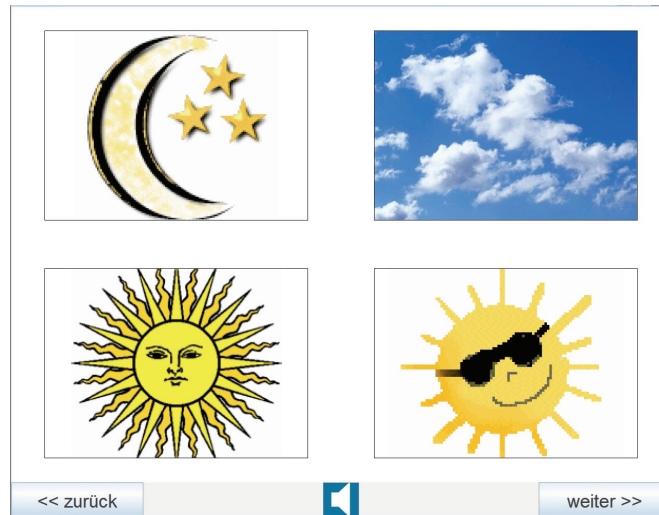
Interaction: Selecting the appropriate image (level: moderate)

Interaction: Selecting appropriate word for the image (level: mild)
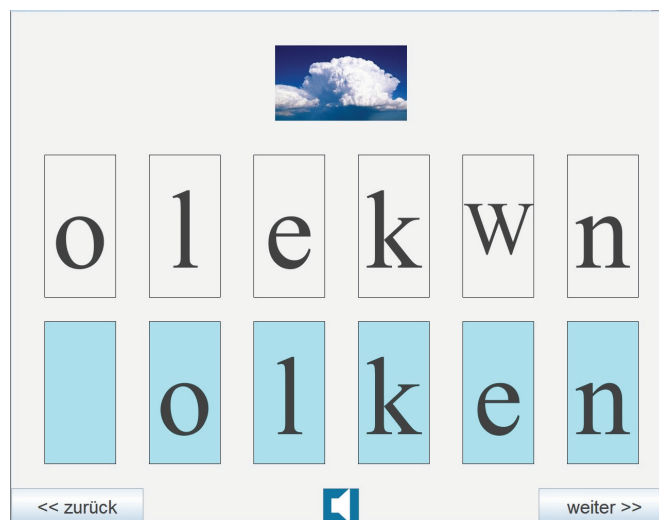
Interaction: Arranging the letters based on the image (level: borderline)
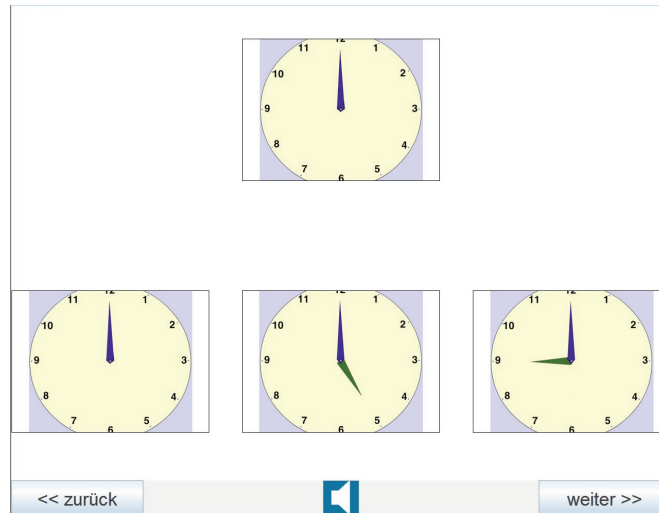
Interaction: Selecting the right image (level: moderate)

Interaction: Selecting the right word based on image (level: mild)

Interaction: Selecting appropriate image based on the text (level: borderline)
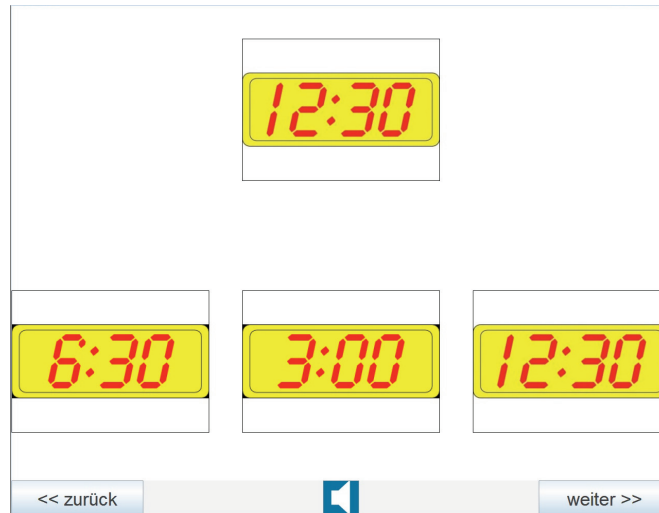
Interaction: Selecting the right image (level: moderate)

Interaction: Selecting the right image based on digital display (level: mild)
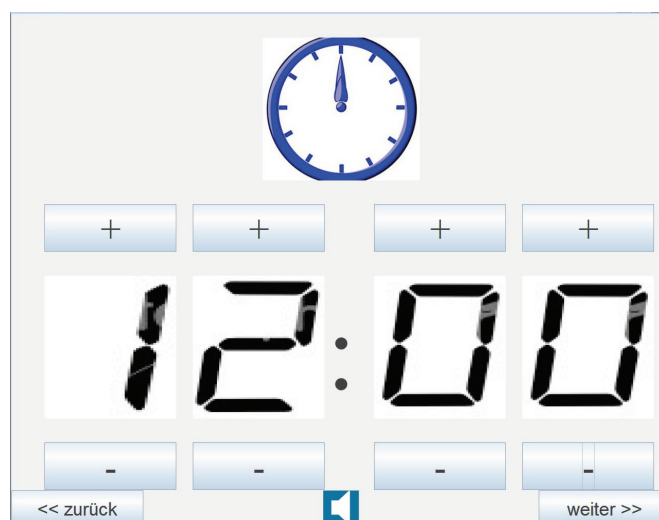
Interaction: Selecting the right digital number based on image (level: borderline)

Teacher Portal Screenshots

Teacher portal login page

All learning materials view

Learning material preparation (without interaction)

Learning material preparation (with interaction)

Test preparation

All tests view

Creating and editing lessons

Creating and editing categories

Learning materials statistics view

Learner statistics view

IMLIS Teacher-Portal

Lerninhalte · Personalisierung · Verwaltung

Material · Test · Benutzer

Statistik · Meldungen

aktualisieren

Name	#Testpersonen	richtige Antworten	Anzahl Antworten	% richtig beantwortet
Frage 1	1	1	1	100.0%
Frage 2	2	3	57	5.26%
Länder in Europa	1	1	3	33.33%
Melone	2	0	7	0.0%

Tests statistics view

IMLIS Teacher-Portal

Lerninhalte · Personalisierung · Verwaltung

Material · Test · Benutzer
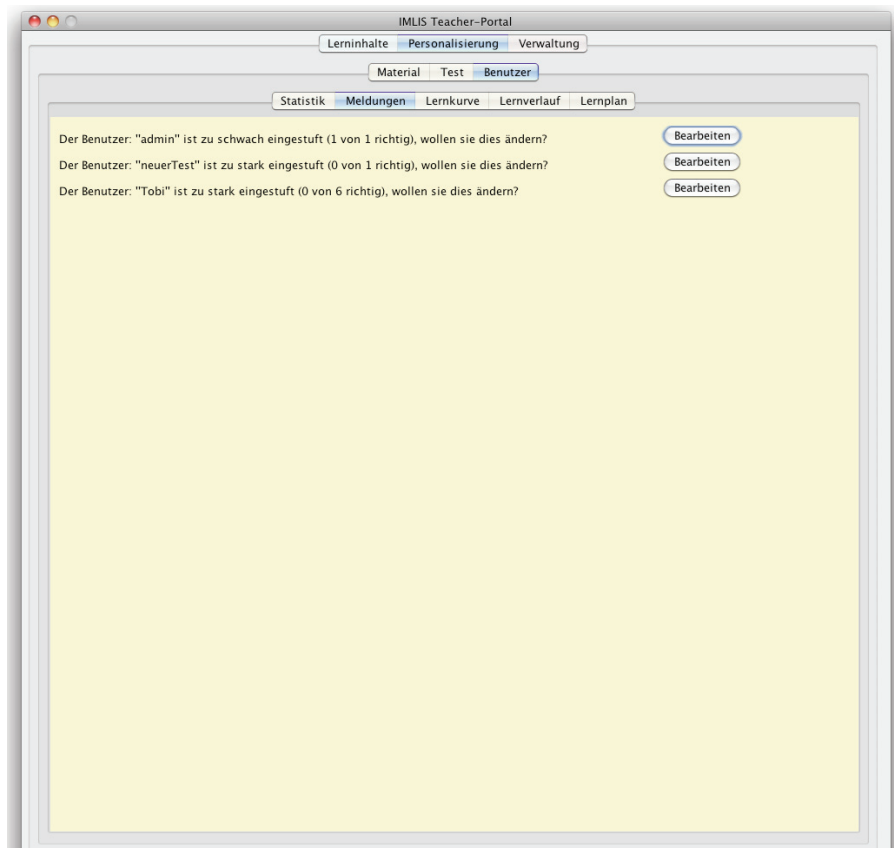
Statistik · Meldungen

Der Test: "Frage 1" ist zu leicht (1 von 1 richtig), wollen sie dies ändern?   Bearbeiten
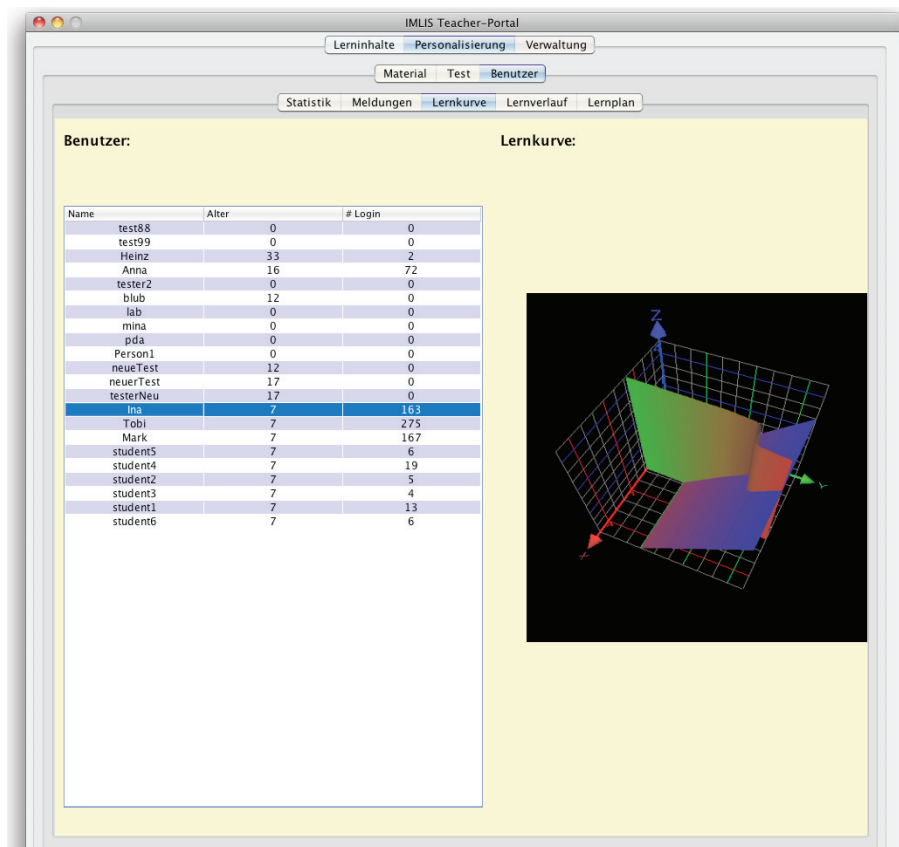
Der Test: "Frage 2" ist zu schwer (3 von 57 richtig), wollen sie dies ändern?   Bearbeiten

Der Test: "Melone" ist zu schwer (0 von 7 richtig), wollen sie dies ändern?   Bearbeiten

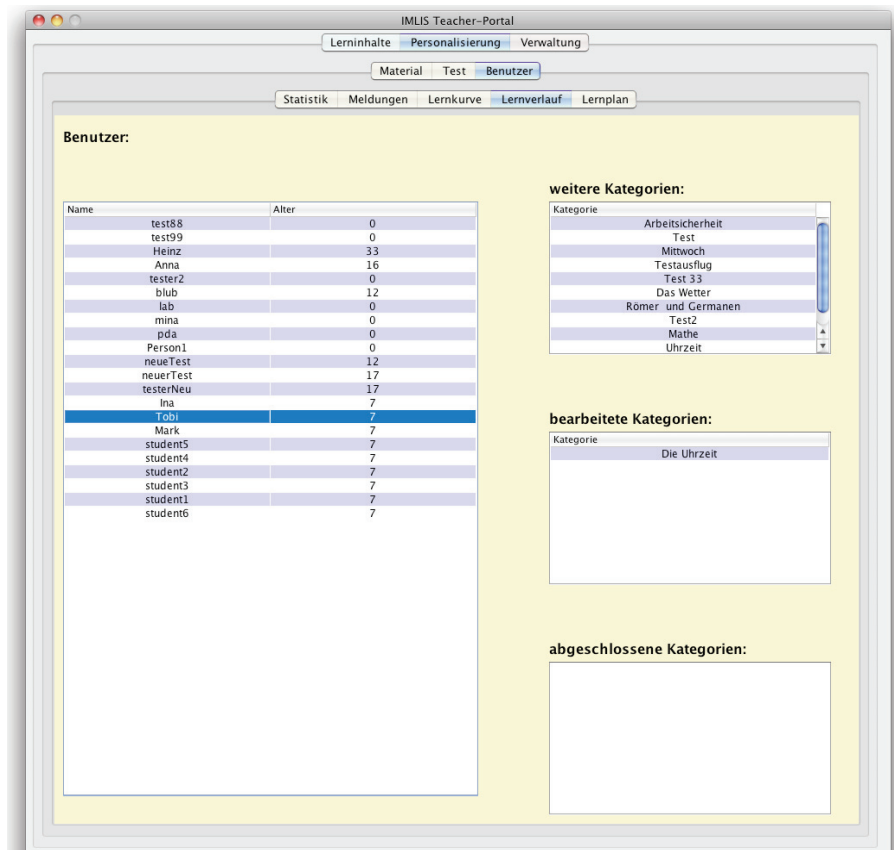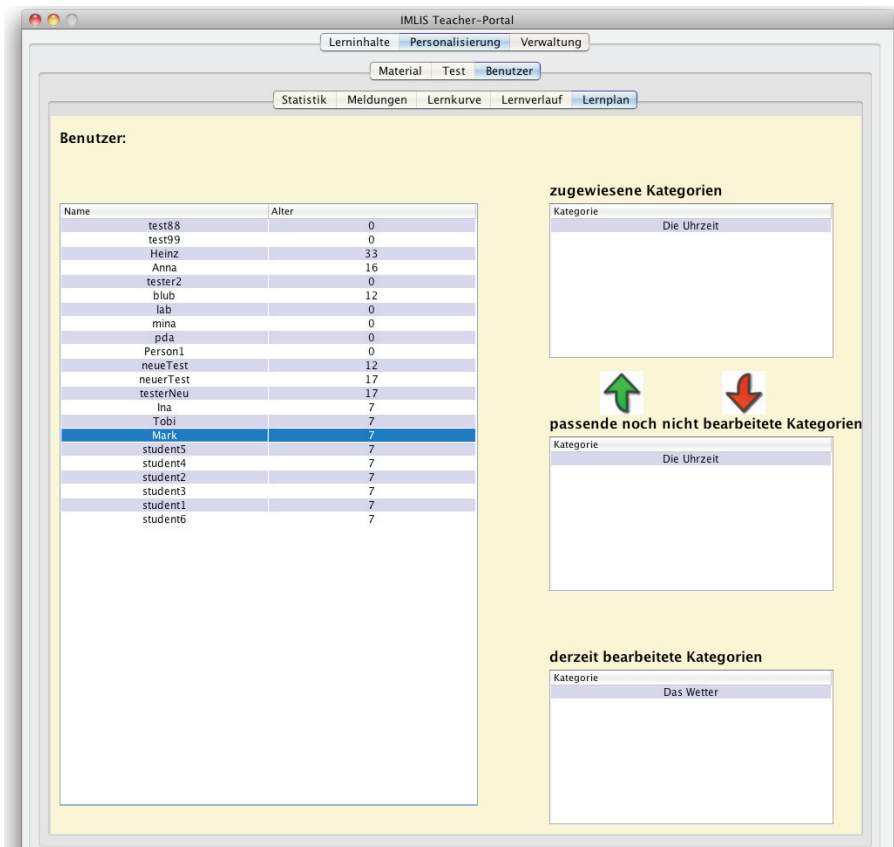Automatic messaging systems for tests
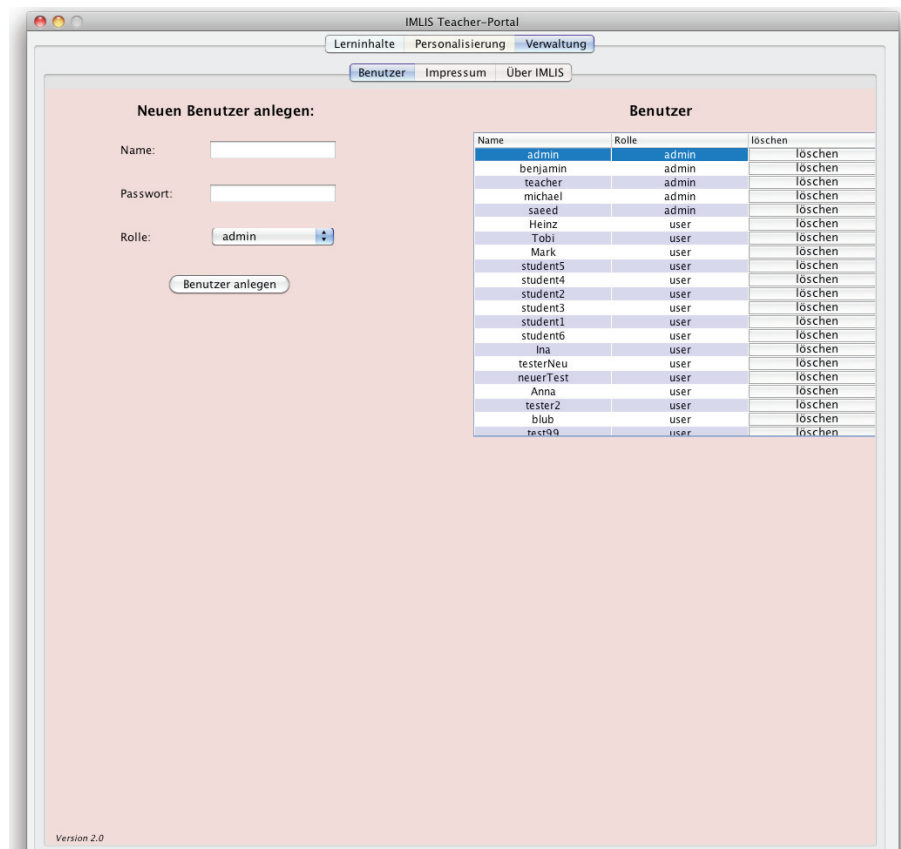
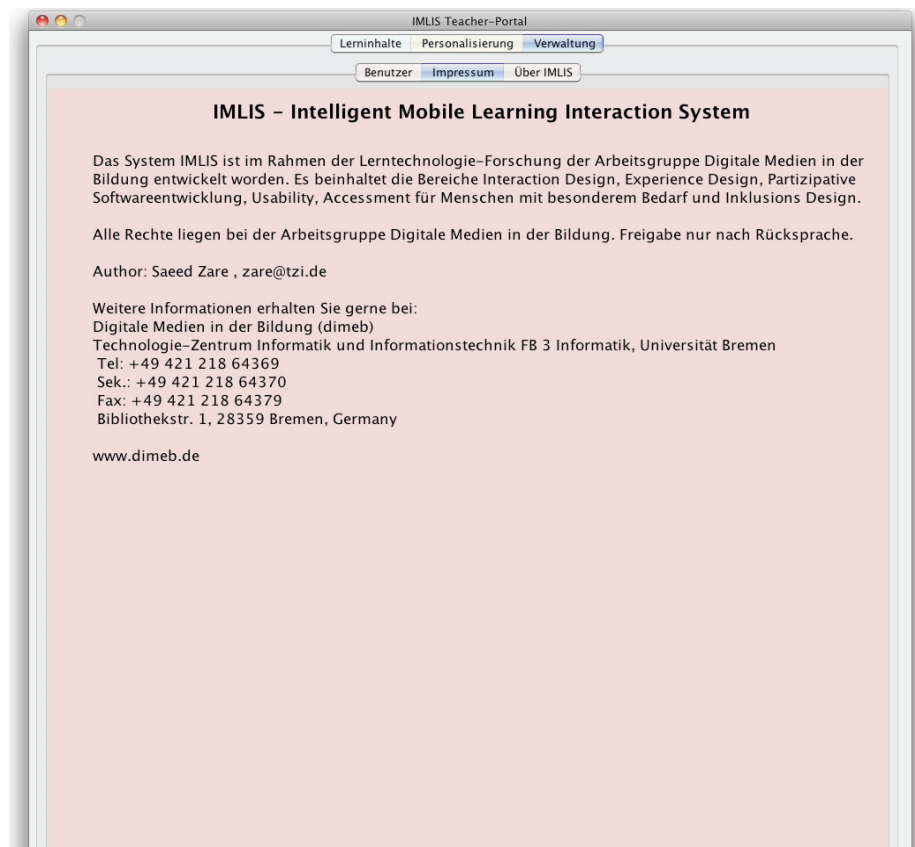Automatic messaging systems for learners

Learner's progress curves

Learner's learning process monitoring

Learner's learning plan page

Users administration

IMLIS imprint

Appendix D: List of Publications on IMLIS

Based on the topic of this doctoral thesis, different scientific papers were submitted and accepted at numerous international conferences. The following list is the published articles about different views of IMLIS contained in proceedings of selected international conferences. As author and primary researcher on the project, I wish to thank, a number of people who helped me by contributing to these papers.

Paper 1: Zare, Saeed., Schelhowe, Heidi., Lund, Michael.: Mobile based Personalized Learning for People with Learning Disabilities. Applied Human Factors and Ergonomics (AHFE) International Conference. Published in: Advances in Human Factors and Ergonomics in Healthcare. ISBN: 9781439834978. Miami, Florida, USA. (2010).

Paper 2: Zare, Saeed., Schelhowe, Heidi.: Intelligent Mobile Interaction: A Learning System for Mentally Disabled People (IMLIS): Universal Access in Human-Computer Interaction. Part I. HCII2009, LNCS 5614, pp. 412-421. Springer Verlag. ISBN: 978-3-642-02712-2. HCII2009 Proceeding, San Diego, CA, USA. (2009).

Paper 3: Krannich, Dennis., Zare, Saeed.: Concept and Design of a Mobile Learning Support System for Mentally Disabled People at Workplace. The International Conference on E-Learning in the Workplace - ICELW. ISBN: 978-0-615-29514-5. New York, USA. (2009).

Paper 4: Zare, Saeed., Krannich, Dennis.:Innovative Use of Mobile Technology for People with Learning Disabilities at Workplace. CHANGE AAW International Conference. Emden, Germany. (2009).

Paper 5: Zare, Saeed., Schelhowe, Heidi.: An Innovative Way of Learning: Adaptive Decision Mobile Learning System for People with Mental Disabilities. ICT that makes the difference. International Conference. ISBN: 978-90-73009-00-4. Brussels, Belgium. (2009).

Appendix E: Project Material DVD

Attached to this thesis, is a DVD which includes the materials and applications, associated to the project.

- IMLIS executable files
- IMLIS source code
- Application should be installed for continuous development
- Interviews with experts (audio and video)
- Photos of workshops

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Declaration

I declare that, I have carried out this work myself, all literally or content-related quotations from other sources are clearly pointed out, and no other sources or aids other than the ones specified are used.

I also confirm that this doctoral thesis has not been previously submitted or published in any national and international universities.

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