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Requirement Engineering for Knowledge-Intensive Processes

Reference Architecture for the Selection of a Learning Management System

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Sven-Michael Wundenberg

Requirement Engineering for Knowledge-Intensive Processes

Reference Architecture for the Selection of a Learning Management System

Foreword by Prof. Dr. Michael Bächle

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Sven-Michael Wundenberg
Laupheim, Germany

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Foreword

This constructivist Master Thesis discusses the development of a reference-architecture for the Learning Management System's (LMS) selection process in a polytechnic-knowledge-transfer organization.

The focus lies on the Requirement Engineering (RE) process's quintessence based on research about standard RE procedures and RE approaches combined with basic knowledge about LMS and best-practice experiences for LMS projects.

The resulting reference-architecture, particularly its frameworks and questionnaires, were tested prototypically in the real-life instance of a polytechnic school, the TA, and delivered outstanding results (rated by stakeholder-representatives and experienced providers of a commercialized LMS). The developed reference architecture was found to represent a solid, easy to use and well-structured guideline for the RE-process, the additional conceptualization and the creation of information necessary to consult the stakeholders.

This advisory information not only recommends which LMS fits the respective school's requirements, business-structure and objectives best, but also provides concepts for the consecutive steps of the LMS-implementation and -operation and it delivers objective data on cost structure and cost-effectiveness considerations in regard to the individual LMS. The reference architecture therefore features clear process models, checklists and a questionnaire which summarizes basic questions and the corresponding elicitation-circumstances for the requirement-elicitation process.

This thesis comprises information from the fields of RE, Knowledge Management Systems (KMS), E-Learning, and cost-utility analysis.

Prof. Dr. M. Bächle

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List of Abbreviations

Abbreviation	Denotation
BL	Blended Learning
BRS	Business Requirement Specification
BRSF	Business Requirement Specification Framework
CEA	Cost/Efficiency Analysis (see also CSA, MoE, MoS)
CM	Change Management
CSA	Cost/Suitability Analysis (see also CEA, MoE, MoS)
CSF	Critical Success Factors
ICB	IPMA Competence Baseline
JRD	Joint Requirements Development
KM	Knowledge Management
KMS	Knowledge Management System
KPI	Key Performance Indicator
LE	Learning Environment
LM	Learning Management
LMS	Learning Management System
LP	Learning Platform
MoE	Measure of Effectiveness (see also CEA, CSA, MoS)
MoS	Measure of Suitability(see also CEA, CSA, MoE)
OCM	Organizational Change Management
PKTO	Polytechnic Knowledge Transfer Organization = polytechnic university/ school
PLE	Personal Learning Environment
PM	Project Manager
RCM	Requirement Change Management
RE	Requirement Engineering
RefArc	Reference Architecture
RM	Requirement Management
RSD	Requirement Specification Document
SRS	System Requirement Specification
SRSF	System Requirement Specification Framework
SOP	Standard Operations Procedures
TA	Name of instance school
TCW	Total Criterion Weight
UI	User Interface
WBS	Work Breakdown Structure

Chapter 1: Introduction

1.1 Initial Situation and Purpose of Study

In modern academies or schools, a KMS constitutes a necessity to support the institute's organization and administration, to enhance the teaching and to promote the communication and the possibilities of data- or information-sharing. Furthermore, KMSs nowadays are a qualifying aspect and figurehead for the business image of a modern institute. Especially a business concerned with the conditioning and transfer of knowledge can gain advantages through the immense potential of Knowledge Management Systems and through the rising service level a KMS provides.

In the area of schools, academies and universities the need for specialized KMSs is high. Consequently, there are a large number of Learning Management Systems (LMS) which can provide those enhancements to the respective institute's core competencies.

This is a constructivist thesis, so the challenge is to formulate a general framework for the LMS selection process based on current scientific data, "best practice" and research as well as on survey and workshops to determine the stakeholders' wishes and needs. This framework should comprise guidelines, process models, selection-support-tools and examples for the data acquisition necessary to formulate requirement specifications, the compilation of use cases for the LMS utilization and the cost-/effectiveness contemplation (Cost Effectiveness/Suitability Analysis, CEA or CSA) to determine the LMS' effectiveness and its respective costs. The framework shall constitute a general means to support the LMS determination for polytechnic and vocational schools.

At present the TA, a polytechnic school, does not yet capitalize KM- or LM Systems but is resolved to expand its services by implementing an LMS. Thus the framework was tested prototypically by applying its methods to the life example of the TA with the aim to find a solution and utilization concepts for LMS employment.

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1.2 Goals and Objectives

The master thesis first objective, due in March 2014, is to devise a Reference Architecture (RefArc) for the introduction of an LMS into a polytechnic school. The architectures development shall be based on scientific research of LMS fundamentals, current best practice methods and “lessons learned” experience as well as on standard procedures for requirements engineering (RE).

The architecture shall cover:

- A framework for the recapitulation on the essential specifications and requirements, based on a survey, workshops and direct discussions with the stakeholders
- A subsequent specification of the necessary LMS modules and elements
- A framework for the selection process
- A framework for implementation and Change Management (CM)
- An operational concept framework
- A cost-benefit assessment framework
- An appraisal on two to three final choice LMS along the above criteria

The second objective is to test the developed Reference Architecture prototypically on a generic instance of a polytechnic school, the “TA”.
To evaluate the architecture’s cogency, its applicability and to find further room for improvement, the respective frameworks were to be employed in the instance of the TA. The result is a specification document containing:

- Recapitulation on the essential determining factors and requirements, based on site survey, census, workshops and interviews with the stakeholders
- A requirement specification containing the necessary LMS modules, features and further criteria
- An LMS implementation plan and Change Management recommendations
- LMS operation concepts
- A cost-effectiveness assessment including a deliberation of open source LMS vs. commercialized LMS services by a professional provider
- The resulting suggestions of the LMS selection process and consequently
- An appraisal on two to three final choice “off the shelf” LMS along the above criteria including recommendations for future adaptation and extensions

As architecture development and testing are conducted in close temporal context the objective is also due by the end of March 2014.

Sub-Objectives:

1. A background research in standard references and a selection of additional sources about the LMS fundamentals and common utilization experiences in order to find:
    - Current “best-practice” and “lessons learned” knowledge
    - Opportunities of “off-the-shelf” LMS on the market
    - A deeper understanding of the problems and possibilities in the LMS’ implementation.

Research results have to give answer to the following questions:

- What are the basic principles of the requirements engineering approach for a LMS requirements definition?
- What is the definition of and differentiation between a KMS and an LMS?
- What are the reasons and necessary pre-conditions to implement and use a LMS?
- Which suitable LMS are available on the market and what kind of services do they provide?
- What best-practice recommendation can be followed in the processes of implementation and later the use of the LMS?
- What are common problems and “lessons learned” in the mentioned processes?
- How can robustness, simplicity and user-friendliness be achieved?
- How can the LMS be designed and presented to gain the highest possible number of content users?

2. The realization of a survey accompanied by workshops and stakeholder interviews to gain an elicitation of the stakeholders’ requirements regarding the LMS and the utilization concept.
For the survey, between 50 and 80 sets of data from the chosen stakeholder groups are planned to be achieved.

Theoretical Part

Chapter 2: Knowledgebase for the RefArc Development

In this chapter an aggregation of fundamentals and principles of RE and KMSs (respectively LMS) in regard to the objectives will lead to formulating the thesis' problem domain.

2.1 Requirement Engineering (RE)

Designing a RefArc in correspondence with this thesis' objectives is primarily a requirement engineering task, centered on process modeling, checklist assembling and template designing.

2.1.1 Definitions

To analyze the RE process, the necessary definitions for requirement, requirement engineering and requirement documentation are:

Requirement:

A requirement is a condition or capability needed by a user to solve a problem or achieve an objective (Institute of Electrical & Electronic Engineers, 1990). Requirements describe user-level facilities, general system/product properties, specific constraints of system/product or constraints of the development (Cockburn, 1998).

Requirement Documentation:

Requirement documentation is the official statement of the system requirements for costumers, end users and software developers/engineers (Cockburn, 2001).
In German speaking countries two types of documents are differentiated:

- Business Requirement Specification (BRS) ➔ what is needed
- System Requirement Specification (SRS) ➔ how it should be build

In English speaking countries, these two aspects are often incorporated in a single document called Functional Specification or (Software) Requirements Specification (Institute of Electrical & Electronic Engineers, 1990).

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Requirement Engineering:

In lack of a common definition, for the purposes of this thesis the term requirement engineering shall be defined as:

All activities involved in discovering, documenting and maintaining a set of requirements for a system or product.

It implies that systematic and repeatable techniques should be used to assure completeness, consistency and relevance of the description (Robertson & Robertson, 2012).

RE can be subdivided (see Appendix E) into the requirement elicitation, requirement analysis, requirement specification and requirement validation. Those are overlapping and often iterative steps in the RE process (Institute of Electrical & Electronic Engineers, 1990).

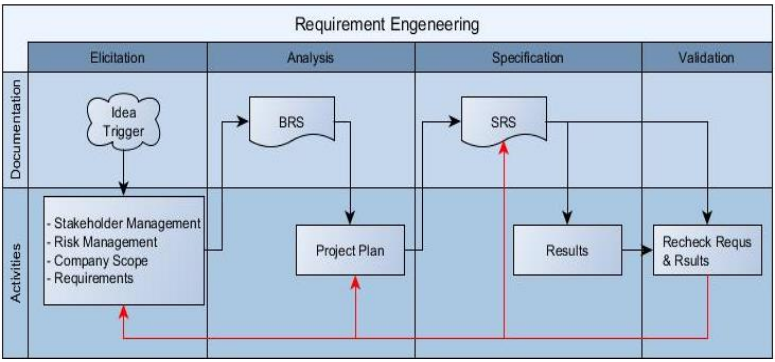

Figure 1: RE Process Model

2.1.2 Requirement Elicitation

The first step in the RE process is the data collection and requirement elicitation. According to the Robertsons (1998, 2003) this includes:

- Trigger for the RE,
- Stakeholder analysis and management,
- Risk management,
- Information about the company's vision, mission, business structure as well as goals and objectives (to create a scope for the RE),and
- The requirement elicitation itself via interviews, surveys, workshops and brainstorming.

The necessity for new requirements can be instigated by legal triggers (regulations, law or standards) economic and strategic causes (product change, profit or organizational change) or technical reasons (new technology, technological problems) (Pohl, 2008).
RE is strongly building on the stakeholders' scope, wishes, and needs. To design the requirements according to those, it is elementary to understand the stakeholders' visions, missions, their objectives and goals as well as their business structure and possible project risks (Robertson & Robertson, 2012).
Consequently, becoming acquainted with the stakeholders and business is the first and most important step as this will carry influence throughout the entire RE process. As stakeholders' backgrounds and objectives may vary widely, it is important to differentiate between the respective stakeholder groups, rather than seeing them as homogeneous (Lamsweerde: & Lamsweerde, 2009).
Stakeholder and risk analyzing tools like portfolios are essential, as are blue sheets on vision, mission and objectives, and business structure, in regard to the requirements that are to be elicited and to be incorporated constantly. Doing so, the company's scope for the project can be framed (Robertson & Robertson, 1998).

The actual requirement elicitation can start once the scope is established, and will employ all means of data acquisition (see Figure 2 and Appendix A). The quality demands for the elicited data are portrayed in 2.1.4.

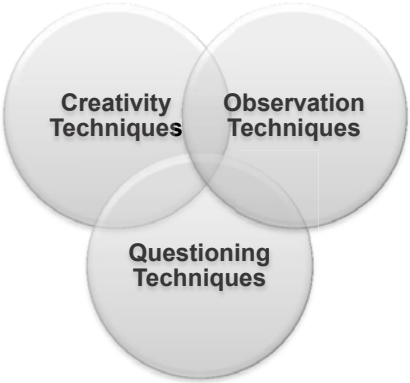

Figure 2: Requirement Elicitation Techniques

2.1.3 Requirement Analysis

After a thorough data acquisition, which does not end with the beginning of the analysis phase (Alain Abran, 2004), the data needs to be analyzed and put in perspective. Continued stakeholder involvement is very advisable (Institute of Electrical & Electronic Engineers, 1990). The data will be translated into requirements and those can be classified, weighted, organized and prioritized (must-, should-, may- and must-not criteria). If necessary, immersed information can be gathered and requirements can be particularized (Robertson & Robertson, 1998).

Robertson (2012) mentions the following criteria for the analysis as:

- Interconnection: Check the separate requirements for interconnections. Do they have a causal relation or can they be implemented independently?
- Association: Group and implement the requirements. Which belong to one special field?
- Role relation: Consider every user/stakeholder individually. Each may have a different view and different requirements. Which must be taken into account?
- Planning: First thoughts on the project planning and realization should be part of this phase.

2.1.4 Requirement Specification and Documentation (RSD)

The step of Requirement Specification and its Documentation, the RSD, contains the finalizing of the requirement into a written down and agreed on document as a foundation for implementation, prizing and jurisdiction.

Within the specification, the requirements are normally allocated to types like non-functional or technical requirements (see Appendix B).

The requirements should fulfill certain quality standards (Institute of Electrical & Electronic Engineers, 1990) (see also Appendix C):

- Correctness
- Unambiguousness
- Completeness
- Consistency
- Verifiability
- Modifiability
- Traceability
- Understandability
- Feasibility
- Necessity

The structure for an RSD typically orientates itself towards the project's work packages and the Responding Work Breakdown structure (WBS) (see Figure 1) (Institute of Electrical & Electronic Engineers, 1990).
Normally, multiple extra documents to specify certain aspects of the RSD like Use Case Diagrams, Approval Documents, Configuration and Design templates or Test Cases are added to the RSD (Robertson & Robertson, 2012).
The RSD's level of detail is largely dependent on the following factors (Institute of Electrical & Electronic Engineers, 1990):

- normal practice of organization
- contracting out the system development/production to another company (more detailed)
- 1st step: high-level description, 2nd step detailed specification
- Stakeholder requirements/ user requirements
- System requirements

Often the analysis, specification and documentation happen parallel and interconnected to each other. Consequently, a versioning system should be used to keep track on the editing status (Robertson & Robertson, 2012).
Detailed templates and instructions on the compilation and writing of an RSD can be found via the Internet. One good example is the "Volere Template" (Robertson & Robertson, 2003). Further pointers to the writing and compilation can be found in Appendix D.

2.1.5 Requirements Validation

As the requirements may need to be refined in the processes of the requirement specification or implementation, a constant validation and quality assurance/ control of the requirements needs to be in place (Robertson & Robertson, 2012).
According to Schienmann (2001), the requirements have to be checked in regular intervals according to the following quality characteristics (see also Appendix C):

- Consistency
- Feasibility
- Necessity
- Priority
- System Usability

2.2 Knowledge Management vs. Learning Management

Within the wide field of interactive media in the Web 2.0 frame, there are several instances of vertical and horizontal specialization. One of those areas of specialization engages in the creation, transformation, acquisition, structuration and cataloging, storage, transfer, validation and sharing of knowledge (Gray, 2009).
A kind of specialization of those Knowledge Management Systems is represented by their derivations used in the knowledge-transfer-service-sector of schools, universities and other knowledge transferring institutes, namely the Learning Management Systems.

For a better grasp of the communalities and differences between KMS and LMS the definitions and differentiations of those terms are necessary.

2.2.1 Definitions: KMS and LMS

To understand the nature of a KMS, the term Knowledge Management needs to be set perspective first:

Knowledge Management System:
According to CWA 14924-1 (CEN, 2004), KM is the management of activities and processes for leveraging knowledge to enhance competitiveness through better use and creation of individual and collective knowledge resources.

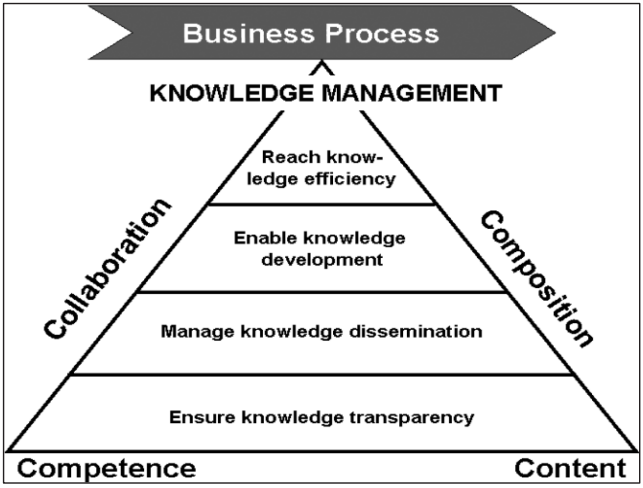

Figure 3: KM Layers and Areas (CEN, 2004)

It can be argued that this definition is not extensive enough and that human-oriented KM (psychological and sociological perspective – the employee is the relevant knowledge bearer) and technology-oriented KM (IT as enabler of KM – Databases and software are key success factors) should be combined into a holistic approach in which the innovative, creative potential of the KM users will be encouraged and supported by IT-based information systems.

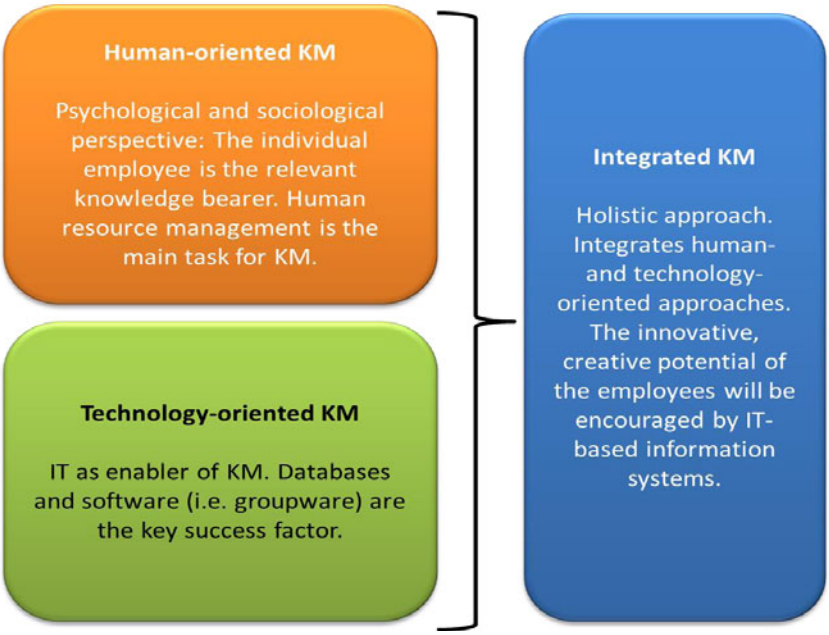

Figure 4: KM Definition

By this definition of KM, a KMS is a form of Web 2.0 based social computing tool specially designed to support the KM processes by providing integrated features, e.g. wikis, blogs, communication devices etc. (Kalz, Schön, Lindner, Roth, & Baumgartner, 2011; Swanger & Whitlock, 2011).

Learning Management System:
The term Learning Platform (LP) or Learning Management System characterizes a complex, often web based software system which pools multiple task specific subprograms under a shared User Interface (UI). These subprograms support, for instance:

- Allocation and organization of learning content for different learning scenarios
- School administration
- Information management
- Online school business related communication.

So the LP or LMS serves as a further interface between students and educational service providers (Baumgartner, Häfele, & Maier-Häfele, 2002), and its multi-media environment hugely enhances the learning experience by providing input signals for multiple human sensory organs. Internal and external communication and administration are supported by distinct communication, administration and information structures (Farmer, 2010).

2.2.2 Differentiation and Evolution: From KMS to LMS

Modern companies often intend to support and promote their business by the means of using Enterprise 2.0 software, which are collaborative Web 2.0 based, emergent social media software tools, to enhance the internal and external communication, knowledge creation, organization and conservation, and project coordination (Koch & Richter, 2009; McAfee, 2006). Often this will be combined in KMSs.
As the company's vision, mission, goals and objectives, its needs and its business intents and structure largely determine the KMS's layout and concepts, a KMS usually needs to be adapted (Riempp, 2003). In the case of knowledge-transferring business, as in schools or universities, this adaptation accounts for a whole new and specialized kind of KMS (Back, 2002), the LMS.
So an LMS basically has to constitute the complete KMS construct (Figure 5), including the basic IT-, database-, and integration infrastructure and the determining strategy and process levels, but with an emphasis on chosen pillars. The major differentiator for an LMS is its "instructing nature" (Piña, 2010).

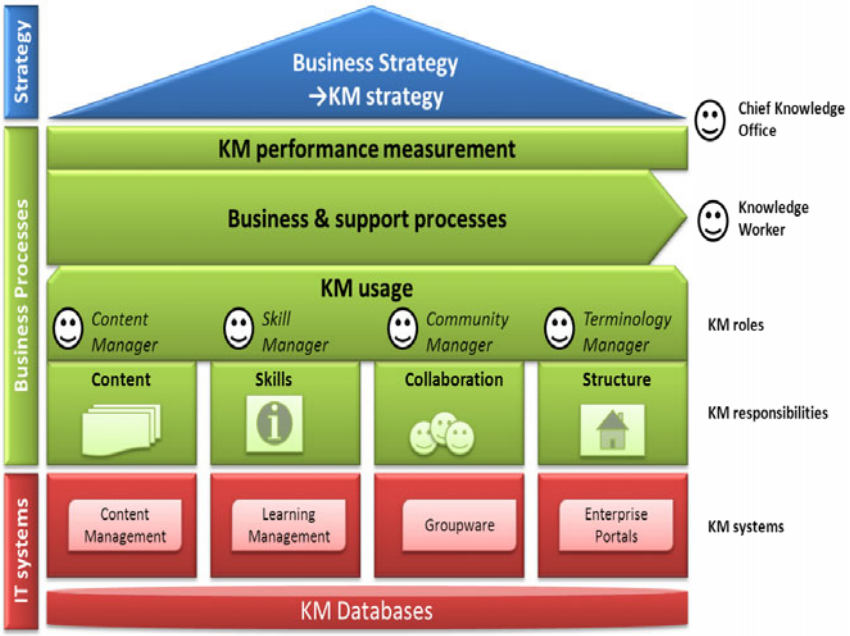

Figure 5: Architecture for an integrated KMS (Riempp, 2003)

Consequently, an LMS is a derivation of a KMS for a specialized company with its attention and business intent centered on skill and knowledge conveyance Therefore the specialized needs in supporting this task lead to a layout which enhances internal and external communication, skill-transfer, group- and content management and the support for the daily business (Back, 2002). Compared to the KM factors of the CWA 14924-1, the activities of knowledge creation, transformation, workflow integration and application for product or service advancement (except for school-services) are less emphasized.

By following these specialized needs, modern LMSs often excel in providing user friendly:

- Learning environments (so called class- or learning areas), to assemble and deliver learning content rapidly
- Communication features like e.g. chat rooms, forums, virtual video meeting places
- Modules to consolidate training initiatives on a scalable web-based platform
- Content- and group structure to organize faculties, topics and classes
- Direct access to relevant information like schedules, plans, current news
- Organizational features like student, staff and source databases for the school administration
- Tools for centralizing and automating administration
- Tools for self- and self-guided services
- Apps to support mobility, portability and standards
- Personalized content and knowledge reuse functions

to support the learning experience and success (Dżega & Pietruszkiewicz, 2011; Piña, 2010).

As the possibilities for the application of online learning are diverse, the LMS has to be designed to support the institution's preferred forms. Derived from the original E-Learning idea, a consensus evolved that Blended Learning (BL) supports the largest portion of those users who are interested in E-Learning (Breu, Guggenbichler, & Wollmann, 2008), but in individual cases other forms may be preferred (Piña, 2010).

2.3 Typical LMS modules, features and elements

Typically an LMS consists of a web based user interface which bonds several applications and features together (Folden, 2011). Those modules belong to one or more of the pillars depicted in Figure 5. Figure 6 illustrates the most common modules within the respective pillar (Itslearning, 2013; Mahara, 2013; Piña, 2010; Stud.IP, 2014).

Those models are of variable relevance depending on the stakeholders' needs. So the required LMS configuration may differ from school to school, and the requirement definition and weighting gains major importance (Salmon, 2004).

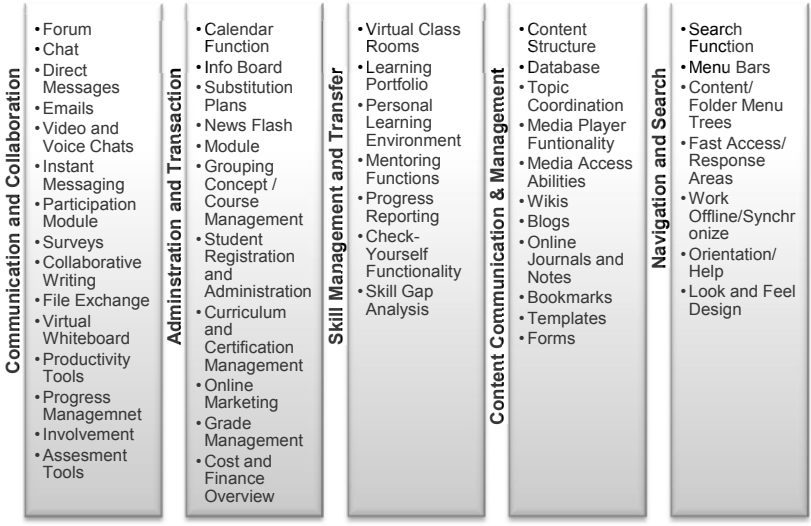

Figure 6: Common LMS Features

The significantly positive attitude of students and teachers towards their individual LMSs (Kvavnik & Caruso, 2005) mainly derives from the advantages is gained through certain features (Piña, 2010):

- Various ways of content and knowledge transfer; communication, assessment and administration of online instruction into a single secure platform that can be accessed by anyone on the Internet (Dabbagh & Bannan- Ritland, 2005, Ullman & Rabinowitz, 2004 as cited by (Piña, 2010))
- The standardized interface of an LMS makes it easy for students to navigate through information, courses and groups.
- The secure password-protected nature of an LMS limits access of instructional resources to users enrolled in the course (Gibbons, 2005), and provides data- and copy-right-security.
- Delivering information and instruction to mobile devices takes advantage of research indicating that many users are increasingly relying upon mobile devices.
- Outcome assessment systems, which work in cooperation with the LMS, support the students' self-evaluation and the teacher-student-evaluation

Furthermore, an LMS also has to represent a number of characteristics to satisfy the stakeholders' needs (Breu et al., 2008; Salmon, 2004):

- User friendly, intuitive design and self-explanatory functionalities
- Adequacy for the users' levels of experience and knowledge
- High system robustness against data-loss or system failure
- High data security standards
- Easy accessibility
- System flexibility for schools' individual configurations and concept adaptations

2.4 LMS in Learning Organizations

The Implementation of an LMS requires knowledge on how to approach the task, awareness of the reasons for the implementation, and awareness of the desired types of LMS application and learning support.

2.4.1 Approaches and Reasons to/for LMS implementation

Kerres (2012) distinguishes two different approaches of LMS implementation, Top-Down (initiated through the schools' managements' visions) and Bottom-Up (initiated through the students' demands and requests). He also highlights several reasons for both approaches. Experiences at German universities (Kruse & Tan, 2011) show that often a combination of both methods is used, based on the combined reasons for the LMS introduction into the educational facility. As the reasons may vary widely between the respective schools, a selection of prevalent reasons will be given.

To meet the high competition in the professional polytechnic school market, modern appearance and media-professionalism are constantly gaining in importance. Changes in student population trigger changes in teaching and learning methods. Nowadays, students participating in learning processes are part of the so called "digital natives", the generation that has grown up with digital technology (Mladenović, 2011).

In modern teaching and learning processes, the learning group is composed of students with different cognitive competences if compared with previous student-generations (Prensky, 2001). Students nowadays have computer literacy; they are very accustomed to internet technologies and being online; they expect immediate

answers to questions posed; prefer learning through experience; have a highly expressed interest in social interaction (so therefore are willing to accept anyone into the group who is a friend of their friend or otherwise connected); prefer working in groups, and look for interactivity within rich-interface-environments (Mladenović, 2011).
Beside the common student population, the importance of part-time-student populations is growing, as the enrollment rate for part-time- or distance-education is ten to fifteen times higher than the rate for fulltime education (E. L. Allen & Seaman, 2007). Those groups have higher and slightly different needs in media-learning-support (Hewitt & Forte, 2006).

Another common reason for the top-down approach is the growing collaboration between educational facilities, or with external companies/industries. Moreover, a regional or national standardization of educational media usage is propagated in several areas (Kruse & Tan, 2011). A highly linked network of online-learning-platforms fostering the worldwide online-education will come into existence, resulting in the fact that individual schools will have to participate or suffer tremendous setbacks compared to their competitors (Rovai, 2004).

A typical reason for bottom-up approach is the informal organization of students into learning- or working-groups. They use social media, cloud sourcing and the Internet extensively in their pursuit of their respective tasks. Coordinating those activities by providing a platform will gain the school a higher customer satisfaction and data-security (Kruse & Tan, 2011).

A shared striving between students and educational-service-providers for time and money optimization, support for administration and organization, and the search for new means of communication are applicable reasons for both approaches (Kerres, 2012; Kruse & Tan, 2011).

Table 1 will give a basic overview over the two approaches:

Approach	Bottom-Up	Top-Down
Proceeding	One faculty or one department starts using an LMS, afterwards other faculties/departments start participating	The key administration pushes the integration of an LMS into the university
Advantages	• The LMS is chosen based on user demands. • Users have concrete ideas and request to use the LMS. • High intensity of usage in courses • High satisfaction with the chosen system refinement • Participation by the users is higher	• High frequency of usage. • Academic staff might get interested in the didactical possibilities during administrative usage. • Other IT systems used at the university can be connected to the LMS support • Authentication can be organized centrally from the beginning. • Students can use one single LMS and not different ones in their subjects.
Disadvantages	• Low number of users. • Coexistence of several LMS in different faculties or departments. • Redundant workload for supporting the different LMSs. • If one LMS is chosen to be the general one at that university: difficulties to merge the different users and data to one LMS. • Several login data for academic staff and students. • Users might have to handle different LMS interfaces. • Other IT systems are most likely not to be connected to the several LMS	• Focus is possibly on administrational processes. • Didactical possibilities might play a minor role. • People might be displeased by the fact that one LMS is forced when they have used another one before. • The LMS might not fulfil the special needs of some academic staff or departments. • Lower intensity of usage in courses
Rate of usage	• Low usage • Few users in the beginning, can increase rapidly	• High usage • Many users from the beginning
Kind of usage	• Didactical focus	• Administrative focus

Table 1: Overview of the two approaches (Kruse & Tan, 2011)

2.4.2 Awareness of Acceptance Factors and the LMS-Application-Type

To utilize an LMS successfully and economically the stakeholders'/users' acceptance of the LMS is critical. Many factors influence the users' acceptance. Al-Busaidi and Al-Shihi (2012) believe the factors depicted in Figure 7 to be critical.

Therefore an adaptation – as accurate as possible - of the LMS to address these critical factors seems to be the best way to ensure the stakeholders' acceptance. Critical parameters regarding the LMS features have to be identified and weighted.

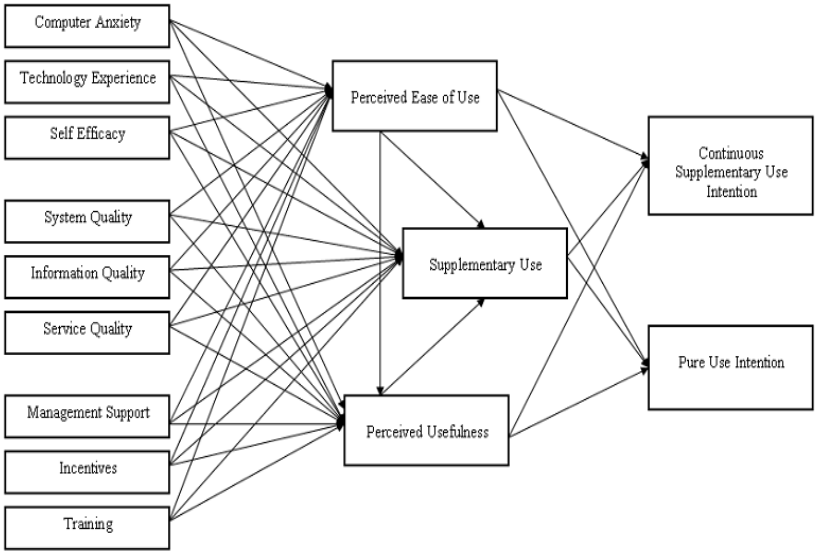

Figure 7: Critical Factors for LMS Acceptance (Al-Busaidi & Al-Shihi, 2012)

Baumgartner et al. (2002) consider the following parameters to be the most applicable:

- Communication possibilities (like internal messages, chats, discussion boards)
- Didactical advantages (like online exercises, tutorials, learning diaries)
- Administrative possibilities (like participant lists, dividing participants into groups, configuration of the whole system based on one's needs)
- Technical possibilities (like stable operation, adaptability to individual means, interoperability with other IT systems, data protection, support)

Salmon (2004) identifies two additional fundamental parameters:

- Design (how attractive, user-friendly and clearly laid out is the LMS)
- Usefulness (which advantages does the LMS offer to the respective user)

Following the argumentation of Rovai (2004) and the creators of the "itslearning" LMS (Itslearning, 2013), another critical factor can be determined:

- networking (how good/useful is the LMS's interconnection with other social media or LMSs of collaborating schools and companies)

As these parameters are regarded as of different importance in every educational institution, they have to be weighted individually to gather a basic picture of the LMS's requirements for the respective institution (Baumgartner, Hartmut, et al., 2002; Kalz et al., 2011; Kruse & Tan, 2011). An extended list of Critical Success Factors (CSF) (Robertson & Robertson, 2012) (Re.ViCa, 2009) can be found in Appendix G.

2.4.3 Type of eLearning – a Fundamental Selection Criterion

An LMS, as described in the definition and differentiation section, specializes, inter alia, in providing an optimized eLearning platform. As the application of online learning differs widely between different schools, caused by different business orientations, the awareness of the individual type of online teaching is essential.

ELearning evolved from a combination of the traditional classroom learning combined with online and multimedia tools to a distinct form of education. Although there are many mixed forms, it is typically divided into the field of distance learning (use of telelearning, only without corporeal attendance to a school) and blended learning (Support of school-bound education through eLearning options) (Folden, 2011). For a depiction of the eLearning evolution see Appendix F.

To determine the respective school's preferred type of eLearning, a deeper understanding of the school's vision, mission, goals and objectives and the business structure is necessary (Riempp, 2003). This can be gained by interviewing the stakeholders intensively. As described in subsections 2.1.2 and 2.4.2, the stakeholders' requirements, in this case regarding the type of online-learning, is of the utmost importance for successful LMS operations. The archetypal stakeholder arrangement can be found in Figure 8.

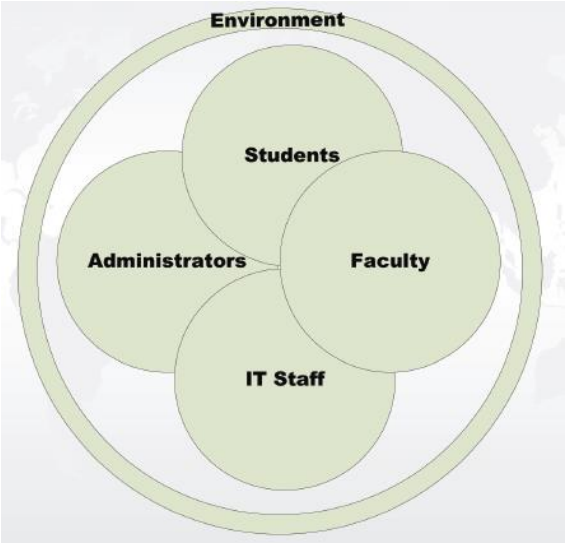

Figure 8: Stakeholder Arrangement (Folden, 2011)

2.4.4 LMS Design – Past, Present and Trends

The chosen and adapted LMS should support the desired style of eLearning. A short summary about LMS design history and trends will help to get an overview about what this entails.

LMSs were originally designed as a document storehouse and a method of distributing content from the instructor to the user (Baylen & Hancock, 2010). This pattern is now being confronted. Open-source-, social networking software or Google threaten the position of the commercial learning-management-system (Young, 2009 as cited by Baylen & Hancock, 2010, p. 81), but constant progress in the LMS development leaves to expect the next generation (or perhaps replacement) of the LMS (Baylen & Hancock, 2010).

Trends in the markets and new prerequisites arise. Current studies show that the growing number of LMS users are favoring mobile technologies over, and perhaps additionally to, desktop and notebook computers and are adept at using the advanced features of these technologies for both entertainment and communication (Rainie & Keeter, 2006; Rainie & Madden, 2005).

Many LMS-service providers now provide mobile-apps for smartphones, PDAs and tablets. Providers failing to catch this trend already notice sales problems and a de-

cline in costumers (Krumm, 2012), but the LMS-market is just beginning to react to this new challenge constituted by the explosion of the Web 2.0 activity that is becoming a routine part of students' lives (Baylen & Hancock, 2010).
The web is growing increasingly participatory. Modern LMS consumers are active content authors, collaborators and contributors. However, the already established blog-, chat-, forum-, and wiki-modules most modern LMS have already incorporated, will not be sufficient for future LMS applications. New user-friendly means of student involvement with fast and easy access need to be designed (Baylen & Hancock, 2010).

The focus of the LMS will be put increasingly on the multi-media, multi-sensory Personal Learning Environment (PLE), which incorporates audio-visual communication and information systems. Cloud sourcing, worldwide content- and learning tracking, just-in-time-learning and talent management are the current buzz-phrases regarding the near future of LMS design (Bhatia, 2014).

2.5 LMS on the market

2.5.1 Commercial Categorization of LMS

LMSs are mostly grouped into three different categories regarding their commercial status: In-House-, Open-Source- (OS) and Corporate-/Commercial-Solutions (Frankfurth, 2010; Krumm, 2012; McIntosh, 2014; Piña, 2010).

In-House LMSs are self-developed, often highly aligned, LMSs. They are often used to get a best-fit solution but with the disadvantage of high effort for maintenance, actualization and development (McIntosh, 2014).

Open-Source LMSs are for the most part LMSs developed by interest-groups using open development structures and allowing a no-cost software-application on a user-allocated server. All administration- or maintenance-work is to be done by the school single-handedly (McIntosh, 2014).

Commercial LMS-Service-Providers normally offer their own LMS solution or a supported OS Solution. In this case the LMS normally offers extensive features and a high rate of support regarding technical administration, help-desk and even cloud-space (McIntosh, 2014).

Sometimes those distinctions are further subdivided into Corporate and Education LMSs, with the distinction being that Companies (Corporates) will need more course planning, while schools, having already course planning in place, will focus on the distribution of the learning content and thusly on the educational versions (McIntosh, 2014). Nowadays this distinction is blurred and the systems are adapted to the individual company or school, impartial to this subdivision and more dependent on individual requirements (Frankfurth, 2010).

Another differentiation is standalone vs. integrated LMSs, distinguishing whether an LMS is integrated into other campus systems and LMS-cooperation-networks or standing on its own to fulfill only a distinct task (Piña, 2010).

As there are hundreds of different solutions available on the market, finding the right one takes a lot of effort, organization and a structured selection process (McIntosh, 2014; Piña, 2010), which incidentally this thesis is about. This is also the reason why only a few selected LMS possibilities will be mentioned within this subsection.

2.5.2 LMS Benchmarking – Standards in the Market

A good way to get a first impression and an idea of the LMS options on the market is to benchmark which LMSs are used by school with a similar focus. This will provide an idea of how LMSs can be utilized, and it may already offer some first- and second-hand experience with the system (McIntosh, 2014).

However, as already mentioned, selection, implementation and utilization are highly dependent on the stakeholders' and the organizations' vision, mission, objectives and business structures. These may already differ between schools with similar educational focuses. Consequently, the requirements will differ as well as the desired way of LMS operation (Frankfurth, 2010; Rovai, 2004).

Many consulting companies, like Saba or Solics, specialize on LMS-benchmarking, -selection and -consulting. Moreover, many lists of LMSs on the market can be found on the Internet. Often those already have some benchmarking-features and provide user-comments and/or experiences as well as links to testing foundations like "Stiftung Warentest" (Barrish, 2013; EduTech, 2014; Re.ViCa, 2009; Solics GmbH, 2012).

In the next subsections a small selection of commendable LMSs centered on the German market, will be given. For web-links to lists of LMS see Appendix H.

2.5.3 Commercialized LMSs

According to Euler (as cited by Frankfurth, 2010), eLearning increasingly has increasingly become a business to make money with. The application of media-didactic technologies provides a vast market to profit from, says Euler. Especially with the demand for eLearning on mobile devices and through the high rate of technological evolution, commercial LMSs have dominated the online-education market for several years now (Leal & Queirós, 2011).

As costs increase, schools and companies are now looking for other options such as OS-solutions that are financially more attractive. However, the cost-comparison has to be done carefully, as OS-solutions often come with hidden costs and efforts (Leal & Queirós, 2011). Professional service providers normally include the costs for hosting, implementing, administrating, maintaining the system into their pricing-structure, as well as the costs for providing cloud space, training the school staff and regularly updating the system.
Other important benefits of commercial LMS solutions are the outsourcing of the security requirements and the provider's higher professionalism in the necessary services.

The most well-established commercial LMSs on the German market at the time of this thesis are (Baumgartner, Häfele, et al., 2002; Runge, 2014):

- "Itslearning®"
- "Blackboard®"
- "EDYOU®"
- "Global Teach®"
- "Learning Space®"
- "ILearning®"

2.5.4 Open Source Project LMS

OS-solutions have financial and programmatic appeal for the stakeholder (Stewart, 2007), but also carry a specific philosophical attitude in regard to open development, commitment to, and dependency on external companies.
In an open source environment, the source code is available free of software licensing fees and free of contractual agreement with a specific provider. Moreover, a program or system based on open source software may be customized and branded

according to a user's or institution's needs and desires (Breu et al., 2008; Krumm, 2012; Piña, 2010). This, however, may require in-house development.

The OS developer community, which fosters the OS software, is diversely active for the respective OS-LMS, so this has to be factored in before choosing an LMS (Breu et al., 2008; Piña, 2010).

The best known OS solutions (Baumgartner, Häfele, et al., 2002; Runge, 2014) are:

- "Stud.IP®"
- "Moodle®"
- "Sakai®"
- "Ilias®"
- "Mahara®"

Many other solutions are available and the importance may vary widely in different regions worldwide.

2.6 Composition of the Problem Domain

This thesis' objectives constitute the need for a "Reference Architecture", so the thesis basically is about the constructivist creation of this RefArc based on research and best practice.

The necessity for such a RefArc is derived from the need for an individual adapted LMS in any respective educational organization and the high number of possible solutions on the market.

Sound requirement engineering is the foundation for a well-designed selection process and an equally well-designed LMS in operation, as the LMS has to be adapted and tailored to satisfy the user's needs and to support the respective business structure in an optimal way. Therefore the choice of the right LMS basis, the conceptualization of the adaptations and the utilization are of essential interest.

The RefArc shall help to identify the school's requirements for an LMS, to compare and evaluate the contestants with the help of the requirements, to develop implementation- and utilization-concepts and to assess the expected cost-effectiveness ratio.

To provide an optimized solution to an organization in search of an LMS, requirement specifications and systematized, generally applicable and scientifically founded selection and evaluation processes have to be devised.

Consequently, the problem domain is inherent to the area of requirement management while also being connected to the fundamentals and best-practice know-how in the following fields:

- LMS basic knowledge as well as understanding of LMS selection, implementation and application
- Project Management (to structure the selection and implementation process effectively and efficiently)
- Data acquisition principles (for the elicitation and weighting of requirements and the gathering of necessary information for the project)
- Conceptualization and process modelling (to support the utilization and support the realization of the requirements)
- Statistic evaluation and utility-analysis (to objectively support the LMS evaluation along the requirements and to enable an objective comparison between the LMSs)
- Economic analysis (to compare cost and outcomes of LMS employment, and to illuminate cost structure and find hidden costs to contrast different kinds of LMSs like open source solutions vs. LMSs from professional service providers)
- Change Management (to support the implementation process and include the stakeholders in the processes and hereby ensure higher LMS utilization and thus higher economic value)
- Business counseling (to present the requirements, results and recommendations appealingly to the stakeholders to grant agreement to the findings)

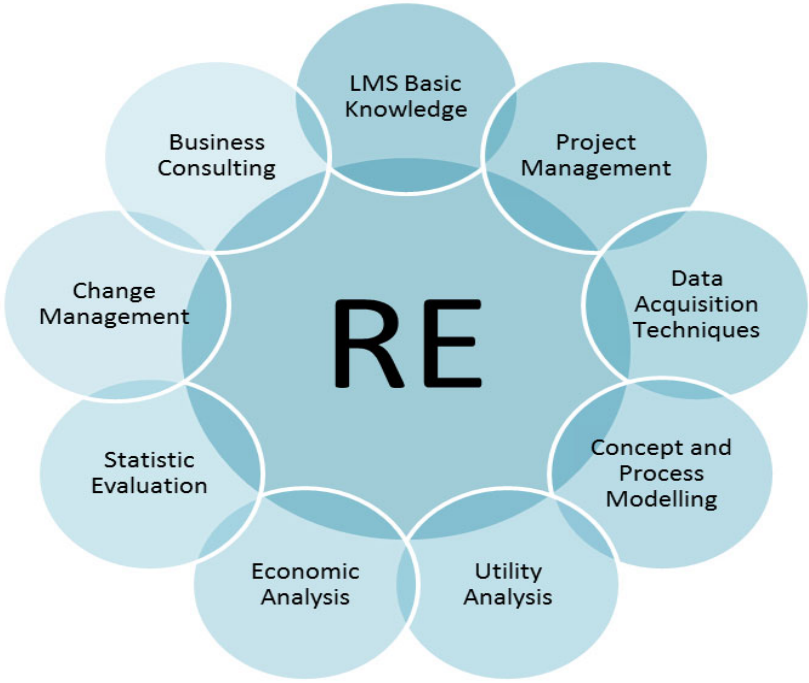

Figure 9: Problem Domain

Constructivist Part

Chapter 3: LMS Reference Architecture Development

Building on the 2nd chapter's theoretical basis, this chapter is about combining research results of LMS-best-practice-experience with the RE to create a general and practically applicable RefArc for the LMS selection and operation-planning processes. General process models, checklists and templates to aid in the actual requirement elicitation and conceptualization processes are the outcome.

The general structure for the RefArc is derived from the RE-principals described in 2.1. This will be complemented by the LMS-know-how research foundation.

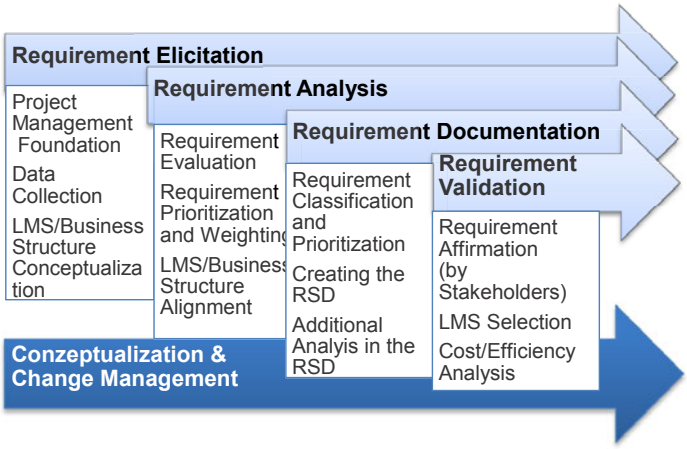

Figure 10: RefArc Steps aligned to RE structure

3.1 Requirement Elicitation Framework

The first step is the requirement elicitation (Robertson & Robertson, 2012) in order to:

- Draw a picture of the initial situation
- Know the reasons and triggers for the implementation enterprise
- Understand the stakeholders and their goals
- Understand the company/school, its vision, mission, business structure and objectives
- Collect the data and impressions necessary for the next steps of analyzing and formulating the requirements

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The following subsections will provide an outline of the areas in which necessary information needs to be gathered. Within the RefArc (Appendix J), this results in:

- Process-sequence and questionnaire-template (Chapter 2 of the RefArc)
- Process-models, checklists and suggestion-collections for the conceptualization (Chapter 5 & 6 of the RefArc)

3.1.1 Project Management – Foundation of the RE

Best practice for all RE-Projects is to use the general steps and tools of a project management approach. This means getting acquainted with the organization, its stakeholders and the reasons for the project. Subsequently, the risks can be assessed. Specifically for RE-projects, the data collection can be realized.

Business Structure Management:

The required LMS is highly dependent on the vision and mission determining the business and its goals, objectives and structures (Riempp, 2003). So to achieve optimal results, the LMS must be aligned to the business at hand (Frankfurth, 2010).

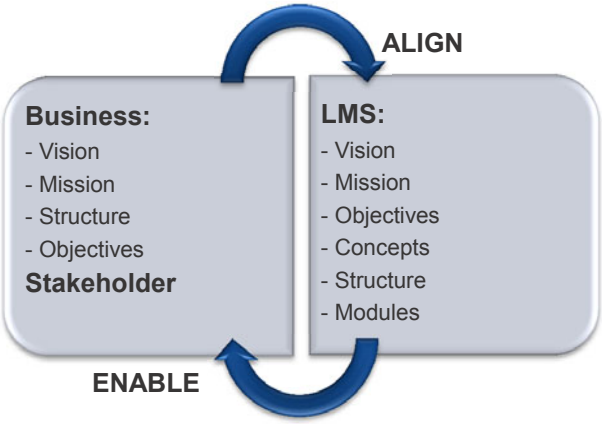


Figure 11: Business/LMS Relation (Frankfurth, 2010)

For practical application, this means that the information gathering process must start with determining aforementioned issues about the organization by interviewing the stakeholders and especially the school's management and administration. This is not a single interview but a repetitive process going along with the requirement elicitation and analysis (CEN, 2004).

Trigger Management:

Closely related to the business structure management is the examination of the reasons which are triggering the desire for an LMS application. Those triggers, the objectives for the LMS-operation and the stakeholder management are pinpoints to constantly remain on screen, as they are the center for the project (CEN, 2004).

Those reasons may vary widely and may be stakeholder-specific, so a good practical option to keep track of the stakeholders' whishes would be a Stakeholder-Intention-Matrix which could be displayed on top of the Central-Project-Board (a tool often used to organize and visualize the project) (CEN, 2004).

Stakeholder Management

Stakeholders are the RE-projects defining customers (Figure 8 & Appendix I), and as such their ideas, needs and whishes are central to the project. Experience in RE shows that constant stakeholder involvement may be detrimental, but the stakeholder inclusion should be as high as possible and as low as necessary to keep the workflow smooth (Robertson & Robertson, 1998). In practical application, this may be achieved through regular meetings and interviews in which feedback and further data gathering can take place. The stakeholders are the main source of information for the requirement elicitation process (CEN, 2004). Moreover, they set the type of approach (top-down, bottom-up) for the project, which is essential for the definition and weighting of the requirement (Kerres, 2012).

Typical stakeholder management tools like stakeholder-portfolios, communication-charts and requirement matrices should be applied prudently (Schienmann, 2001).

Risk Management

In any project, there are a multitude of risks prone to jeopardize the RE project's success. Experience in project management shows that it is essential to keep track and control of those risks, and to prepare emergency plans and "What If"-scenarios (Caupin, Knöpfel, & Morris, 1999).

Generic project management issues of the RE shall not be discussed further in this thesis, although knowledge of these issues and tools are important. For more detailed information, see the references Caupin et al., 1999; CEN, 2004a; Robertson & Robertson, 2012 may be considered commendable.

3.1.2 Data Collection

The first parts of the data/information gathering process are the interviews with stakeholders and an initial site examination. When the intents of the organization's and the stakeholders' are established, further means of collecting data, information and impressions collection can be planned, organized and followed through (CEN, 2004).

The data should be objectively evaluable, but subjective impressions, ideas and a "feeling about the project and its setting are equally important to qualify the data in the analysis phase (Robertson & Robertson, 2012).

For the RefArc established in this thesis, an idea for an elicitation-process-sequence and a template questionnaire were developed (Appendix J). They shall give an indication about what to ask in which elicitation-stage, within which setting and whom to ask it.

As circumstances may be very diverse in different scenarios, this RefArc is to be understood as a guideline only, with no claim for completeness or applicability in the respective situation. It only represents a collection of the most frequently asked questions, extracted from the research.

Company/ Business Profile					
No	**Answer**	**Prio**	**When**	**Who**	**How to elicit**
1.	**What is the institute's vision?**	1	Phase 1	School Management	Interview
6.	**Which ideas/concepts regarding the LMS utilization already exist?**	1-2	Phase 1, 2, 3 and 5	School Management, Administration	Interview, Workshops
LMS capability/module elicitation					
No	**Answer**	**Prio**	**When**	**Who**	**How to elicit**
1.	**Which communication modules should be supported? (chat, forum, direct message, dashboard, blog, wiki)**		Phase 1, 2, 4	Main target groups	Survey, Interview

Table 2: Excerpt for Elicitation RefArc Questionnaire

Defining the Questions – Content Side:

In devising a questionnaire, the basic problem is the content side; as initially no data is allocated, it is hard to know which questions to ask productively. Hence the first

interviews are more about impression than about data (Robertson & Robertson, 2012). However, as the project management side of the elicitation has to be settled first (MIT, 2011), this is a good venture point from which to start developing the questions. Most of the questions will be provided by the stakeholder involvement, as they have the best notion about possibilities and problems regarding their organization (CEN, 2004; Robertson & Robertson, 2012).

Questions may vary widely in any organization; nevertheless, there is a set of necessary material to be gathered in any organization (Koch & Richter, 2009), so the questions need to be formulated according to this set (Chapter 2, Appendix J). This concerns information about:

Perspective/ Field (Source)	Examples
Business and Organization (Baumgartner, Hartmut, et al., 2002; CEN, 2004; Koch & Richter, 2009)	• Stakeholders, triggers and scope for the project; • Existing ideas and conceptions; • Existing software and hardware structures; • Timeframe, budget etc.
ELearning and Organization's Learning-structures (Kerres, 2012; Zellweger, 2003)	• Preferred type of teaching/online-learning; • Type of learning motivation; • Expected teaching-assistance; • Type of learning and evaluation environment; • Class-size, -structure and –composition etc.
LMS Modules (Al-Busaidi & Al-Shihi, 2012; Kerres, 2012; Koch & Richter, 2009)	• Preferred/necessary communication- and administrative- modules; • Collaboration management; • Additional modules etc.
LMS Characteristics (Baumgartner, Hartmut, et al., 2002; Cerioli, Ribaudo, & Rui, 2011; Kerres, 2012)	• Preferred/important characteristics (robustness, user-friendliness, etc.) and how to create them

Table 3: Perspectives for the Questionnaire Design

Defining the Means – Tool Side:

It is not enough to know about which questions to ask; they also need to be organized and presented in the right way, at the right time, within the right context and using the right means. Of the techniques discussed in 2.1.2 and Appendix A, interviews, workshops (creativity techniques), site surveys and polls have proven very serviceable (Baumgartner, Hartmut, et al., 2002; Seufert, 2002).

To reach as many users/stakeholders as possible, an online survey is the tool of choice (Triantis & Ventouras, 2011). Using online services like "LimeSurvey" and

questionnaire guidelines (MIT, 2011; whitehose.gov, 2006) is advisable for the survey-designing.

3.1.3 LMS Conceptualization – A Part of the Data-Collection

Conceptualization, as defined in 3.3.1, is one of the RE's accompanying processes (Figure 10). In this process, the LMS-application-concepts are, inter alia, aligned to the business's structure and ideas (Riempp, 2003). Detailed information about these structures and ideas need to be considered, which makes this process is an important part of the requirement elicitation. The use-cases and process-models themselves may even represent a part of the RSD.

The term conceptualization is defined and the processes are outlined in section 3.2.

3.2 Requirement Analysis Framework

The second step according to the RE is the requirement analysis, in which the collected data has to be screened, organized, evaluated and weighted. In practice this phase overlaps with the elicitation and documentation phase (Schienmann, 2001), and close contact to the costumers/stakeholders is mandatory to avoid misunderstandings in the requirement definition. This step is put into practice in Chapter 2 and 3 within the RefArc (Appendix J).

3.2.1 Requirement Evaluation

In the requirement elicitation phase the mass of information gathered is raw data. Some data will already be requirements, other data needs yet to be analyzed and translated into requirements (Robertson & Robertson, 2012). The result is a collection of user-/stakeholder-requests. In German-speaking countries those are normally collected in a Business Requirement Specification (BRS) (Pohl, 2008).

The framework within the RefArc needs to allude to the important evaluation characteristics: interconnection, association, role relation and planning/conceptualization, as described in 2.1.3. Moreover, every requirement must be relevant, clear, quantifiable, and detailed enough for all involved parties to understand the respective subject. The requirements must express "what" is to be built and NOT "how" it is to be built (CEN, 2004; Robertson & Robertson, 2012).

Another important practical reason for the requirement analysis is to provide a big picture about the desired LMS in regard to the business structure and the stakehold-

ers' expectations, so that all necessary requirements and their interconnections may be discovered (Robertson & Robertson, 2012).

Experiences (Frankfurth, 2010; Kruse & Tan, 2011; Solics GmbH, 2012) provide a selection of best-practice methods to apply to the evaluation process:

Method (Source)	Description
Templates (Robertson & Robertson, 2003)	Providing information about the entire process of requirement analysis
Use-Case-Diagrams (Robertson & Robertson, 2003)	Establishing correlation between the requirement and the respective use-case within the business-structure;
Data-Flow-Charts (Robertson & Robertson, 1998)	Visualizing correlation between the requirement and business structure
Process-Models (Lamsweerde: & Lamsweerde, 2009)	Visualizing the flow through the processes of the project or the processes of the LMS's
UML-Activity-Diagrams (Lamsweerde: & Lamsweerde, 2009)	Visualizing interconnections within and outside of the LMS structure
Sketches (Robertson & Robertson, 1998)	Establishing a big picture and evaluating the requirements' quality in a fast and informal way
Examples (Robertson & Robertson, 1998)	Visualizing and thereby evaluating requirements via examples, especially in the area of design
Checklist (Robertson & Robertson, 1998; Solics GmbH, 2012)	Finding all necessary requirements by tick-marking the respective fields/use-cases; Checking the requirements for their characteristics; (SMART-/Requirement-characteristics-checklist)

Table 4: Examples for Popular Methods in Requirement Analysis

When raw requirements are composed of the raw data from the elicitation process, they should be collected loosely (pre-step to the RSD) or already formalized (BRS), so that they may be entered into a tool or structure which is designed to organize and compare requirement significance (Baumgartner, Häfele, et al., 2002; Institute of Electrical & Electronic Engineers, 1990; Mintz, 1994; Seufert, 2002). In this thesis, such a structure (1), and a model for the evaluation and documentation processes (incl. a line of procedure, see Appendix J, Chapter 3) were devised from the aforementioned experiences.

In practice, requirement evaluation always encompasses the deliberations between the stakeholders and the project-team on which requirements need to be part of the system and which to leave out. Often requirements are only whims and not really important or beneficial for the business at hand (Robertson & Robertson, 2012).

3.2.2 Requirement Prioritization

The so far collected, evaluated and organized requirements need to be weighted, prioritized and possibly rejected next, as not all requirements are within the scope, and financial resources or implementation time are normally limited (CEN, 2004).

A first step is to allocate the requirements to the categories of the "Kano-Model", thereby creating a requirement portfolio (Spool, 2011).

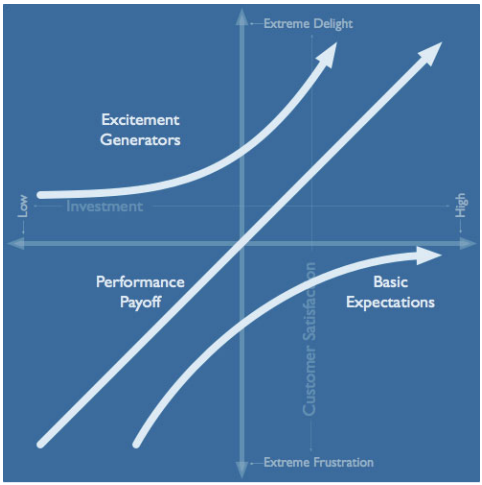


Figure 12: "Kano-Model" (Spool, 2011)

This portfolio and all significance assigned to the respective requirement must derive from the stakeholders'/users' perspectives. To really grasp this perspective, the stakeholders/users need to be involved (Robertson & Robertson, 2012).

In the case of a survey used to elicit the data, the results may already imply an objective measure. In the case of interviews or workshops, the participants should always be encouraged to weight the respective requirement according to a preset rating system (Robertson & Robertson, 2012).

In practice, the four-grade-rating system (very important/must, important/need, neutral/may, unimportant/must-not) is widely used in the significance elicitation (Mintz,

1994). This system is normally not directly connected to the “Kano-Model”, but to be considered additionally and separately before fusing them into a final impression in the documentation phase (Robertson & Robertson, 2012).

For this RefArc’s “Scoring Model” (1) the influence of the respective stakeholder-group (deduced from the stakeholder portfolio) was added to the significance this group assigned to the requirement; then, combined with the other stakeholders relative weight, a weighted mean value was calculated (for details see Appendix J). Thus, the stakeholders’ influence could be factored in and thereby a personalized weight assessment could be achieved. This is on the basis of “Technique for Order Preference by Similarity to Ideal Solution” (TOPSIS) (Peters & Zelewski, 2007), as part of the utility analysis (Bensberg, 2013).

3.2.3 LMS Conceptualization – A Part of the Data-Analysis

During the conceptualization workshops the hitherto elicited requirements are presented and rechecked with the stakeholders’ representatives according to their applicability to the business-structure and the stakeholders’ desires (Cockburn, 2001). Moreover, collected data can be analyzed in, and incorporated into the respective concepts, thereby supporting the conceptualization and providing deeper insight into the data’s significance (Robertson & Robertson, 2012). This makes the conceptualization an essential part within the data-analysis.

3.3 Developing Models for LMS application

The conceptualization or case/process-modeling is one of the project related-processes (Figure 10) of the RE. In the Joint Requirements Development (JRD, IEEE, 1990) a deeper understanding for the requirements, their interconnection and connection to the business-structure can be established. Moreover, it is a preplanning and visualization process (Cockburn, 2001; Robertson & Robertson, 2012) in which the RE-team and the users/stakeholders can model the structure, process and specifics of the LMS and how they want to use it (Institute of Electrical & Electronic Engineers, 1990). This is important as the system needs to support to the business structure (Riempp, 2003).

3.3.1 Conceptualization – Term Definition

The term conceptualization, used throughout this thesis, shall be defined for the purpose of this thesis as the process of devising concepts and ideas for LMS-utilization or –employment within the respective organization. This includes the identification of standing structures and procedures with which to align the concepts, the collection of ideas and wishes about how to structure and operate the system as well as the concrete composing of use-cases, process-models and structures for the LMS-implementation or -application.

3.3.2 Best Practice in LMS Implementation

There is not really one best way to organize the LMS implementation process for practical application, but regularities in approaches found in research (Al-Busaidi & Al-Shihi, 2012; Baylen & Hancock, 2010; Cerioli et al., 2011; Frankfurth, 2010; Kruse & Tan, 2011) can be summarized into a process model and a checklist (Chapter 5 of RefArc, Appendix J).

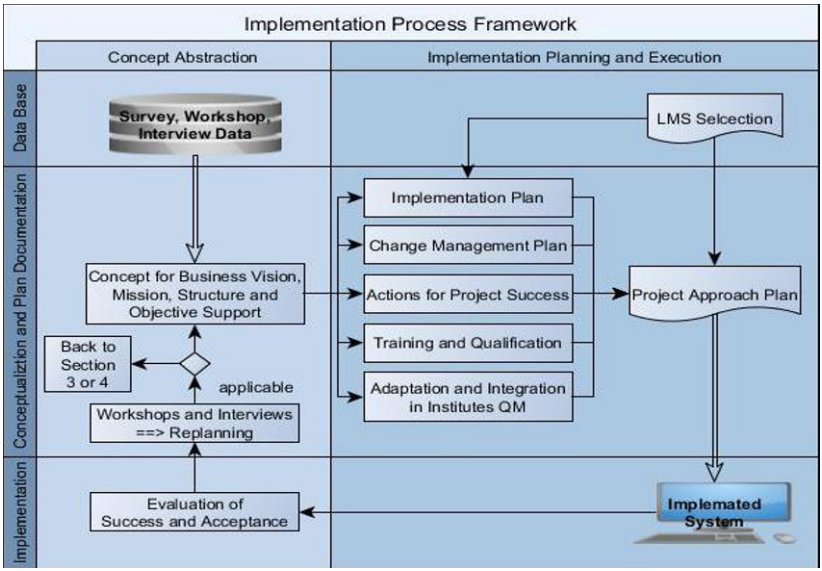


Figure 13: Implementation Process Framework

This model constitutes one part of the framework regarding the implementation and interlacing of the LMS into the school routine. The other part is the recommendations for the necessary Change Management in Chapter 3.6.
It is mostly a project management process combining the usual project planning, Change Management and feedback routines with the implementation of the stakeholders' operational ideas and the developed routines and structures into the LMS.

Devising the plans, processes and routines should be a workshop based activity which builds on the experience of school-management and -administration, teachers and students (Baumgartner, Hartmut, et al., 2002).

3.3.3 Best Practice for LMS Operation

Caused by the diversity of business concepts between schools and educational organizations, even by narrowing the scope down to the field of polytechnic schools, there is a multitude of operational concepts for LMS application (Babo, Rodrigues, & Queirós, 2011; Baumgartner, Hartmut, et al., 2002).
As these concepts are mostly geared to the respective business model no common process model can be devised for the LMS application conceptualization section in the RefArc, but rather a compilation of best-practice experiences (Al-Busaidi & Al-Shihi, 2012; Babo et al., 2011; Frankfurth, 2010; Kalz et al., 2011; Kruse & Tan, 2011). This compilation can be found in Chapter 6 of the RefArc (Appendix J).
Those experiences are mostly related to the alignment between actual business structures and LMS-operation-structures (Figure 14).

In practice there are several concepts to be developed, as suggested by the RefArc (Appendix J, Chapter 6). The concepts should be considered additionally in regard of the quality management system and integrated into the workflow and work-processes. Moreover, the future trends observation, both in the school's business processes and in LMS utilization should be considered, so trends can be noticed and implemented if applicable (Breu et al., 2008; Frankfurth, 2010).

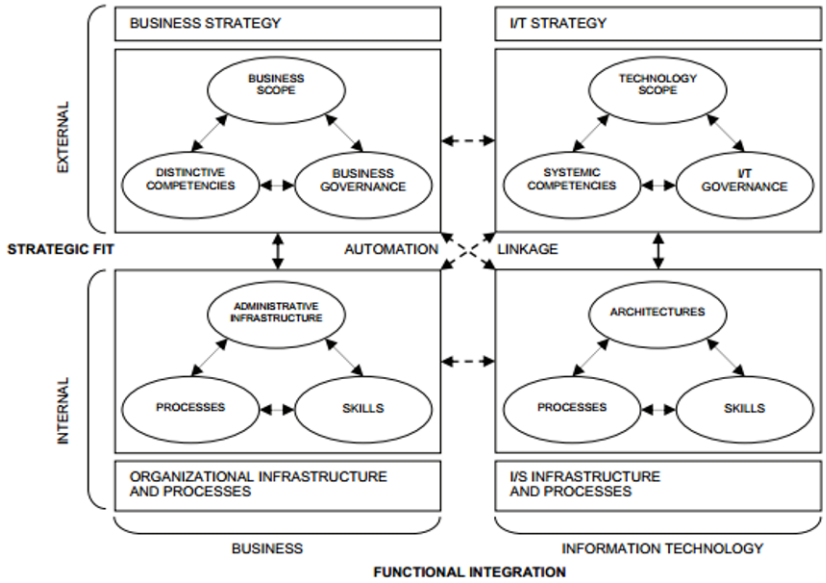


Figure 14: Strategic Alignment Model (Henderson & Venkatraman, 1993)

3.3.4 Best Practice for LMS Administration and Customer Assistance

Considerations about the LMS-inherent tasks of system- and database-administration, organizational system management, further development, ticket system (user support in case of problems) and help desks are often lost from screen when designing use concepts for an LMS application (Krumm, 2012). According to Al-Busaidi & Al-Shihi (2012), this also often happens during staff training and the LMS documentation (online help wikis etc.)

Having sound ideas for all those things is important as they are directly connected to the LMS's operability and the users' satisfaction. Experience shows that allocating those tasks to the users as an additional workload hugely diminishes the motivation for the use of an LMS (Al-Busaidi & Al-Shihi, 2012). Good instruction and support for the LMS operation, or even mentoring programs, on the other hand, boost the interest and motivation for the LMS immensely (Baumgartner, Hartmut, et al., 2002).

Chapters 5 and 6 of the RefArc (Appendix J) contain recommendations on keeping these issues on the screen.

3.4 Requirement Documentation Framework

Although often considered a tedious and interminable task by those assigned to do it, the Requirement Documentation is of utter importance and should be done with all diligence. The RSD is the central, legally binding agreement between the contracting entity and the contractor hired for the realization (Fandl, 2004).

The RSD basically serves all affected parties as a mutual, unambiguous agreement about the background settings, requirements and approach plans for the project (Caupin et al., 1999).

For the RefArc, the basic pillars for this task were integrated into a process model and combined with examples and templates to provide a basic framework for the RSD.

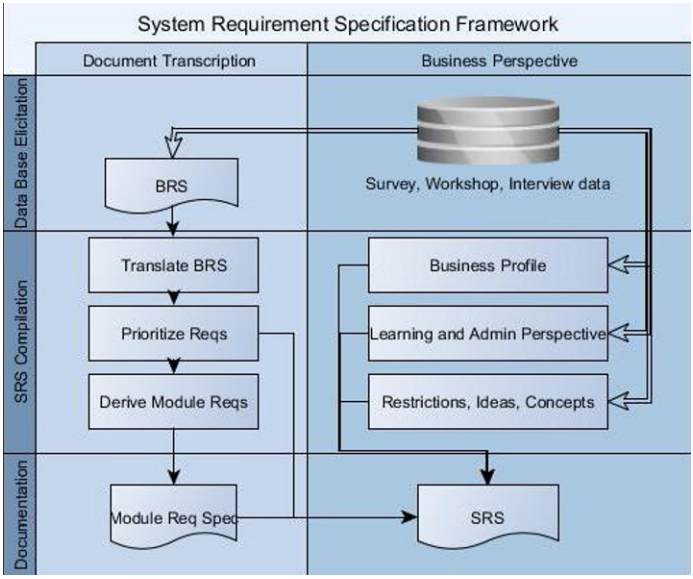


Figure 15: Process Model – Creating the RSD/SRS

However, on the note of the RefArc devised in this thesis, the RSD is not only supposed to be a list of requirements and business-environment data, but should also be a recommendation (discussed in 3.4.3) for the respective school, including valuable information (LMS comparison according to the requirements, concepts for implementation and application, cost-effectiveness analysis) to aid the school management in the selection of the best fit LMS.

3.4.1 Requirement Classification and Prioritization

In the preceding, and overlapping, elicitation and analysis phases the requirements were prompted, evaluated, reformulated and partly weighted (see 3.2.2). Within the RefArc this is done in the creation of the BRS from raw elicitation-data. These steps provide a pre-classification for the requirement cataloging necessary in the RSD.

Based on this pre-classification the requirements need to be translated into technical specifications (without becoming incomprehensible for the stakeholders) and prioritized (Institute of Electrical & Electronic Engineers, 1990). There are many guides for the specification wording online and in literature, e.g. the “Volere-Template” by Robertson & Robertson (2003) (see Appendix Q).

In practice there are several prioritization systems in use (Robertson & Robertson, 2012), but the differentiation between must-, need-, may- and must-not-criteria is most frequently used in the examples and templates found online or in literature (Mintz, 1994). Through the prioritization process some requirements may be considered unnecessary and therefore will not make it into the RSD. However, they should be recorded extra in the RSD in case of a requirement change or the need to reproduce the elicitation- and analysis-patterns (Lamsweerde: & Lamsweerde, 2009).

The next step in the pre-writing stage of the RSD compilation is to assign the specific requirement types (see 2.1.4 and Appendix B). Assigning each requirement an identification-number or -code and administering them in a “Requirement-Type-Prio-Matrix” (Table 5) is advisable (Robertson & Robertson, 2012).

Requirement Type	Requirement Code	Must	Need	May	Must-Not
Functional Requirement	**R-F.1.1**	X			
	R-F.1.2			X	
	R-F.1.3				X
Non-Functional Requirement	**R-NF.1.1**		X		
	R-NF.1.2		X		

Table 5: Requirement-Type-Prio-Matrix – Example

When the data-collection, -evaluation and -organization is considered sufficiently far progressed, the RSD can be written. Practically these activities overlap to the extent of being parallel. Therefore, the RSD will evolve gradually and tracking status and versioning gains in importance (Robertson & Robertson, 2012).

3.4.2 Creating the RSD

Through exhaustive preparation in the elicitation and analysis phases, the creation of the RSD respectively the SRS in German-speaking countries is mostly about the data and requirement formulation and formatting into a document. As this is often done simultaneously to the evaluation, this opportunity should be used to recheck the requirements for the quality standards (e.g. completeness, consistency, unambiguousness and feasibility, see 2.1.4 and Appendix C).

Screening RSD templates and examples from online- (Appendix Q) and literature sources (Cockburn, 1998; Fandl, 2004; Pohl, 2008; Robertson & Robertson, 2003), certain standards (see Figure 16) for the RSD can be found. As the Volere-template (Robertson & Robertson, 2003) combines these standards to a high degree it is recommended as an RSD-foundation.

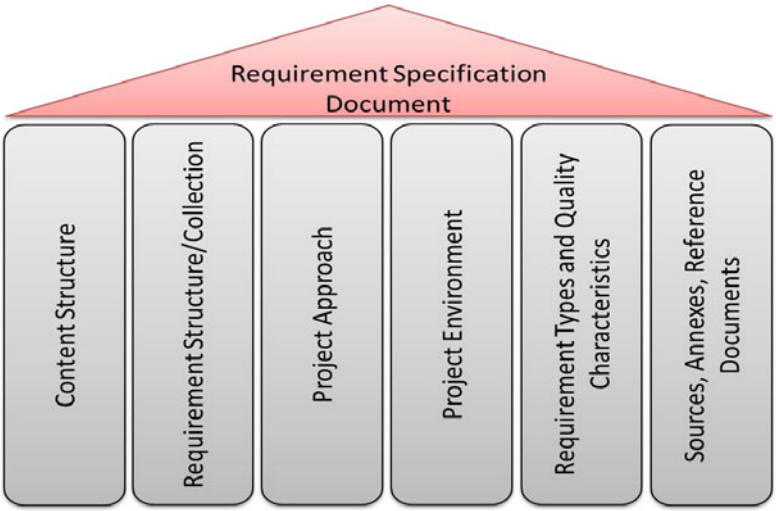


Figure 16: Pillars of the RSD

The content structure is about organizing the RSD into an official document as needed for the respective customer/provider-combination. Practical standards (recapitulated from Caupin et al., 1999; Institute of Electrical & Electronic Engineers, 1990; Pohl, 2008; Robertson & Robertson, 2012) are the structuring into:

- Introduction (including: general context, project objectives, project environment and organizational data)

- Initial situation (including: project approach, triggers, status of requirement elicitation/analysis and conceptualization)
- Requirement description (including: requirement structure/collection grouped by type and prioritization, quality characteristic (Appendix C) fulfilled)
- Aggregation and conclusion (including: further course of action)
- Appendix (including: document versioning management, sources, reference-/supplement-documents/pictures/overviews etc.)

For the RSD-framework considered in this thesis, additional information has to be integrated into the RSD to fulfill the particular organization's need for consultancy. This will be discussed in the next subsection.

The organization of the requirements can be supported through the methods discussed in Table 4 in subsection 3.2.1, requirement-identification-codes and/or "requirement-shells" (Robertson & Robertson, 2003). These shells can be organized in a card system, administrated and depicted within the RSD through a matrix and treated like document-attachments. Moreover, the development-/implementation-process can be simplified through the use of these shells (Robertson & Robertson, 1998). Examples can be found in Figure 17and Appendix R.

Must-Criteria:

Denomination	Type	Source	Weight
Description		**Trigger**	
FM 1	Functional	Survey	3,7
The LMS must provide a tool for intra-group-chat-communication		Direct group internal communication	
FM 2	Functional	Survey	3,2
The LMS must entail an information-board-tool for school management and administrative purposes		School administration	

Figure 17: Requirement Shell – Example

3.4.3 Additional Analysis in the RSD

The RefArc's objectives not solely include the framework-composition for the LMS implementation's RE processes, but also the consultative part of LMS-selection and -recommendation. This is the reason why the RSD-framework needs to imply the presentation of the conceptualization results and, all the more, both the LMS comparison/selection-recommendation and the CSA-results (both analyses are discussed in subsection 3.4).

43	UI Personalisation possible	1,9	3	5,7	2	3,8	4	7,5	3	5,7	4	7,5
44	Summary Module Perspective		3,3	175,8	2,7	146,3	2,8	151,3	3,3	183,6	3,3	179,8
45	LMS adequate for User knowledge/experience level	3,1	3	9,4	3	9,4	3	9,4	3	9,4	4	12,6
46	LMS promotes motivation for ist use	3,2	3	9,5	2	6,3	2	6,3	4	12,7	4	12,7
47	Good Intuitivity	3,6	3	10,8	3	10,8	3	10,8	4	14,4	4	14,4
48	High System robustness	3,7	2	7,3	2	7,3	2	7,3	4	14,6	4	14,6
49	Accessability through school website supported	3,0	4	12,0	4	12,0	4	12,0	4	12,0	4	12,0
50	Desired profile and access managemnet supported	2,9	3	8,8	3	8,8	3	8,8	4	11,8	3	8,8
51	Mobile (Smartphone) Accessibility supported	2,8	2	5,7	1	2,8	1	2,8	3	8,5	3	8,5
52	Summary Feature Perspective		2,9	63,6	2,6	57,6	2,6	57,6	3,7	83,4	3,7	83,6
53	Max Score/ LMS mean value; LMS respective Scores	516,0	3,2	411,9	2,7	352,4	3,0	382,6	3,4	446,0	3,6	470,9
54	% Score	100%		79,81%		68,28%		74,15%		86,42%		91,25%

Figure 18: Scoring Model – Example

In practice (Kruse & Tan, 2011; Seufert, 2002), the direct contrasting lineup of the LMSs for selection purposes seems to be the tool of choice (Ciampi, 2007; Niklas, 2002). It is subdivided into LMS-application/information-areas which are further detailed through requirement references, and combined (Figure 18) with graphical illustrations (Figure 19). This lineup provides good comparability and an excellent overview of requirement-fulfillment. Using this proposition, the Scoring-Model-Excel-Template (1) was designed for the RefArc and its resulting RSDs to be used as an attachment.

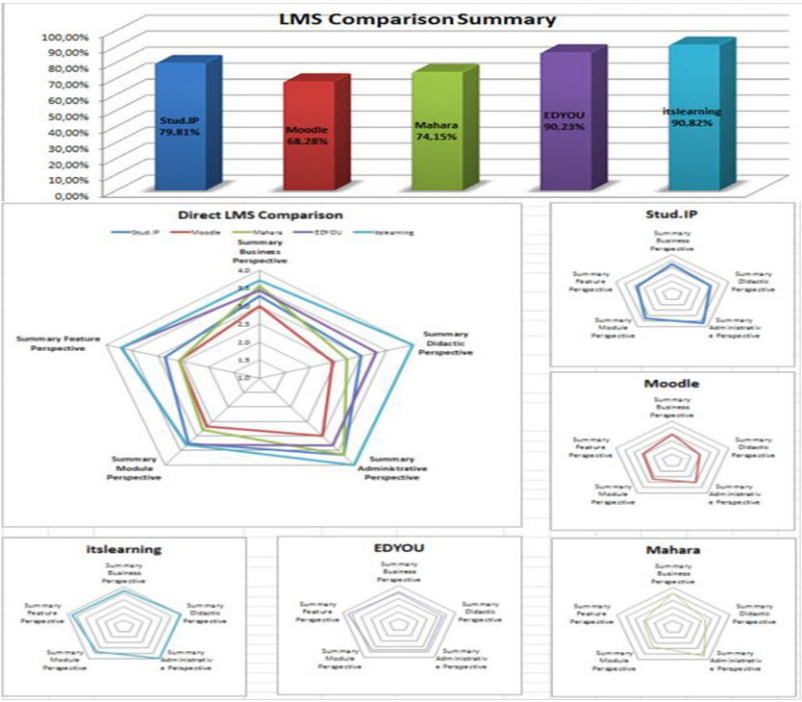


Figure 19: Soring Model – Graphical Illustrations – Example

For practical reasons the Measure of Suitability/Effectiveness (MoS/MoE) achieved through Cost-Suitability Analysis (CSA) respectively a Cost-Effectiveness Analysis (CEA) done through means of Excel charts/calculations (Kubr, 2002) utilizing the data gained from the requirement-elicitation process and in LMS-instance research (Kruse & Tan, 2011; Piña, 2010). This is represented through the Cost-Effectiveness-Analysis-Excel-Template attached to the RefArc (Appendix L).

To subsume the recommendation data and to give a nutshell-recommendation, the aggregation-chapter of the RefArc endorses a set of key factors in a checklist (Appendix J, Chapter 8) which seem to be important for the counseling of the school's management (Ciampi, 2007; McIntosh, 2014).

3.5 Requirement Validation Framework

The requirement validation phase is an essential part of the LMS RE. In this stage the elicited, evaluated and documented requirements and business-environment information is to be rechecked for their applicability (Robertson & Robertson, 2012) in the LMS-project. This phase is repeating itself through the rest of the project under constant stakeholder-involvement (Institute of Electrical & Electronic Engineers, 1990).

Regarding the RefArc, the validation is not only about the rechecking but much more about validating the stakeholders' requirements against the reality of the LMS market to provide an LMS-selection-recommendation for the school management. Therefore the actual LMS-comparison and -selection processes as well as the CEA are vital to the validation phase.

De facto the RefArc provides a process-model (Figure 20) and the Scoring Model (Excel attachment) for the LMS-comparison and -selection, based on fundamentals of utility analysis (Niklas, 2002), in addition to procedures, checklists and the CEA/CSA (Peters & Zelewski, 2007) and the appending Excel-charts.

3.5.1 LMS Selection

The creation of the LMS-selection logic (see Table 6) is straight forward along the lines of utility-analysis (Hafner & Winter, 2005; whitehose.gov, 2006).

To determine which requirements to include into this selection process and which to leave out, stakeholder-involvement and reference to the requirement priority, and the best comparable features of the LMS on the market have proven prudent in practice (Baumgartner, Hartmut, et al., 2002). Lists of prominent features can be found online, e.g. Runge (2014) or in the relevant literature, e.g. Baumgartner, Häfele, et al. (2002)

Keeping the business vision, mission and objectives on screen as well as the stakeholders' wishes and the reasons and objectives for the LMS-implementation is very

important to avoid deviation from the productive course of action (Kruse & Tan, 2011; Sampson & Zervas, 2011).

Step	Procedure
Step 1	• Conduct systematic market research (see 2.4), including a pre-selection according to the requirements in order to find the best-fit LMSs for the respective organization; • Select three to eight likely candidates (Baumgartner, Hartmut, et al., 2002; Kerres, 2012)
Step 2	• Weight requirements according to stakeholders' specifics; (see Chapter 3:); • Grade LMSs according to requirement criteria (see procedure model of 1) • Combine weight and the grade by multiplication
Step 3	• Add up the aforementioned combinations for each LMS and the calculation of the mean; • Line up those results and the maximum of possible points in order to perform a percent comparison (see Figure 18 and 1) • Additionally, perspective bound KPIs can be calculated in similar fashion ➔ web-diagraph
Step 4	• Give a graphical depiction of the overall results
Step 5	• Re-evaluate weights and grades with stakeholders ➔ feedback loop

Table 6: LMS Selection Logic – Procedure

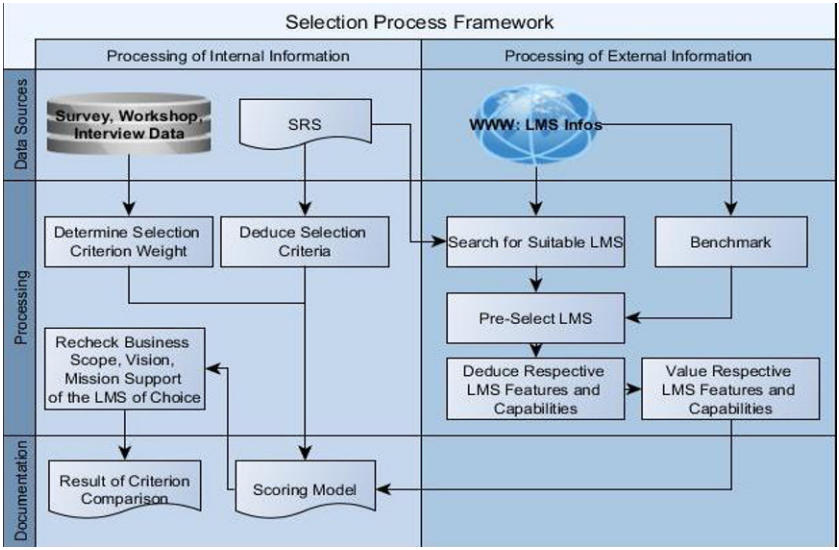


Figure 20: LMS Selection Framework – Process Model

As already mentioned in Step 5, this process includes a feedback loop in which the concept team, consisting of stakeholder-representatives, can adapt requirements, weights, prioritizations and LMS grades to optimize the selection to their needs (Kruse & Tan, 2011). Furthermore rejection-conditions can be formulated to reject a LMS-candidate completely, if an essential requirement is not fulfilled (Cerioli et al., 2011).

3.5.2 Economic Considerations

Another very important part of the requirement validation is the assessment whether the realization costs for the requirements as defined are within the budget. If the requirements overdraw the budget, the stakeholders have to redo their prioritization (Hirschmeier, 2005).

Furthermore the proportion between the costs of an LMS-implementation and –utilization, and the perceived benefits of its application are of high interest to the school-management and should therefore be assessed to provide a solid foundation for the school management's decision (Hirschmeier, 2005).

As the benefits, however, are often hard to put into numbers, a special variation of the cost/benefit-analysis, the cost/effectiveness-analysis provides a form of economic analysis that compares the relative costs and outcomes of two or more courses of action (Bleichrodt & Quiggin, 1999). CEA is distinct from cost-benefit analysis, which assigns a monetary value to the measure of effect. Typically the CEA is expressed in terms of a ratio where the denominator is a gain in utility from a measure (time saved, grades improved) and the numerator is the cost associated with LMS-utilization. Cost-utility analysis is used similarly to cost-effectiveness analysis (Bleichrodt & Quiggin, 1999).

In practical application, CEAs are often visualized on a cost-effectiveness portfolio, consisting of four-quadrants. Outcomes plotted in Quadrant I are more effective and more expensive, those in Quadrant II are more effective and less expensive, those in Quadrant III are less effective and less expensive, and those in Quadrant IV are less effective and more expensive (Black, 1990).

Regarding the RefArc (Appendix J, Chapter 7), an approach to the CEA is proposed combined with a collection of typical costs and benefits (see Table 7) to consider. Appendix L provides an additional Excel based calculation model for the CEA. According to the experiences of Kruse & Tan (2011), Cerioli et al. (2011) and I. E. Allen

& Seaman (2007), the typical costs and benefits (Table 7) should be assessed for short-, middle and long-term effectiveness. Expenditures of costs and time are usually high in the short-term perspective (up to 18 months (Hirschmeier, 2005)) but level out in mid- (up to 36 months (Hirschmeier, 2005)) and long-term (longer than 36 months). This is mostly due to the starting effort for the users, especially the teachers, of switching to the new system and transcribing their teaching material to the system's capabilities, and also due to the implementation and training efforts (Baylen & Hancock, 2010).

Costs	Benefits
Introducing and implementing an LMS at the school	Additional services
Resources, personnel	Saving time and labor
Change Management and continuing motivation processes	Marketing platform and qualifying element in the competition
Continuous use, maintenance and service	Communication gain
Cost for marketing utilization and QM	Acceptance though modern media usage
and further programming	Expected service, Benefit of Image
Additional work in restructuring and re-preparing content	Customer satisfaction, employee satisfaction
	Enhanced business quality
	Optimized data-/ contend-**structure** □ **faster** access

Table 7: LMS Application – Common Costs and Benefits

Most sources (I. E. Allen & Seaman, 2007; Cerioli et al., 2011; Hirschmeier, 2005; Kruse & Tan, 2011) agree that the economic utilization of an LMS depends, among others, on two major issues: maximum utilization and efficient utilization. According to Al-Busaidi & Al-Shihi (2012), the former is mostly dependent on the user's motivation (see 3.6 and Figure 7) and therefore the LMS's user-friendly configuration, while the latter is mostly dependent on the conceptualization (see 3.2).

A very different kind of economic analysis is used for the direct comparison of two LMSs to find the optimal cost/effectiveness-ratio for the respective school. This analysis also applies to the comparison between commercialized and open source LMSs (see 2.4) (Folden, 2011; Piña, 2010). An honest consultation for the school-management in regard to the right-choice-LMS must include this cost/effectiveness comparison, as it is one of the school's management's decision-making bases (Gebert, Geib, Kolbe, & Brenner, 2003). The RefArc includes this via a line-up of the

last-choice-LMS's cost/effectiveness structure (see Appendix L and Examples in Appendices M and O).

3.5.3 Recommendation and Feedback Framework

As already mentioned, the frameworks integrated into the RefArc serve the goals of supporting the LMs-requirement-specification and the LMS-selection as well as the recommendation purposes. Presenting these findings in the right way is very important when providing the consultancy services the stakeholders require. Therefore it is essential to create an abstract of the RSD, summarizing the most important issues while providing all information needed in a concentrated form (Kubr, 2002).
The abstract may also be used as a platform to provide the stakeholders with short feedback about the RE processes and the support and participation by the assigned stakeholders' representatives. This usually provides a sense of how accurate the elicited data is and consequentially how relevant the results are deemed to be (Koch & Richter, 2009; Kubr, 2002).

The RefArc defines the objective of this conclusion as a comparative appraisal of two to three best-choice-LMSs in regard to these LMS s' applicability to:

- Business structure
- Vision, mission and business objectives
- LMS utilization objectives
- Planned LMS utilization concepts
- Didactic application
- Cost-Efficiency Considerations
- Further prominent points and reasons

In addition, it may be determined practically advisable to specify important excerpts from the conceptualization, or important possibilities, or risks/apprehensions (Ciampi, 2007).

The conclusion should end with a look ahead, describing the next necessary steps in the project (Kubr, 2002).

Bearing in mind that the stakeholders' time is supposed to be very valuable good, these essentials for the recommendation should not exceed the length of one page (Caupin et al., 1999).

3.6 Change Management (CM)

Within the extent of this thesis, two different issues can be denominated with the term Change Management: the process and management of a requirement change, and the management of business/organizational change necessary due to the implementation of an LMS.

3.6.1 Requirement Change Management (RCM)

As this thesis's problem domain is Requirement Engineering and Management, the RCM is one type of change management to be considered in this thesis, although it is not considered in the RefArc. It is part of the requirement validation process, or may be a reaction to changes in the stakeholders' needs after the requirements documentation within the RSD.

In the sense of RCM, the term refers to the reaction to proposed changes in the requirement definition. The aim of this type of CM is to reduce the amount of unplanned work and to trigger the Claim-/Supplemental-management. In practice, this management is important for protecting/considering the budget, own resources and timeplans against unreasonable demands (Schelle, Otmann, & Pfeiffer, 2008). Furthermore, the later in the project changes are required, the more expensive they will be and the higher the consequences for the project (Caupin et al., 1999).

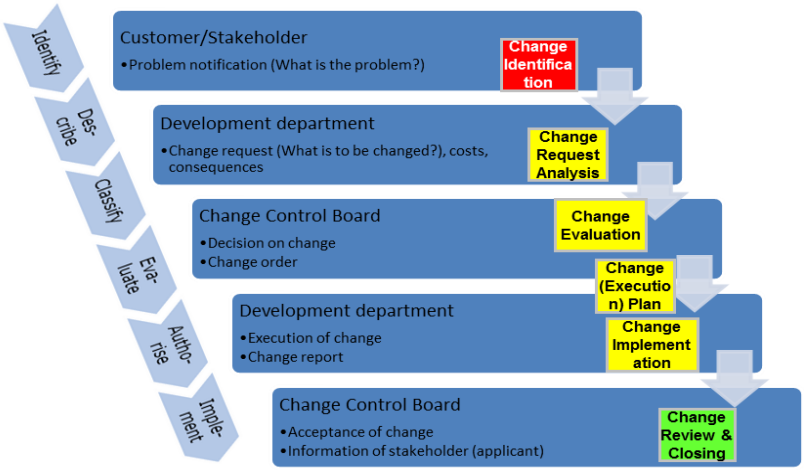


Figure 21: RCM Approach (dependent on Schelle et al., 2008)

This trigger for RCM should be an official change request from the stakeholder/s as a basis for the negotiations. In practice, however, the process often starts off-the-record and is treated unofficially, which usually makes it hard for the parties to address the cost issues.

The typical approach to the RCM is conducted in the six steps depicted in Figure 21 (detailed process model in Appendix S).
This kind of change management is of interest after the finalization of the RSD, as changes during the first validation-loop can still be integrated into the RSD. This thesis focusses on the processes up to the RSD's finalization, and consequently the RefArc does not include a framework for the RCM. This can be found in Appendix S.

3.6.2 Organizational Change Management (OCM)

Regarding the implication for the RefArc and the LMS-implementation, the more important interpretation of the ambiguous term CM (see 3.6) is the OCM. OCM means to plan, initiate, realize, control, and finally stabilize change-processes on both, a corporate and a personal level (Doppler & Lauterburg, 2002).
Change is the continuous adaptation of corporate strategies and structures to changing external conditions. Today, change is not the exception but a steady ongoing process (Recklies, 2010).

RE, configuration, implementation and utilization of an LMS for an educational organization represent immense changes for the organization's business structure. As humans generally tend to react aversely to bigger changes, a coordinated OCM is essential to successfully and economically implement and operate the LMS.
In order to successfully manage change processes, it is necessary to analyze the phases of change, in dependence on Kübler-Ross (2009).
Understanding these phases, and knowledge about the employees' psychological reactions and their needs in the respective phases (Figure 22) are a valuable guideline for the manager and therefore for a successful implementation (Paton & McCalman, 2008). In this context it is highly relevant to keep in mind that the stakeholders are a heterogeneous group with different needs and objectives and accordingly different levels of motivation for the change process and different reactions in the different phases. Intensive stakeholder-care and -involvement is mandatory (Doppler & Lauterburg, 2002).

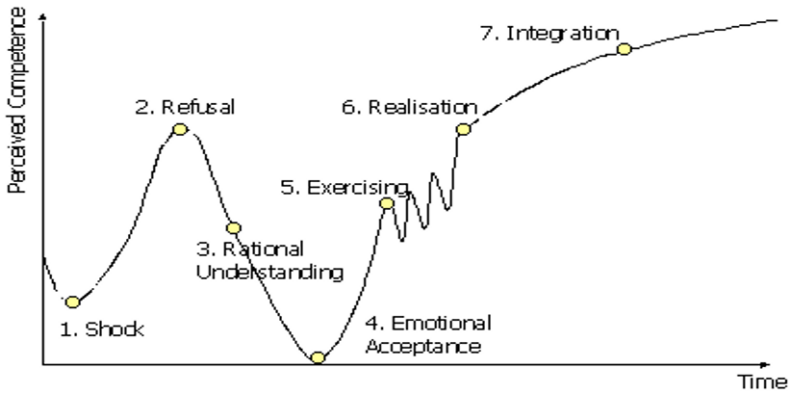


Figure 22: Phases of Change (Recklies, 2010)

OCM specific Critical Success Factors (CSF):

Generally, there are several critical success factors (Figure 23 and 0) for an effective change management process (Government Queensland, 2008). Within the RefArc, these are collected in a checklist in the implementation-conceptualization chapter (Appendix J, Chapter 5).

Figure 23: Management specific CSF for OCM

Involving the Stakeholders:

Involving the stakeholders in the decision-making process and making them an active part of the transition is the key to a smooth change in the Standard Operating Procedures SOP (Paton & McCalman, 2008).
In practice this means to integrate them into the RE process as much as possible, to regularly inform them about preliminary results, mile-stones, further approaches and next steps and, most of all, to always emphasize the importance of the LMS and their personal benefits derived from implementing it (Eggs, 2012). Examples for these stakeholder-group-individualized benefits are collected in Appendix I.

LMS specific Critical Success Factors (CSF):

The transition to an online-learning-platform-utilizing organization must not only be supported by management-based activities, but rather by LMS-specific features, too. The LMS's systemic layout, its modules, features and characteristics, it's operation structure and intent themselves need to be designed to optimally create motivation to use and exploit the LMS (Hebbel-Seeger, 2012). Neither the gaming character (Hebbel-Seeger, 2012) nor the allure of the novelty needs to create this motivation by itself. In fact, the utility and the appeal of the LMS should be the leading enthusiasm factors.
In practice, a number of LMS characteristics facilitate the LMS acceptability (Al-Busaidi & Al-Shihi, 2012; Baumgartner, Hartmut, et al., 2002; Koch & Richter, 2009; Piña, 2010; Zellweger, 2003), as shown in Figure 24.
An additional approach that is not to be neglected is to create acceptability through mandatory use of the LMS and through pooling information without redundancy on the platform only. If users have to use the system they will use it. But these steam-roller tactics must only be taken after exhausting all other methods to create motivation and acceptance for the LMS (Baylen & Hancock, 2010; Kalz et al., 2011).

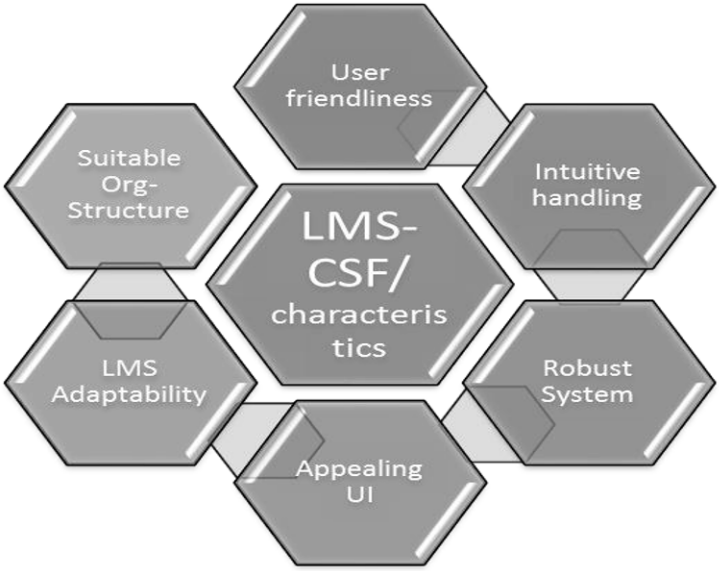


Figure 24: LMS Specific CSF for OCM

Practical Part

Chapter 4: Testing the Reference Architecture

In Chapter 3:, the best practice ideas found in literature have been integrated into the frameworks which are combined in a RefArc designed on the theoretical foundation discussed in Chapter 2:.

This master thesis's second major objective is to test the RefArc in the real-life-instance of a polytechnic-knowledge-transfer organization. The approach, its results and the conclusions of this prototypic trial are recorded in this chapter.

4.1 Test environment – The TA.

The general idea of the RefArc's prototypic application as a check for feasibility and practical applicability is to utilize the frameworks, process models and checklist while running through the complete RE-procedure in a real school which is determined to implement and use a LMS.

The prototypic experiment should offer a valuable outcome for the school as it is time-consuming and dependent on the patronage of the stakeholders and especially the school-management.

The test bed for the RefArc procedure and framework testing was the TA, a polytechnic school located in A. in the southern part of Germany. The school's characteristics are illustrated in Table 8:

Name:	TA
School Type	• State Recognized School for technically oriented and state accredited degree programs • Certification: certified engineer • Full-Time Courses, Part-Time Courses
Faculties	• Mechanical Engineering • Electrical Engineering • Environmental Engineering • Mechatronics • Applied Computer Science
Size:	• Ca. 1000 Students • Ca. 200 Instructors • Ca. 20 Management and Administration Members
LMS Users	Students, Instructors, Management, Administration, Alumni

Table 8: School Characteristics – TA

Sven-Michael Wundenberg, *Requirement Engineering for Knowledge-Intensive Processes,* BestMasters, DOI 10.1007/978-3-658-08832-3_4, © Springer Fachmedien Wiesbaden 2015

The initial situation at the TA, as deduced from the initial interviews (see 4.2.1), is that the TA is developing media standards but has not implemented an LMS yet. Management, administration and most of the teaching staff are highly resolved to address this issue and are equally motivated to use new kinds of teaching-, communication- and administration media. Consequently, the basis for the RE and the LMS-selection-process is good.

The major reasons triggering the LMS application are both top-down and bottom-up. The school management wants to consolidate the school's position on the market for advanced engineering education and qualification by boosting the school's media environment, and by utilizing a modern LMS to enhance learning and intra-organizational communication. Teaching and administration staff are looking for support and new media platforms to enhance their exercise portfolio. Students require a modern LE based on a suitable LP.

The stakeholder portfolio (Figure 25) provides an overview of the individual stakeholder's influence and interest in the LMS-venture at the start of the project. The attitudes towards the project could be further improved through the application of OCM methods (according to the RefArc Chapter 5 in Appendix J).

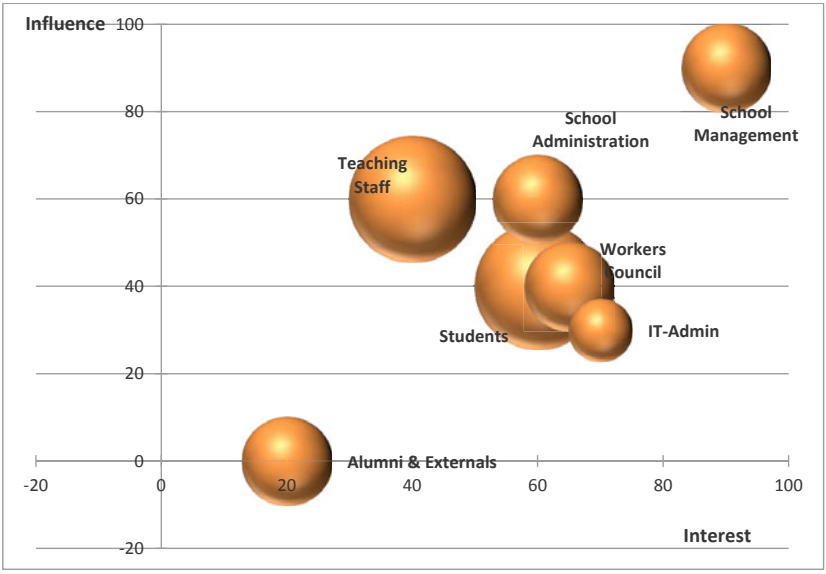


Figure 25: Stakeholder Portfolio – TA

Further details about the situation at that school will be referred to in the respective sub-chapters within the framework of the data-assembly-, data-evaluation- and documentation-processes.

4.2 Gathering Data, Information and Impressions – Methodology

The first step of the RE-process, the requirement-elicitation, started with the collection of data, information and impressions about the organization. This was done from 24th September 2013 to 31st January 2014. During this time several stakeholder interviews, workshops, on-site surveys and an opinion-poll were conducted.

4.2.1 Initial Interview – Introduction into TA

The initial interview, in which the mandate to conduct the RE-process at the TA was formalized, took place on 24th September 2013, on TA premises. It was followed by an initial site/tech-survey (see 4.2.2).

The main participants were: the school's management, represented by the school's headmaster, Mr. S., and the author, also the LMS project manager (PM) to be. Additionally, the author was introduced to the vice-principal, Ms. S., the Head of Administration, Ms. E. and the Head of Office, Mr. H.. Those were to be the main contact persons on the management- and administration side and part of the LMS-concept-team.

In the interview with the principal, the first issues discussed were the already mentioned reasons for the LMS implementation and the raised expectations. The most prominent expectations for the LMS were:

- Enhancement of intra-school communication, student-student communication and instructor-student communication
- Support for students in learning and thus in accomplishing their educational-goals
- Making new ways of media utilization available for the school and its stakeholders and thereby strengthening the school's market-position
- Support for the school administration, e.g. in organizing student affairs or information exchange

In compliance with the RefArc, the author subsequently requested information about the TA's vision, mission and its goals regarding the LMS operation. This information

was provided in form of a business-vision leaflet and discussed with reference to its impacts on the LMS-project. The results can be found in subchapter 2.2 of the TA's SRS (Appendix M).

Next, the TA's business structure and SOPs were discussed and a first concept-draft for the LMS's adaptation to this structure was devised by the principal, the head of administration and the author.

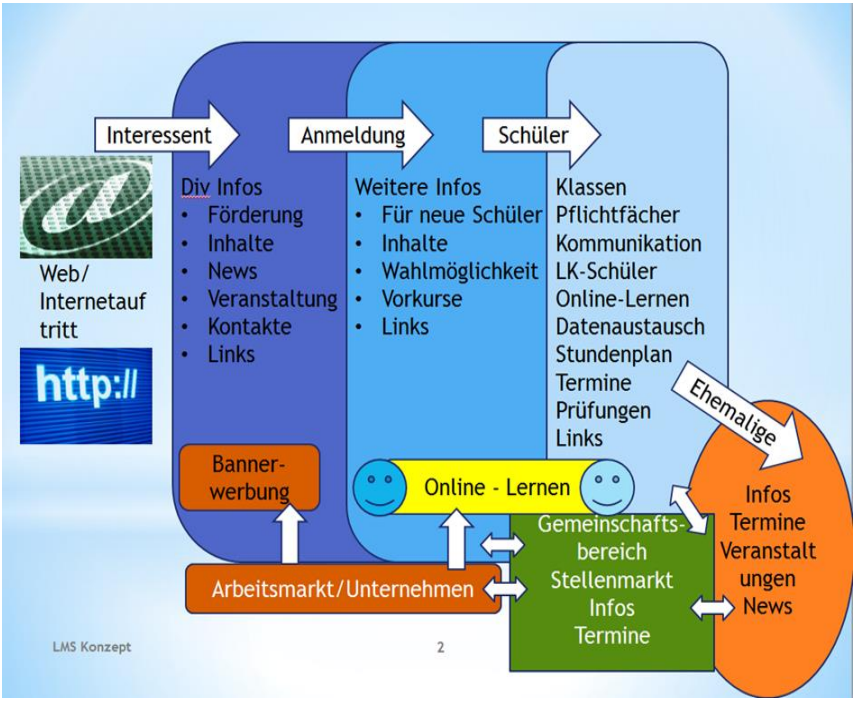


Figure 26: LMS Adaption to Business Structure (Draft in German)

This concept is about integrating prospective students gradually into the platform, along with the process of student promotion and integration into the TA. Once a user is an active student, full learner's access is granted and the LP can be used. This concept had to be particularized through subsequent concepts, which were to be created in the workshops, but on this foundation.

The initial interview was finalized with the determination of contact-persons in the different stakeholder-groups, which were informed about the LMS project by the headmaster. He also asked these persons to be ready, as far as possible, for any

assistance the author needed during the RE procedure. Moreover, the headmaster scheduled a meeting with those instructors who already had experience with LMS utilization, in order to accumulate the experiences and impressions and to introduce the PM to the teaching staff most likely to be interested in joining the LMS-concept team.

4.2.2 Stakeholder Interviews

In concordance with the RefArc's recommendation regarding the data-elicitation (Chapter 2 of Appendix J) and the stakeholder-involvement in line with the OCM, several interviews were held with different stakeholder representatives.

School Management:

After the initial interview with the headmaster of the school, meetings with him were held in regular intervals (a meeting list may be found in Appendix M), both to provide the school's management with feedback about the project's status, and to further elicit important data from the most important stakeholder.

As the headmaster was in general rather busy, scheduling was usually a problem and keeping the meetings short was mandatory. The scheduling problems eventually resulted in a reevaluation of the initially generated risk assessment, and in the raising of this risk's probability and impact.

The interviews were mainly about the business and concept-related questions defined in Chapter 2 of the RefArc (Appendix J). Further topics were the realization of the opinion poll, presentations, meetings and workshops, all in line with the RefArc.

School Administration:

Three interviews were held with the school's administration:

The first interview, with participation of the Head of Administration and the Head of Office, focused on general expectations, problems to be addressed while implementing the LMS (e.g. standardization of communication channels or centralization of school-organization tools) and existing ideas about the LMS operation. The interview's purpose was to gain a basic impression and the administration's basic requirements. It took place as a relaxed meeting with the RefArc's questionnaire as a guideline only.

The second interview, with the Head of Office only, was about specific SOPs in the office, e.g. which resources were going to be managed with the LMS, which regular routines should be supported by the LMS, which information was to be distributed in which ways and which typical modules, features and characteristics should the LMS constitute to support the office-activities optimally. As specific requirements were inquired in this interview, the RefArc-questionnaire was essential and the requested information was completed by the conceptual ideas of the interviewee.

In the third interview the Head of Administration as chief of all administration units explained about the interfaces and software tools already in use and about required interconnections between those and the LMS. Of special interest was the interconnection between several Excel-charts in use to keep track of students, their respective faculty, class and group affiliations, and the LookIn organization software used by the BBZ, the parenting school-collective to which the TA belongs. Significant room for synergetic effects and economy of time was identified in this interconnection. The Head of Administration also answered the questionnaire and added her own expectations, concepts and ideas.

Teachers:

Over the requirement-elicitation period, several members of the teaching personnel were interviewed. They were chosen for their experience with the school's SOPs, their teaching skills, their hands-on experience with online learning, their interest in the project or simply for the fact that they had approached the PM in order to express ideas, wishes or apprehensions.

It soon became apparent that the teaching personnel are a very heterogeneous group with widely varying computer skills, and likewise varying experience with online-media and social media. Although the general motivation and anticipation was positive and high, especially some of the instructors with little computer affinity articulated their reservations and apprehensions. All input was appreciated and recorded in an executive summary as an attachment to the RSD (Appendix M). This was in accordance with the RefArc's endorsements on OCM.

Additionally, every interviewed instructor was asked to answer detailed questions from the questionnaire about the online learning-perspective, the teaching SOPs, the expected LMS features and characteristics, and their personal notion of LMS operations.

The following issues are an excerpt (full list in Appendix M and Appendix P) of the inputs offered by the teaching staff:

- Start LMS operations with a basic version and expand it as necessary
- Provide user training, a helpdesk and solid online help tools (like a special wiki) along with the system
- Make the LMS the primary source of information and its use mandatory
- **Avoid unreasonable extra workload for all personnel; do not have the staff manage all LMS-related tasks in addition to their normal tasks; contract these tasks out to a professional provider**

Workers Council:

To keep the workers council in the loop about the project is a commendation of the RefArc that prompted regular meetings with the workers council. As its members are simultaneously instructors with long years of teaching experience at the TA, the meetings were also used as interviews along the RefArc's criteria to produce more data for the RE process. In addition to the standard questions, the members of the workers council were asked for information about procedural knowledge in the areas of school management (as an additional source of interpretation), school administration and the teaching perspective, as they are a primary contact point for suggestions among their peers. The results were also put on record for further evaluation in stage two of the RE procedure.

Student Representatives:

The degree involvement of the students as the largest stakeholder/user group's for the LMS at the TA had to be decided first. The headmaster delegated this decision to the LMS concept team. As the students are also a very heterogeneous group and their motivation to take part in the additional work which the LMS project constitutes may for the most part be limited. It had to be decided whether to involve only a selected few (e.g. the students council or a class within the IT faculty), while only informing the majority or whether to integrate the majority in the opinion poll and interview only a few. It was agreed on that two volunteers from each class should participate in the poll, while the majority was informed via an internet presentation. Further interested volunteers were to contact the PM for an interview. Although over 40 students stepped up, only fifteen interviews were conducted due to capacity-/time-issues. These interviews were led like the interviews with the teachers, by using the

questionnaire and asking for expectations, impressions and ideas. The ideas were noted in Appendix P. The interviews resulted in a solid impression and some basic concepts for LMS-operations.

IT-Provider:

Lan4You, the TA's IT provider could only be interviewed briefly, as staffing shortages prohibited the administrators to spend more time to answer questions. Due to a specific request for an interview forwarded by the principal, an interview with one of the managers could be arranged.

The manager did not participate in filling out the questionnaire, as he defined himself as "outside the TA's area of interest" and "only a service provider". However, he was otherwise very supportive in answering all questions about LMS-related administrative and technical feasibility on the given infrastructure and the possible support Lan4You could provide for the project. Negotiations about costs and services were postponed to a more detailed request from the headmaster and more detailed information. The project manager inferred the impression that although Lan4You was under heavy strain due to staff shortages they would be happy to provide any service necessary for the LMS application.

4.2.3 Site- and Technical-Survey

Due to the school management's very supportive attitude, the TA's organizational, physical and technological environment could be inspected at leisure. This was done by the PM and the LMS concept team as was deemed necessary to answer arising questions.

After the initial interview, the initial site survey was conducted under the lead of the Head of Administration and with the participation of two supportive teachers. During this site-survey, the entire premises were inspected, including staff- and boardrooms and offices, and the PM was introduced to administration staff members and several teachers.

In regard to the LMS project information-boards, IT-infrastructure (see Appendix M), facility structure and classrooms were of particular interest, as these hinted to the potential LMS operation background. Since every school is organized differently, the RefArc was not designed to give specifics about the site survey. However, using the questionnaire and the process model for the requirement evaluation, significant facts

and circumstances like WLAN accessibility, staff coordination, info-board structure and data/file management could be identified.
Parallel to the site survey, the Head of Administration explained about the SOPs for the premises and provided folders with those SOPs, including the official professional school regulations and the TA's layout.

Regarding the technological equipment, the site survey was held on the physical premises as well as virtually. For the implementation and operation of an online learning platform it is logical that specific technological foundations like a server- and database-infrastructure as well as media computers and -projectors, and a sufficiently fast WLAN-structure need to be available.

The TA's computer-environment consists of:

- Four computer laboratories
- Several specialized computers in four additional laboratories
- One PC per classroom
- Ten teacher-preparation computers in the staff room and teacher-preparation offices and
- The individual administration staff computers.

The PCs are deemed to be sufficient for the LMS utilization. The WLAN-structure, however, is unable to cope with the number of devices the students would use in LMS operations. Moreover, the media-projector equipment is unsuitable for a massively computer-based learning environment, as the school only features six beamers plus one in each laboratory. Consequently, the media equipment needs to be improved parallel to the LMS implementation. On the software side, the school provides a number of special software-licenses on its laboratory computers and a basic but sufficient office-software installation on each PC.
The current database-infrastructure for school and student administration may cause overhead workload. Already the data has to be maintained redundantly under great effort. The BBZ's mandatory system, LookIn, lacks several important filtering and allocation features, so parallel Excel-charts have to be maintained.
As mentioned before, the school's entire hardware and software structure is administrated and maintained by the external service provider Lan4You. The provider is willing to support any required hardware and software upgrade. Lan4You is also prepared to provide and maintain the hardware equipment (server and database-

platform) for the LMS, but not to implement and administrate the LMS-software. This exclusion also comprises both, the LMS-software related help and support functions as well as the data-security requirements which would consequently be in the school's own authority. Even during the tech-survey, the PM regarded this as problematic and therefore necessary to put on the agenda for the workshops.

4.2.4 Stakeholder Opinion Poll

The main means of gathering data for the RE-process was an opinion poll conducted at the TA from November 25th 2013 until December 15th 2013 with the LimeSurvey online tool (The LimeSurvey project team, 2011) on a server provided by the master thesis's supervisor.

The poll was announced in the context of the TA's "Pedagogic Day" on November 20th 2014 in the setting of a full staff-meeting (see 4.2.4). The invitations for the poll were sent to every staff member via email with the kind request to give voice to her/his opinion regarding the questions asked in the poll. The student involvement was decided, as already mentioned, in the first workshop. Two reliable volunteers from every class, per request of the class teachers, were to contact the PM to receive their invitation to the poll. Based on the decision of the school management, alumni and external cooperating organizations were not to be included in the poll.

The survey's questions (Appendix P) were based on the RefArc's questionnaire in context with the interviews' and site-/tech-surveys' impressions and findings. The survey included 13 questions, in parts with multiple sub:

Part	Content
Address of welcome	Welcome and thanks for participation Assurance of absolute anonymity and voluntariness of participation and answering
Personal skill assessment	Personal computer skills Skills and previous experiences with social media and LMSs
Expected LMS features	Expected or preferred modules for communication, teaching, information transfer, etc.
Expected LMS characteristics	Expected characteristics, e.g. user-friendliness, robustness, intuitive handling
Content and structural expectations	Free answer possibility about how to use the LMS, how it could be structured, how the UI could be laid out, how communication could take place, which kind of content should be featured
Demographic questions	General optional questions about gender, age, user-group-affiliation

Table 9: Survey Structure and Content

The poll-questionnaire was designed as an online-survey in the LimeSurvey tool and presented to the school management, the workers council and the master thesis supervisor for affirmation prior to the survey launch.

The main goal of the opinion poll was to elicit objectives and measurable data with which to engineer and evaluate requirements. The second objective was to gain further input from the free answering questions about the expectations regarding the LMS operation.

About 150 members of the school's staff and 50 students were invited to volunteer their voices in the online opinion poll. The actual total number of participants was 64. The group distribution (left chart Figure 1) shows an almost equal participation between students and teachers. The low number of participants from the school management and administration was expected, as those had, for the most part, already been interviewed and had answered the questionnaire in the interview setting. Consequently, these answers had to be considered additionally in the evaluation process. The dominance of male participants (right chart Figure 1) was also to be expected as both, the student body and the teaching staff are heavy on the male side, as is to be expected at a polytechnic school.

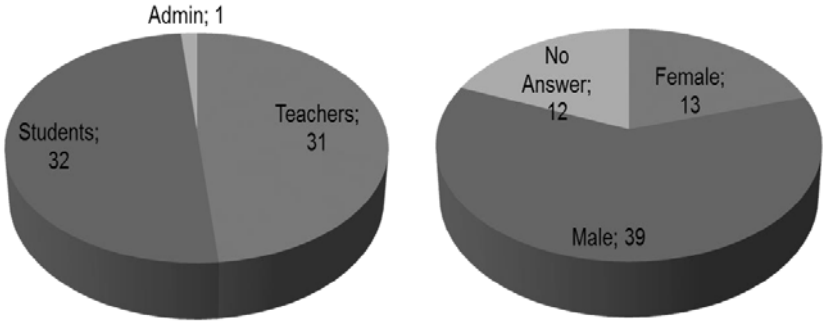


Figure 27: Survey Distribution – TA

The poll's results were presented and discussed for their implications on the conceptualization and the requirements in the context of the second workshop. More details may be deduced from the excerpt of the result-evaluation in subchapter 4.2.5.

4.2.5 Workshops and Presentations

In the run of the RE process, several workshops, meetings and presentations were held for conceptualization, requirement evaluation and requirement validation as well as for project feedback and general information. For the most part the workshops were attended by the PM and the LMS-concept team, which consisted of representatives from the school management, the administration, the workers council, students and teachers. The activities, including an agenda and a summary of the respective findings, are noted in this subchapter.

Presentation Meeting with LMS-experienced teachers:

As already mentioned in subchapter 4.2.1, the headmaster organized a meeting with LMS-experienced and interested members of the teaching and administration body, which took place at September 24th 2013 on TA premises and in which previous experiences with online-teaching projects were presented and discussed. Additionally, the TA's LMS venture was announced and a basis for "viral-promotion" among the staff was created.

In concordance with the RefArc, all input on experience and ideas was noted and organized by the PM.

Presentation at "Pedagogic Day":

On 11th November 2013, the "Pedagogic Day", the LMS implementation venture was initially presented in front of the TA's entire teaching staff and the school's administration and management. The content of the presentation included:

- Presentation of LMSs in general, incl. online-examples (Mahara (Mahara, 2013) and Moodle (Moodle, 2013) demonstration)
- Presentation of the TA's LMS venture as a test bed for the master thesis's resulting RefArc
- Presentation of objectives of the TA's LMS venture
- Request for active support
- Announcement and request for support for the coming activities like the opinion poll and the workshops.

After the presentation, the PM had the chance to answer questions from the audience. The questions related to data security, additional workload for teachers and administrational staff, group-access management, and to who would be responsible for the creation and implementation of the online/blended learning course.

Orientation Workshop:

The first workshop took place on November 22nd 2013 in one of the TA's computer laboratories with the attendance of twelve voluntary teachers who had signed up for participation after the initial presentation at the "Pedagogic Day", the principal, and the designated members from the administration staff; all in all nineteen participants. There were representatives for all faculties among the teachers. The agenda for this orientation and introduction workshop was as follows:

- Familiarization of the concept team with typical LMS structures, modules, options/possibilities and restrictions
  The participants had to complete several tasks in the online demo-LMSs, like join and create groups; administrate new members, create new forum topics; adjust personal profiles; use chat features.
- Discussion about similarities, differences, implications, chances and restrictions between commercialized, in-house and OS solutions
- Mutual brainstorming about expectations, requirements and specifications
  Results entailed thoughts about data and information redundancy, a basis for the group structure development (to be done in the next workshop), student self-organization within the LMS and necessary means of support, like a helpdesk.

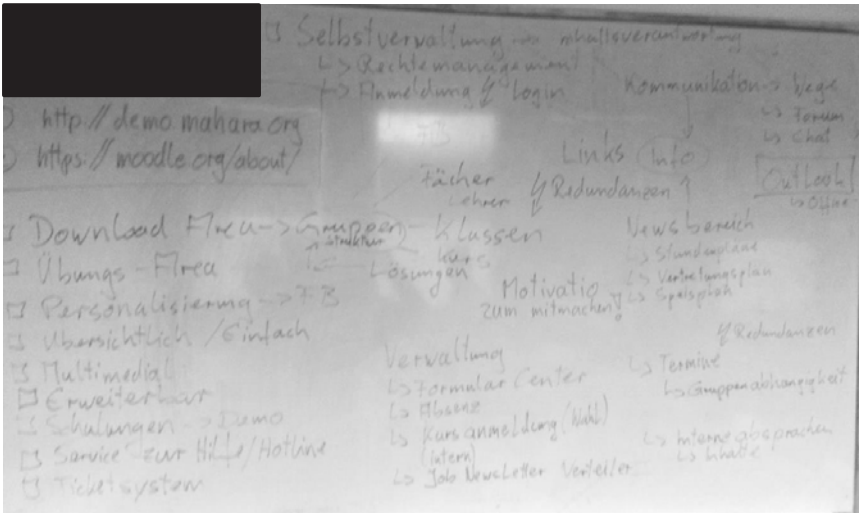


Figure 28: Brainstorming Results Orientation Workshop

- Mutual brainstorming and decision about student involvement in survey, in LMS and RE processes, and in implementation and operation processes:
  It was decided that two voluntary students per class should be recommended by the class teachers to achieve a representative demographic profile. The student council was to be offered to send representatives of the student body to take part in the workshops. Decisions about student involvement in the LMS operation and in further development were postponed.
- Building the core team for the LMS concept team from the workshops participants and other interested TA affiliates

1st Concept Workshop:

The first concept workshop took place on December 13th 2013 in a computer laboratory. Participants were the core concept team consisting of the PM, the principal, the Heads of Administration and Office and seven interested teachers representing the faculties. The student council sent no representative to this workshop.

Topics on the agenda were:

- Presentation and discussion of the hitherto extracted survey results and the Orientation Workshops minutes
- Demonstration of the LMS StudON as an example for group management, content management and access rights management
- Mutual Development of group structure and content structure based on the business structure concept developed by the principal, the Head of Administration and the PM (Figure 26)

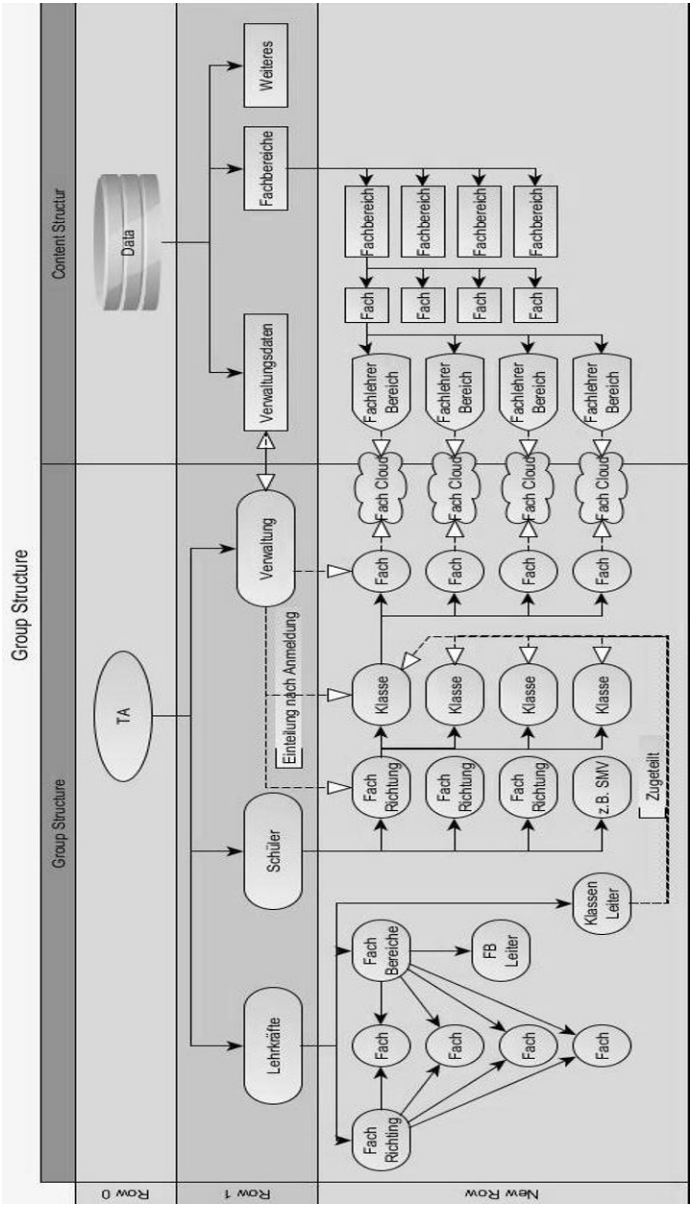


Figure 29: Concept Base for Content/Group Management – TA (in German)

During this development brainstorming, the principal dominated the scene due to his experience and overview over the school's structure and his precise conceptions about the target structure. With additional well founded interjections and input from the concept team, a solid concept foundation for structural combination of content, groups and access rights could be designed (Figure 29). Furthermore, the concept could be extended to cover the content distribution management (Figure 30)

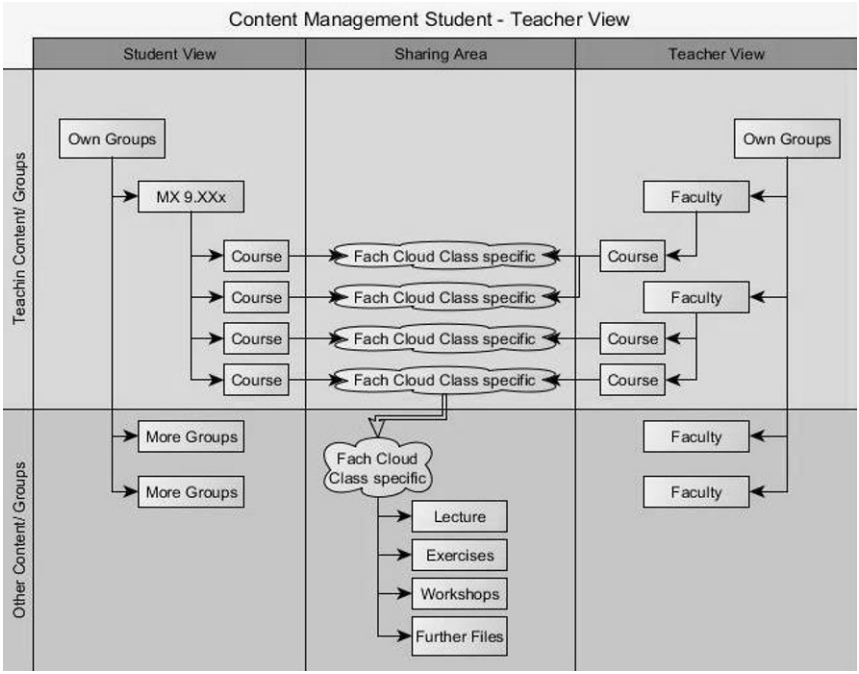


Figure 30: Content-Distribution-Management – TA

2nd Concept Workshop:

The scope of the second concept workshop was the conceptualization of the communication and information management based on concepts from the first concept workshop (Figure 29 and Figure 30) and the LMS business concept (Figure 26)

The resulting thoughts were:

- *Avoid increased workload caused by redundant information channels. Chose channels adequate to the task and avoid additional email utilization.*
- *Means of information transfer like info boards, calendars etc. need to be interlinked to keep information up to date on all those means*

- *Administrational tools like the LookIn-database need to be connected to the LMS to guarantee data currency*
- *Content responsibility for the class and subject specific virtual environments rests with the respective teacher. Copyright issues must be considered. The assignment of access rights also rests with the teacher responsible for the cloud environment.*
- *The encoding of the LMS and a restrictive access policy in regard to the LMS and the respective groups are the foundation for data security and copyright safety.*
- *The respective subject instructor arranges communication rules for his/her course. The teacher is not expected to be continuously reachable. The communication platform shall mostly step up the inter-student-support.*
- *The responsibility for posts always rests with the particular author. Offensive behavior or virtual mischief must be monitored and eventually punished through school officials. Communication always takes place under the true name.*
- *The online office-application, provided by Lan4You and already in use, needs to be linked to the LMS. Address books and calendars need to be interconnected and auto-synchronized.*
- *Technical administration, system maintenance and development, helpdesk service and ticket system shall be outsourced to a professional external contractor*
- *Staff training and help wikis need to be provided by said contractor*

4.3 Data Sample – Preparing the Scoring Model

In this subchapter an excerpt of the gathered data will be presented. First of all, two types of data need to be differentiated. On the one hand, the created database contains organization-specific data gained through the requirement elicitation process and under the guidance of the RefArc. On the other hand, there is the data about the LMS options, gathered through benchmarking and research on market, internet and literature, to match against the requirements.

As mentioned before (subchapters 2.1.2, 3.1.2 and Chapter 4:), several sources of data were used in the requirement-elicitation process and the resulting flood of data

had to be brought together to become analyzable. Often stakeholder statements could not be translated into specific requirements and therefore had to be interpreted as impressions to further qualify as a requirement in the evaluation process. An example for such a statement (translated from a German free-text comment in the opinion poll) is:

"The LMS must not be a data-kraken!" (Appendix P)

This statement can be interpreted as an apprehension that the LMS may be used as uncoordinated and unmanaged data storage like a harddrive in which data will just be stored, copied multiple times into personal folders and backups and will eventually be forgotten, obsolete and/or lost. The statement may also be interpreted as seeing the LMS as a "beast" engulfing all information and putting work in it but not releasing it as needed, consequently pointing to the difficulties in finding and transmitting the data as needed. Both meanings show the need for a coordinated and elaborate content management.

An example for statements directly translatable into specific requirements and for which the significance and consequently the prioritization could be assigned straightforwardly, is the communication module issue.

All stakeholder groups expressed the need for further means of intra-school/-group communication. Typical communication modules provided with the LMS are forums, chat rooms, direct-messaging systems, emails, virtual voice or video-conference rooms, as well as blogs, wikis, or pin boards which offer "like" and/or comment possibilities.

Using these communication possibilities and stakeholder input in combination with the RefArc's questionnaire system and the corresponding weighting system (2.1.3) in interviews and the opinion poll, the results depicted in Figure 1 could be elicited.

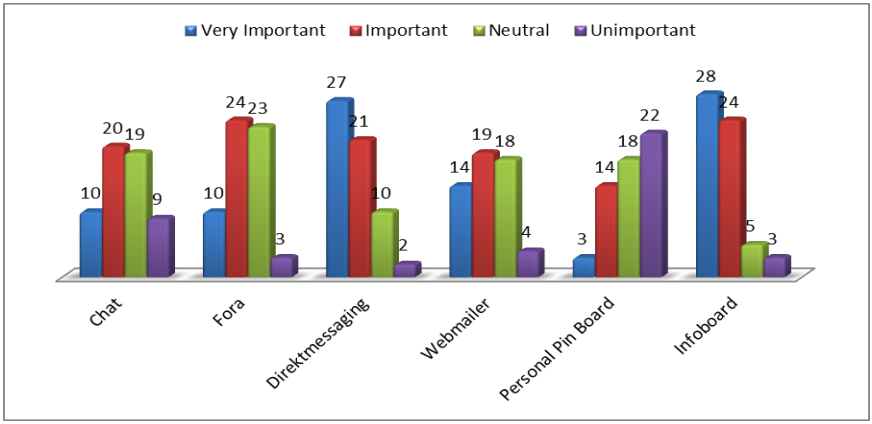


Figure 31: Weight Assessment Communication Modules – TA

Noticeably, the info-board and the direct-messaging module have the highest acceptance rates for integration into the TA's LMS. By crating the total criterion weight and classifying it against the thresholds defined by the concept team, the criteria prioritization decides which modules to integrate.

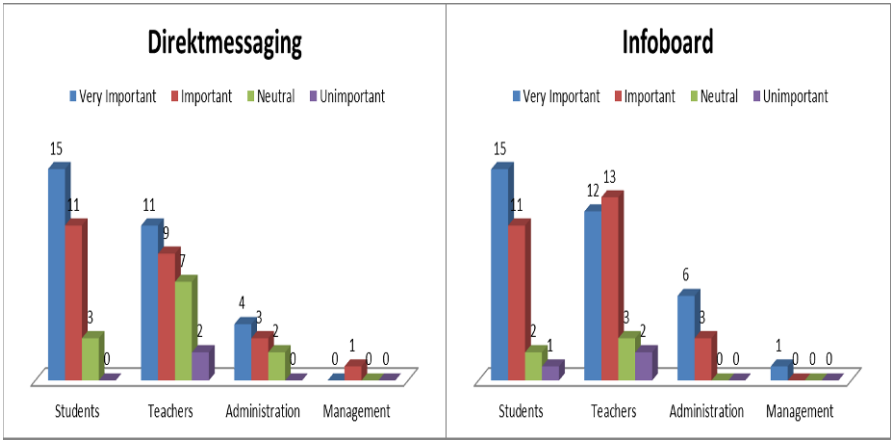


Figure 32: Stakeholder/Weight Distribution Example – TA

The assessment terms "very important", "important", "neutral" and "unimportant" need to be assigned to the weights four to one. As the individual stakeholder groups' influence on the LMS design varies (the principal, for instance, has more influence than the alumni) their significance must be considered in the resulting weight. Combining

the individual stakeholder group significance (deduced from the stakeholder portfolio (Figure 25)) with the respective weight (assigned by the stakeholder-group) a weighted criterion significance could be produced. Building the mean of those values generates the total criterion weight TCW (see Figure 33).

Stakeholder Group	Teacher		Students		Management		Administration		Alumni		Externals		Result
Stakeholder Influence (from Protfolio)	6		5		9		7		0		0		27
	Weight (Survey/ WS)	Result Weight	Weight (Survey/ WS)	Result Weight	Weight (Survey/ WS)	Result Weight	Weight (Survey/ WS)	Result Weight	Weight (Survey/ WS)	Result Weight	Weight (Survey/ WS)	Rsult Weight	
Chat Module included/ supported	2,5	15	2,8	14	3	27	3	21		0		0	2,85185185
Forum Module included/ supported	2,7	16,2	2,8	14	3	27	3	21		0		0	2,8962963
Direct Messaging Module included/ supported	3,2	19,2	3,4	17	4	36	4	28		0		0	3,71111111
Dashboard Module included/ supported	1,9	11,4	1,9	9,5	1	9	3	21		0		0	1,88518519
Personal Blog Module included/ supported	1,4	8,4	1,8	9	1	9	1	7		0		0	1,23703704
Wiki Module included/ supported	2,1	12,6	2,7	13,5	2	18	2	14		0		0	2,15185185
Infoboard Module included/ supported	3,3	19,8	3,4	17	4	36	4	28		0		0	3,73333333
Email Blast Module included/ supported	2,8	16,8	2,9	14,5	3	27	3	21		0		0	2,93703704
Email Info Module included/ supported	2,8	16,8	2,9	14,5		0	4	28		0		0	2,1962963

Figure 33: Total Criterion Weight Calculation Example – TA

In the first concept workshop, the TA's LMS-concept team analyzed the thitherto gathered results from survey and interviews, and specified the thresholds for the requirement arrangement into the priority groupings. The specification was supported through the general impressions about the individual requirements gained through the data-collection. It was decided that:

- Must-criteria require a total criterion weight of greater than or equal 3.2
- Need-criteria require less the 3.2 but greater than or equal 2.7
- May-criteria range between 2.7 and 2.0 and
- Everything lower than 2.0 will not be considered for implementation into the LMS.

In regard to the example depicted in Figure 33 the following priorities were assigned to the respective requirements:

Criterion Denomination	TCW	Priority
Chat Module included/supported	2,85	Need
Forum Module included/supported	2,89	Need
Direct-Messaging Module included/supported	3,71	Must
Dashboard Module included/supported	1,88	Must-Not
Personal-Blog Module included/supported	1,23	Must-Not
Wiki Module included/supported	2,15	Need (Team-Decision)
Info-Board Module included/supported	3,73	Must
Email-Blast Module included/supported	2,93	Need
Email-Info Module included/supported	2,19	May

Table 10: CTW/Priority Realation Example – TA

The LMS market research provided an overview of the available LMSs, their differences, their focuses, their costs, their benefits and drawbacks, the available modules, their popularity and benchmarking rating, and the trends in the market. The essentials are summarized in Appendix G, Appendix H and Figure 6 and Figure **7**.

Utilizing the RSD's requirement compilation and the appendant priorities, the information about 37 LMSs on the market (attachment to Appendix M) was matched against the requirements and general impressions. This percolation process helped to identify five last-choice/best-fit LMSs for the systematic chart comparison.

The best-fit candidates for the TA were EDYOU, itslearning, Mahara, Moodle, and Stud.IP. These five LMSs were deemed to have the best chance to create maximum value for the TA and to support the TA's business structure, vision, mission and structure optimally. In addition to these features, they were deemed to be well supported, of current technology and to represent established standards in the education landscape, making interconnection feasible.

4.4 Data-Evaluation – Utilizing the Scoring Model

Once the scoring model is prepared in regard to the requirements (4.2.5), the necessary information about the ultimately chosen LMS has to be inspected according to these same requirements. The scoring model calls for a comparative grading of the requirements while agreeing with its respective suitability for application in the TA.

Criterion	Weight	Stud.IP		Moodle		Mahara		EDYOU		itslearning	
		Grade	Result	Grade	Result	Grade	Result	Grade	Result	Grade	Result
Supports the institute's vision	3,4	3	10,1	3	10,1	3	10,1	3	10,1	4	13,4
Supports institute's mission	3,1	3	9,4	3	9,4	3	9,4	3	9,4	4	12,6
Supports Business structure	3,6	3	10,8	3	10,8	4	14,3	4	14,3	4	14,3
Supports Business Goals and Objectives	3,2	4	12,8	4	12,8	4	12,8	4	12,8	4	12,8
Technical, hardware, organziational and conceptual requirements can be met	3,0	4	11,9	3	8,9	4	11,9	3	8,9	3	8,9
Project timeframe can be kept	3,1	3	9,2	3	9,2	3	9,2	4	12,2	4	12,2
Supports the required PR Effect	2,9	3	8,7	2	5,8	4	11,7	3	8,7	3	8,7
Summary Business Perspective		3,3	72,9	3,0	67,0	3,6	79,4	3,4	76,5	3,7	83,0
Suitable for designated user group [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible] teaching environment)											
Desired Online Evaluation supported (Automated, manual, open design)	2,7	3	8,2	2	5,5	2	5,5	3	8,2	4	11,0
Educational Objectives supported	3,2	3	9,6	3	9,6	3	9,6	3	9,6	4	12,8
Summary Didactic Perspective		3,0	63,5	2,4	51,7	2,7	57,5	3,3	69,8	4,0	84,6

Figure 34: Scoring Model Utilization Example – TA

The PM graded the rate of requirement fulfillment based on his information gained through the RE process and the market research. The grades were discussed with stakeholder representatives in the second conceptualization workshop and specifically with the school management in an interview. Some ratings had to be adjusted to fit the stakeholder's view.

The scoring model automatically calculated the requirement and LMS specific points, through multiplying result of weight by grade (Figure 34). The grades were also combined to average grades, both for the specific perspectives (Figure 34) and the total comparison (Figure 35). The requirement and LMS specific points were added up to total points, both for the specific perspectives (Figure 34) and the total comparison (Figure 35).

	Desired profile and access managemnet supported	2,9	3	8,8	3	8,8	3	8,8	4	11,8	3	8,8
	Mobile (Smartphone) Accessibility supported	2,8	2	5,7	1	2,8	1	2,8	3	8,5	3	8,5
	Summary Feature Perspective		**2,9**	**63,6**	**2,6**	**57,6**	**2,6**	**57,6**	**3,7**	**83,4**	**3,7**	**83,6**
	Max Score/ LMS mean value; LMS respective Scores	516,0	3,2	411,9	2,7	352,4	3,0	382,6	3,4	446,0	3,6	470,9
	% Score	100%		79,81%		68,28%		74,15%		86,42%		91,25%

Figure 35: Scoring Model Result Example – TA

Figure 35 also shows that the total points which an LMS scored were compared to the maximally possible points, created by multiplying every requirement's weight by the highest possible grade, which was decided to be 4, for the purposes of the scoring model. Thus, a percent number for each LMS's probable fulfillment of the TA's requirements was created.

Another important feature of the scoring model is the setting of a rejection threshold. If a criterion with a weight higher than this threshold gains a grade 1 the LMS will be rejected completely as an essential factor cannot be fulfilled. This fact will be shown in a popup messagebox, and will point to the individual cell in which the rejection occurred.

After running 37 popular LMSs (attachment to Appendix M) through the requirement filter and comparing the five LMS with the best score more intensively, a ranking of those could be agreed on by the concept team, the PM and the school management.

For a final agreement on this ranking, not only the LMSs' percent numbers were significant but also the distribution of characteristics and features throughout the five perspectives. These could be assessed best by utilizing web charts (Figure 36).

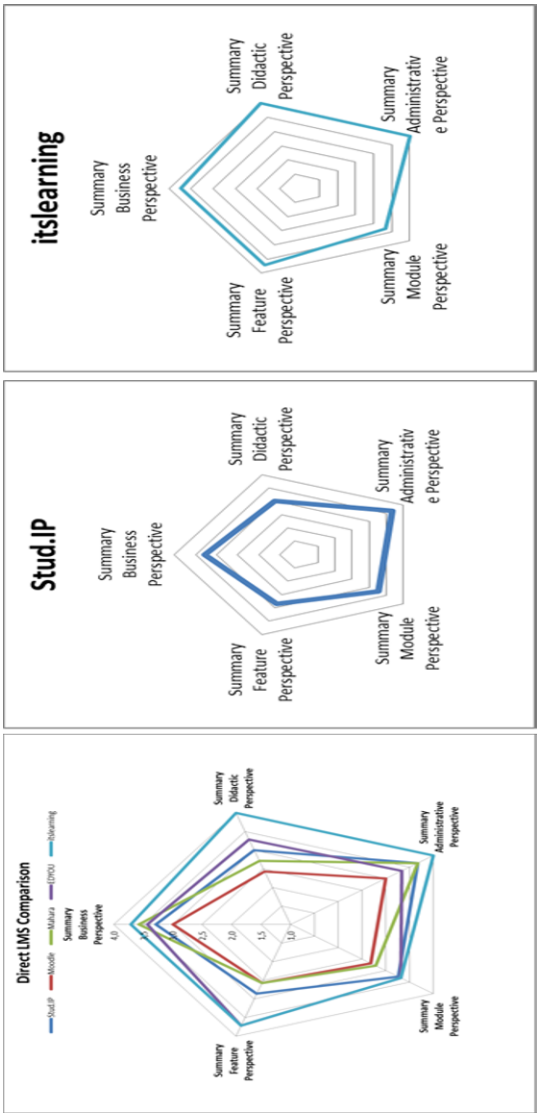


Figure 36: Web Chart Result Example – TA

From theses web charts it could be interpreted immediately that the commercial solutions “EDYOU” and “itslearning” would provide the necessary services best, compared to the other LMSs, followed by the OS solution Stud.IP.
However, as commercial LMSs are normally perceived to be more expensive than the OS ones with their free source code, the CEA became of enormous interest as eventually the LMS application comes down to the expenditure-gain relation.
This important factor is discussed in the next subchapter including the actual SRS creation for the TA.

4.5 Advisory SRS

Almost simultaneously to the LMS-selection process, the PM had to create the SRS. This took place in January 2014. This RSD was not only to be created as a summary of requirements and a foundation for the selection and implementation of the LMS, but also to fulfill recommendation purposes in advising the school management. To realize this function in addition to the classical function of the RSD (Robertson & Robertson, 1998), the SRS had to be devised in four general parts:

- The introduction, including an analysis of the project’s and the school’s initial situations
- The requirements summary
- The concept and recommendation part
- The conclusion

Classical SRS Parts:

As advised in the RefArc, the first two modules, which are standard SRS parts, were drawn up from the basis of the Volere template (Robertson & Robertson, 2003) and the example RSDs (Appendix Q) found online. This synopsis process was executed exactly along the lines described in chapter 3.4.2.
The PM, in collaboration with the concept team, formulated 45 requirement criteria for the TA’s LMS (see Appendix M). The criteria were classified into functional, non-functional and design requirements, and prioritized according to the illustration in 4.2.5.
Many of the criteria, however, cannot stand alone and consequently relate to the designed concepts which were in turn described in the advisory parts of the TA’s SRS and the corresponding attachments.

Advisory part:

The additional advisory function of the SRS was put into effect through the elaboration on the concepts, the LMS recommendation and the CEA.

Concepts and LMS selection for the TA were already discussed in other subchapters (4.2.4, 4.3) and were consequently summarized and depicted in a reader-friendly manner utilizing charts, process models and rankings.

One major aspect for the school management's final decision is the cost-effectiveness ratio. The RefArc and the affiliated ECA-Excel-chart (Appendix J and Appendix L) instructed the PM about the procedure of creating the ECA for the TA based on market research, benchmarking, best-practice experience (3.5.2) and the school's individual data (4.1, Chapter 4:).

The first step was the identification of possible costs and benefits from the aforementioned research data for the incorporation into the ECA-Excel-Chart (Figure 37 and detailed in Appendix O). Moreover, to the costs and benefits had to be assigned to the figures and assessments depending on short-, middle- and long-term considerations. This was done comparatively for OS and commercialized LMS solutions.

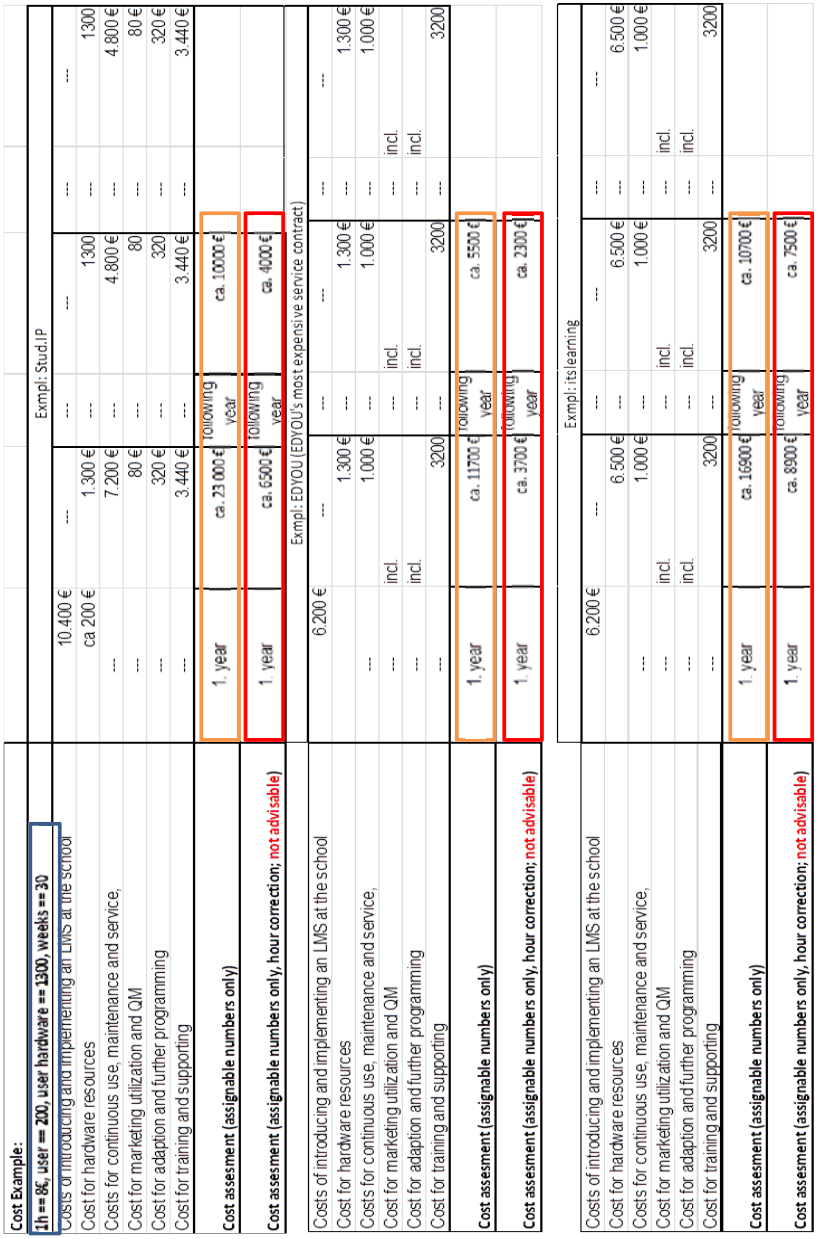
As seen in Figure 37, the assessments are often vague, especially in regard to the benefits. As discussed in 3.5.2, most sources agree on the benefits' effectiveness rates being dependent on the LMS utilization and application efficiency. To provide the school's management with a better decision basis, the three best-fit LMSs were calculated using paradigms. This circumstance is illustrated in Figure 38 and detailed in Appendix O.

The necessary assumptions for the calculations are shown in the blue box in Figure 38. These cautious estimates provided the basis for calculating the costs, including the costs for personnel time.

As discussed in the second workshop (4.2.4), additional effort for the staff must be considered and incorporated into the calculations, but the school management may argue that these costs are already compensated with the salaries. Therefore the cost discussion delivered two ballpark assessments, the first one (orange boxes) including all costs (even the costs for staff in training with LMS operations) and the second one adjusted to exclude the working-hours (red boxes).

	Open Source					
Cost:	Shorttime		Midtime		Longterme	
	<18 months		<36 months		>36 months	
	one time	regular	one time	regular	one time	regular
Costs of introducing and implementing an LMS at the school	5h/user + 300hforsetup	---	---	---	---	---
Cost for personell (staff: utilization time)	high	middle	---	middle	---	low
Cost for hardware resources	ca 200€	1€/user to 3€/user	---	1€/user to 3€/user	---	1€/user to 3€/user
Costs for change management and continuing motivation processes	high (min 2h/user)	middle	---	low	---	low
Costs for continuous use, maintenance and service,	---	30+h/week	---	20+h/week	---	20+h/week
Cost for marketing utilization and QM	---	10h for Admin	---	10h for Admin	---	10h for Admin
Cost for adaption and further programming	---	40h for Admin	---	40h for Admin	---	40h for Admin
Cost for training and supporting	---	30h for prep 2h/user	---	30h for prep 2h/user	---	30h for prep 2h/user
Cost for additional work in restructuring and re-preparing content	high	middle	---	middle	---	low
Benefit:						
Benefits of additional services		high	---	middle	---	middle
Benefits of saving time and labor	negative	low	---	middle	---	middle
Benefits as marketing platform and qualifying element in the competition	---	high	---	middle	---	middle
Benefits through communication gain	---	low	---	middle	---	middle
Acceptance though modern media usage	---	high	---	high	---	middle
Expected service, Benefit of Image	high	high	---	middle	---	middle
Benefit of better results of students	---	low	---	middle	---	high
Customer satisfaction, employee satisfaction	---	high	---	middle	---	middle
Quality	---	middle	---	middle	---	middle
Saving ressources like printing material	---	low	---	middle	---	middle
Optimized data/ contend structure è faster access,	---	low	---	middle	---	high
Revenue						

Figure 37: ECA Example OS-solution – TA



Cost Example:						
1h == 8€, user == 200, user hardware == 1300, weeks == 30	Exmpl: Stud.IP					
Costs of introducing and implementing an LMS at the school	10.400 €	---	---	---	---	---
Cost for hardware resources	ca 200 €	1.300 €	---	1300	---	1300
Costs for continuous use, maintenance and service,	---	7.200 €	---	4.800 €	---	4.800 €
Cost for marketing utilization and QM	---	80 €	---	80	---	80 €
Cost for adaption and further programming	---	320 €	---	320	---	320 €
Cost for training and supporting	---	3.440 €	---	3.440 €	---	3.440 €
Cost assesment (assignable numbers only)	1. year	ca. 23.000 €	following year	ca. 10000 €		
Cost assesment (assignable numbers only, hour correction; not advisable)	1. year	ca. 6500 €	following year	ca. 4000 €		
	Exmpl: EDYOU (EDYOU's most expensive service contract)					
Costs of introducing and implementing an LMS at the school	6.200 €	---	---	---	---	---
Cost for hardware resources		1.300 €	---	1.300 €	---	1.300 €
Costs for continuous use, maintenance and service,	---	1.000 €	---	1.000 €	---	1.000 €
Cost for marketing utilization and QM	---	incl.	---	incl.	---	incl.
Cost for adaption and further programming	---	incl.	---	incl.	---	incl.
Cost for training and supporting	---	3200	---	3200	---	3200
Cost assesment (assignable numbers only)	1. year	ca. 11700 €	following year	ca. 5500 €		
Cost assesment (assignable numbers only, hour correction; not advisable)	1. year	ca. 3700 €	following year	ca. 2300 €		
	Exmpl: itslearning					
Costs of introducing and implementing an LMS at the school	6.200 €	---	---	---	---	---
Cost for hardware resources		6.500 €	---	6.500 €	---	6.500 €
Costs for continuous use, maintenance and service,	---	1.000 €	---	1.000 €	---	1.000 €
Cost for marketing utilization and QM	---	incl.	---	incl.	---	incl.
Cost for adaption and further programming	---	incl.	---	incl.	---	incl.
Cost for training and supporting	---	3200	---	3200	---	3200
Cost assesment (assignable numbers only)	1. year	ca. 16800 €	following year	ca. 10700 €		
Cost assesment (assignable numbers only, hour correction; not advisable)	1. year	ca. 8900 €	following year	ca. 7500 €		

Figure 38: Cost-Structure Example Calculations – TA

All LMSs, especially the commercialized ones, have different cost structures, so the direct figure assignment is in some parts complicated. EDYOU, for instance, has a simple cost structure which only orients itself by the number of users and the chosen package, while itslearning refuses to give generally applicable figures as they customize the costs to the tailored LMS and services offered to a particular organization.

This is why the SRS, and especially the advisory parts, should not be presented solely as a document but should rather be accompanied by an explanatory Q&A meeting (see 4.5).

4.6 Presenting the RE-Results

The results of the RE process establish a sound foundation for the final selection, implementation and utilization of the LMS. This final decision, however, lies with the stakeholder. Consequently, the primary audience for the SRS and the corresponding Q&A meeting are the involved stakeholder representatives. In case of the TA, this means the headmaster and, subject to his approval, the concept team.
Although the TA's principal tried to be as involved as possible during the RE process, many concepts and findings were created without his direct involvement.
While the classical part of the SRS is easily understood and essentially a foundation for the later implementation and application of the LMS, the advisory part needs additional oral explaining and the chance for Q&A. This is mainly due to the fact that the consultation provides the school management with core information, but also due to the (in parts) high data density in the Excel-charts which cause need for explanation for persons not directly involved in the creation of those charts.
The primary audience for the SRS and the corresponding Q&A meeting are the involved stakeholder representatives.
As suggested by the RefArc, the main points of the presentation were the list with the LMS-ranking results, the explanation why the chosen LMS particularly complies with the requirements, the alternatives, the CEA and the projections describing the next steps to be taken in the project.

To get the school management to accept recommendations, the SRS's and Q&A's focuses lay on the CEA and the LMS selection, following the path of the money, the required effort and efficiency-necessities like user motivation. Consequently, the re-

sults were mostly presented under the application of objective charts and numbers and facts.

	LMS Name	%-Rating	Comment
1	itslearning	91 %	Commercialized LMS, many references, high number of implementations worldwide, long-standing experience, ca. 5000-8000 €/year
2	EDYOU	86 %	Cheaper option, very good price/performance ratio
3	Stud.IP	80 %	Best Open-Source solution; however, considering the CEA, a commercialized LMS seems to be more opportune
4	Mahara	74 %	Very adaptable, high initial effort
5	Moodle	68 %	Most widely used standard in the German market

Table 11: Results LMS-Selection Process – TA

Itslearning seemed to be the best-fitting LMS for the TA for the following reasons:

- Full compliance with all requirements and capable of high individualization
- Very thorough and professional system administration and support service
- Distinguished user-friendly and robust system concept
- Compliance to Bavarian School-Data Security Standards
- Established successes in und awarded system for eLearning-support

The following constraints were detected:

- Middle to high cost structure dependent on system package (but not higher than with a comparable OS system)
- Use of itslearning's cloud structure mandatory

The comparative contemplation of EDYOU and Stud.IP were presented in the SRS (Appendix M).

A summary (Table 12) of the cost-structure calculations (Figure 38) was presented and explained to clarify the cost-structure differences between OS and commercialized LMS solutions, and to illustrate the hidden costs often not considered in OS LMS application.

	Open Source LMS	Commercialized LMS
Costs per year	1st year: 23000 € Subsequent: 10000 €	1st year: 12000 € - 17000 € Subsequent: 6000 € - 11000 €
Costs per year, adjusted to exclude working-hours (costs for school-staff is not included)	1st year: 6500 € Subsequent: 4000 €	1st year: 4000 € - 9000 € Subsequent 3000 € - 8000 €

Table 12: Cost Comparison OS vs. Commercialized LMS

The presentation and Q&A was completed by the discussion of the next steps in the project. These steps were:

- Final selection of the LMS for the TA by the school management
- Beginning of negotiations about service requirements with the respective service provider (based on the SRS) or download of an OS LMS from a respective homepage
- Negotiation with Lan4You about hardware allocation
- Test implementation and operation of the LMS

4.7 Prototype Test: Summary and Interpretation

The aim of the prototypic testing of the RefArc on the example of the TA was to determine its feasibility and applicability in a real-life environment. Naturally the RefArc could not give detailed instruction to every single step the PM had to fulfill, as it was designed as a guideline only.

In the run of the RE process, the PM and the concept team oriented their activities strongly towards the RefArc and tried to structure and conduct the whole procedure as proposed. Both PM and concept team found the RefArc to be an excellent guideline which offered first-rate clues about what to ask, who to ask etc., and also about the process structure and approach for the RE process. The PM was aware of the current and next steps at all times and was consequently able to guide not only the concept team, but the stakeholders in general through the RE process.

It is worth mentioning, that the RefArc postulates experience and solid understanding of project management activities along the guideline of the IPMA-Competence-Base-

Line (ICB) (Caupin et al., 1999). The PM needs to address the project along this baseline, and several activities like the management of the stakeholder, the risks and the workflow are fundamental.
Especially the stakeholder management, incorporating the compilation of stakeholder portfolios and communication matrices as well as OCM activities proved to be essential during the LMS project, as stakeholder involvement and stakeholder questioning constituted the majority of the activities.

Another very important factor not explicitly described in the RefArc was the supervision and control of the risks and the preparation of backup plans in case a risk occurred. The risk assessment had to be adjusted several times during the project. Especially the risks of absences of key-personnel or merely their unavailability posed problems in meeting the time line. In this context it has to mentioned that stakeholder time is a most precious good and thusly has be factored in the planning. Consequently, the interviews, workshops and surveys needed to be well prepared to guarantee maximum output in the limited time available. Additionally, the PM required good mediation and presentation skills for the workshops and interviews.

Time and time again the RefArc attachments (Scoring-Model-Excel-Chart (1) and ECA-Excel-Chart (Appendix L)) turned out to be a helpful guide in generating the requirements and recommendations, and in selecting the LMS. The Scoring Model made a certain format of requirement weighting and LMS rating necessary. These issues exacted a stringent workflow and promoted objective comparison between the requirements regarding their weights on the one hand and the LMSs regarding their respective ratings on the other hand. Although objectivity was aspired and encouraged wherever possible, often a pre-selection or last decision had to be made via subjective impressions gained through the PM's involvement in the RE process. The PM always tried to back up those decisions through consensus with the stakeholder representatives.

A problematic issue in this RE project was the fact that it stretched out over a long period of time and interim periods between individual activities like workshops or interviews were frequently long enough to disrupt the workflow. As similar projects are deemed to be part-time projects as well, this fact is an expectable obstacle which should be faced with well-established communication, and information and motivation plans and -activities.

In general summary, the stakeholder representatives considered the LMS-project to be a great success. The school's headmaster in particular was pleased with the resulting LMS recommendation and especially with the tractability of decisional factors within the Scoring Model and the ECA. The calculated examples of the ECA found his praise as they enabled him to make decisions based on solid data.
Other stakeholder groups, namely the school administration and the teachers, applauded the concept and the consideration of their input.
The students' council also agreed with the concepts and thanked for their chance of involvement and the appreciation of their input.

The resulting SRS, including the conceptualization outcome, the ECA and the requirement summary seems to be an excellent foundation for the necessary decisions regarding the LMS selection, the preparation for the LMS implementation/ operation and the corresponding project management activities.
Considering initial negotiations with the commercialized LMS provider "itslearning", their reaction to the kind of preoperational work the SRS represents was respect and astonishment. They commented that in over 10 years of experience and over 400 client schools they never had seen an organization this well prepared and this certain of their requirements. In consequence the costs for implementation were reduced massively within their proposal, as the RE-process was already largely finished.

Chapter 5: Conclusion

The aim of this thesis was to create a reference-architecture for the requirement-engineering process necessary for the LMS-selection aimed at the implementation in a polytechnic-knowledge-transfer organization. Furthermore, the frameworks the RefArc consist of, were to be tested prototypically in a real-life instance of a polytechnic school, the TA.

Based on research about standard RE-procedures and -approaches, LMS-basic knowledge and -best-practice experiences, a RefArc was created.

Considering the significant variety in schools' business structures and the huge range of LMSs on the market combined with the diversity of people engaged in the respective LMS-selection project, general applicability for such a RefArc is hardly achievable and the result will always strongly depend on the individual settings and skills:

- Not all necessary information about the required skills could be integrated into the RefArc due to lucidity and compactness.
- The RefArc represents but one way for the LMS-selection process
- The RefArc is linked to other guidelines and sets of skills

This means, for instance, that the created RefArc is based on profound knowledge and skills in basic Project Management. In practice, a designated Manager for the project may gain this knowledge through consulting the ICB (Caupin et al., 1999).

Nevertheless, the RefArc represents a solid, easy to use and well-structured guideline for the RE-process, as well as additional conceptualization and the creation of advisory information. It offers a clear overview over the commended processes via process models and checklists, and a questionnaire which summarizes the basic questions and the circumstances of the elicitation. Moreover, it expands the range of other approaches like the ones from Saba (2013) or Kerres (2012) in order to include:

- Consultative information to aid in the LMS selection and
- Conceptualization guidance to aid in LMS-implementation and -operation.

In the practical application the utilization of the RefArc was demonstrated satisfactorily and with outstanding results, as rated by the stakeholders' and "itslearning"-representatives. Again, the project-management skills were the foundation on which to operate the RefArc.

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BestMasters, DOI 10.1007/978-3-658-08832-3_5, © Springer Fachmedien Wiesbaden 2015

The application of the Excel-Charts belonging to the RefArc turned out to be very productive, and the results were deemed to be the most important information for the stakeholders in choosing an LMS.

This thesis concentrates the relevant information from the fields of RE, KMS, or in this instance LMS-selection, -implementation and -application, and utility analysis. Due to the huge number of possible resources and the high number of different opinions and thoughts in the area of LMSs, this thesis cannot cover every aspect, but has to focus on research directly connected to the RefArc's creation and utilization. To fully grasp the underlying aspects of RE, KM and LM as well as the best practice in each case, background reading in the denoted sources may be required for more detailed information.

Suggestion for Improvement:

While the practical application of the RefArc in the example of the TA, room for improvement of the RefArc and its frameworks was identified:

- The Scoring Model had to be rounded off with a detailed description- and example-box on its utilization.
- The CEA required much explanation in regard to the figures used to calculate the individual cost and therefore to compare the LMS-solutions against each other. Consequently, the CEA could be designed in a more detailed and commented fashion.
- Examples for the project-management-activities, -portfolios, -matrices and -diagrams were created and could be added to the RefArc to simplify the RefArc's utilization even more.
- The RefArc could be further interlinked to other connected guidelines like the ones form Kerres (2012) or the ICB (Caupin et al., 1999).

Need for Supplementary Research:

The RefArc is based on best-practice experiences and therefore may be refined by integrating further experience gained while using the RefArc.

As the PM in the prototypical testing of the RefArc was simultaneously the creator of the RefArc and as such deeply involved in the underlying research, the RefArc should be tested additionally by independent PMs with different skills and different

knowledge bases. Through their experience the RefArc could be evaluated much more meticulously and the general applicability could be improved.

Furthermore the RefArc, which at this point addresses only polytechnic schools, could be adapted to other forms of knowledge-transfer organizations like professional schools, private-teaching organizations and universities.

Scope of Application:

The scope of application for this thesis and the corresponding RefArc is the RE-phase for equivalent schools which are determined to implement an LMS. This thesis's knowledge base and the RefArc shall provide those schools with a low-cost, internally accomplishable way to determine their requirements objectively and in doing so, enabling them to decide which LMS fits their needs, vision and business structure best.

The limitation to polytechnic schools only may be disregarded and the RefArc may, perhaps with some further research, be adjusted to fit other types of schools as well.

Annotation:

Appropriate to the topic the thesis's mentoring was solely conducted in using virtual-online-media. The regular online-meetings were held via Skype, data-exchange happened through group-folders in Dropbox. The interactive online experiences combined with outstanding mentoring strengthened the understanding of using various eLearning methods and consequently proved enlightening for the PM in regard to the extent to which eLearning is feasible, and in regard to the positive feeling of LMS-support.

Appendices and References

Appendices

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Appendix A Examples of Requirement Elicitation Techniques

Creativity Techniques	Observation Techniques	Questioning
Paper prototyping	On site client	Questionnaire
Brainstorming	Site survey	Stakeholder Interview
Brain Writing	Apprenticing	User stories
Ishikawa	Filed observation	Workshop
Thought mapping	Online support	Meeting

Appendix B Types of Requirements

Type of Requirement	Examples
Functional	• Features of systems (online help, printing, workflow, interfaces) • Functionality of product • Changed processes or standard operations procedures (SOP) in organizations
Non-functional	• Service level of product • Supportability (system can be tested, adapted, maintained, • Usability (aesthetics and consistency in the UI) • Reliability (availability, system “down times”, accuracy of system calculations, recover time • Performance of IT-System • Characteristics of a product
Technical	• Technical standards used • Programming language of new IT-system
Quality	• Qualification of project staff • GxP regulations in Pharmaceutical industry • Q-standards required, process requirements
Legal	• Go live date • Contractual penalties
Project Constraints	• Product-fit into business reality • Interfaces and interconnections
Project Drivers	• Business related forces • Stakeholders
Project Issues	• Project conditions • Coherent picture of all factors contributing the suc-

	cess or failure

Appendix C Quality Standards for Requirement Specification

Quality Standard	Annotation
Correctness	Stakeholders have access to specification for approval
Unambiguousness	No recourses to technical jargon or acronyms. Objective facts, no subjective opinions. Only one interpretation.
Completeness	Document is fully stated in one place with no missing information
Consistency	No contradictions between requirements and full consistency with all authoritative external documentation
Verifiability	Functionalities can be verified by inspection, demonstration, test or analysis
Modifiability	New functionalities/ information can be included
Traceability	Unique identification of requirements is possible
Understandability	Related to technical and social background of stakeholder
Feasibility	Requirement can be implemented within the constraints of the project
Necessity	An optional Requirement is a contradiction in terms!
Priority	Requirements need to be prioritized, Typical levels are: Must, should, may and must-not criteria
Usability	The System needs to be usable even if only partially realized

Appendix D Documentation of requirements

In concordance with Cockburn (2001); Pohl (2008); Robertson & Robertson (2012)
"The difference between the almost right word and the right word is really a large matter – it's the difference between the lightening bug and the lightning."
Mark Twain

Structures
Start by building up the structure of the document. Introduce a certain strategy for your document. This will help the reader to follow your thoughts:

- Start with the general overview and then go on with the details
- Start with describing interfaces of a software system and go on with process description
- Start with the main success scenario and proceed with the extensions
- Start with the purpose of a new product an go on with technical details

To assure traceability, never express more than one requirement in one sentence (or even in one paragraph).

- Keep your text short and simple:
- Keep sentences and paragraphs short
- Structure your text clearly
- Use lists and tables to present complex information
- Use simple and concise language

Transforming information into written words
Describing requirements as natural text is a challenging task. Some writing techniques that will improve the quality of your text are described above.

Avoid deletion
Deletion is a process for focusing on information that we mean to be essential for us. For example: in a babble of voices on a crowded railway station, we are able to focus on our communication with our partner. When we write down text in a document, we sometimes omit information that is unimportant to us, but essential to know for the readers. To ensure that you do not "delete" important information from your text:

- Use the active rather than passive voice
- Use main verbs
- Search for incompletely specified process words (to recognize, to report, to monitor…)
- Incomplete comparative or superlative of adjectives

Generalization
Quantify words such as "not", "any", "each", "always", "every"…
Example: does "not" really mean under any circumstances? Or does it mean in general, or only sometimes?

Comments
Separate comments from requirements
Separate requirements from explicitly excluded requirements from project scope
Liability of text

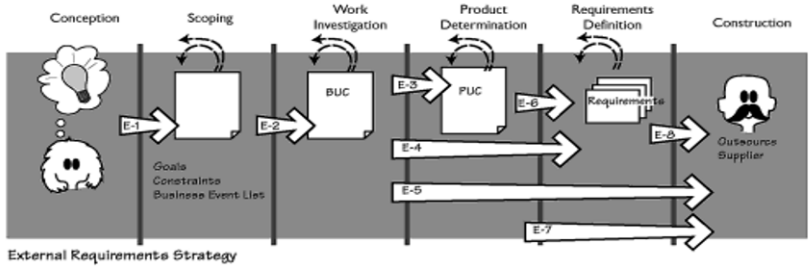
- Differentiate between the following words carefully:
- Shall/(must): requirement is mandatory
- Should: requirement is desirable
- May: requirement is possible to realize (should be avoided)
- Will: feature is externally provided

Pay attention to spelling and grammar. A correct text enhances acceptance of your document.

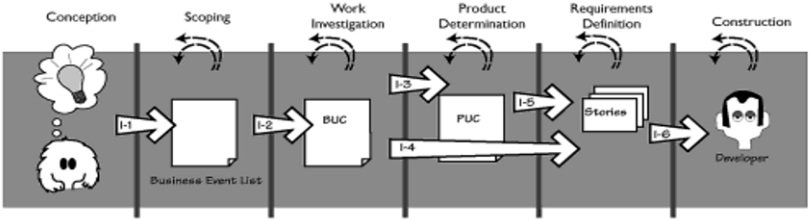
Appendix E Different RE Strategies

By Cockburn (2001)

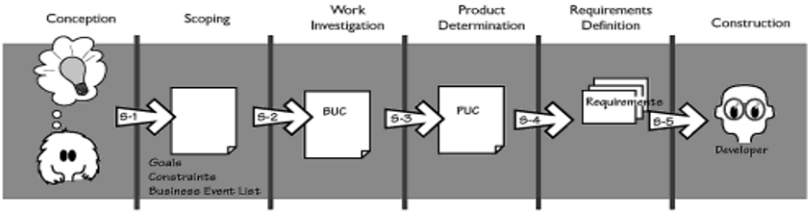
Requirements Strategy Maps



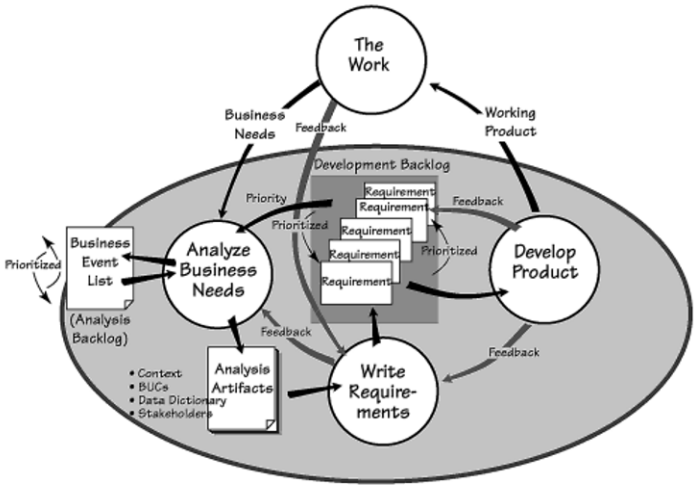
External Requirements Strategy



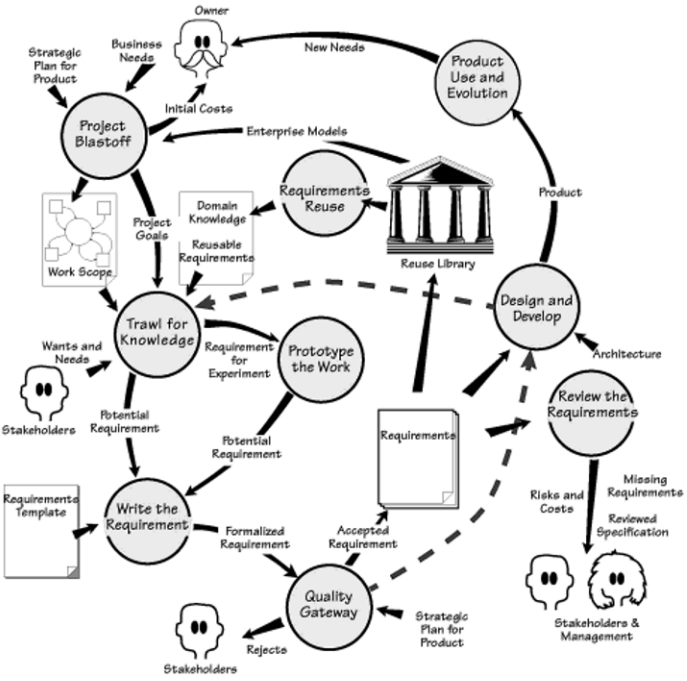
Iterative Requirements Strategy



Sequential Requirements Strategy

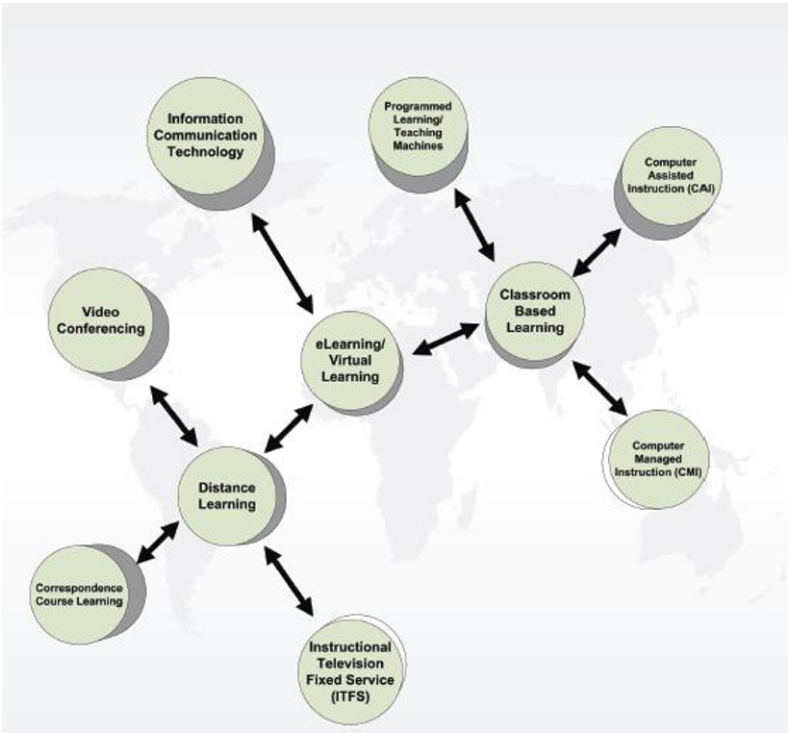


Iterative Requirements Process



Appendix F Roots of eLearning

By Folden (2011)



Appendix G Critical Success Factors for LMS operations

From Re.ViCa (2009):

- Organizational Learning (OLG) - The institution is a learning organization on all core aspects of e-learning.
- Leadership in e-Learning (LEL) - The capability of leaders to make decisions regarding e-learning is fully developed.
- ELearning Strategy (ELS) - The organization regularly updates its e-Learning Strategy. That strategy is integrated with learning- and teaching strategy (and all other related strategies such as IT etc.).
- Management Style (HYB) - The management style is a hybrid of academic and corporate, accepted by staff.
- Quality Assurance (QAS) - Conformance to external quality agency precepts for the country or region, and to institutional guidelines for e-learning within an overarching methodology of quality (for example EFQM or other)
- Planning Annually (PLA) – There is an integrated annual planning process for e-learning that is integrated with overall course planning.
- Staff Recognition and Reward (SRR) - All e-learning experts have been explicitly recognized and rewarded (in a financial way) appropriate to their contribution to the institution, with a regular appraisal process.
- Collaboration for e-Learning (CFE) - The institution has a reasoned approach to collaboration at various levels to gain additional benefit from sharing e-learning material, methodologies and systems (for example within an OER approach or via other methods, not excluding payment).
- Costs (CNL) – The institution uses a costing system based on principles of activity-based costing (and that is used throughout the institution).
- Foresight (FOR) - The institution has look-ahead capability and for example developmental labs so that new styles of e-learning can be to some extent predicted and piloted.
- Brand Management (BMG) - The institution has a reasoned approach to managing its brand.
- Market Research (MRE) - Market research is done centrally and in or on behalf of all departments, and is aware of e-learning aspects; it is updated annually or prior to major program planning.
- Selling (SEL) - The institution has widespread skill in selling e-learning and the theory to support the skills.
- A decision on Programs (DPG) – There is effective decision-making for e-learning across the whole institution, including variations when justified.
- A decision on Projects (DPR) - There is effective decision-making for e-learning across the whole institution and in departments.
- Collaboration Roles (COL) - in each collaboration the roles and responsibilities of each collaborative partner are clearly defined and the procedures always followed.

- Dissemination Internal (DIN) - The institution has a systematic managed process of internal dissemination of good practice.
- Academic Workload (AWK) – The work planning system recognizes the main differences that e-learning courses have from traditional.
- Technical Support to Staff (TSS) - All staff engaged in the e-learning process have "nearby" fast-response technical support.
- Security (SEC) - The institution has a system where security breaches are known to occur very rarely, and when they do they are fixed fast (which allows staff and students to carry out their authorized duties easily and efficiently).
- Performance (PER) - All e-learning systems operate in their uptime within documented and accepted response guidelines.
- Reliability (REL) -The e-learning system is highly reliable - typically 0.999 (99.9% availability on a 24x7x365 basis).
- Student Understanding of System (SUS) - Students have good understanding of the rules governing assignment submission, feedback, plagiarism, costs, attendance, etc. and always act on them.
- Student Help Desk (SDH) - The institution's Student Help Desk is deemed as best practice.
- Student Satisfaction (SAT) - The institution has an annual Student Satisfaction survey which explicitly addresses the main e-learning issues of relevance to students.
- Employer Engagement (EEN) - The institution has a managed approach to involvement of employers of students in creating or updating courses to be delivered to their employees which include appropriate amounts of e-learning.
- Usability (USA) - All services usable, with internal evidence to justify this.
- Training (TRG) - All staff is trained in use of the e-learning system, appropriate to job type – and retrained when needed.
- Organization (ORG) - An organizational unit to support e-learning exists and that is fit for purpose – (typically with a Director-level institution manager in charge and links to support teams in departments).

Appendix H Lists of LMS on the Market (Links)

- http://www.capterra.com/learning-management-system-software
- http://en.wikipedia.org/wiki/List_of_learning_management_systems
- http://de.wikipedia.org/wiki/Liste_von_Lernplattformen
- http://www.leftbrainmedia.com/2.1_lms_systems.html
- http://www.trimeritus.com/vendors.pdf
- http://www03.lernmanagment.de/blogs/blog1.php/main/lms/com-lms/

Appendix I Examples for Stakeholders and Benefits

To persuade people to take part in the project and the survey it is important to point out the LMS's benefits to those stakeholders:

Benefits for the sponsor organization:

The organization ultimately will gain a recommendation for a specifically selected LMS which takes into account best practice research, actual state of the knowledge about LMS and individual needs and wishes. This LMS shall provide benefits to the communication, the administration, the teaching, the marketing and will boost the schools service level.

Benefits for the teachers:

The teachers will gain the chance to be an active part in the LMS's selection and conception, so they will be able to influence the result and thus create their own benefits in designing the LMS alongside their wishes. Moreover the prospect of new and additional methods for knowledge transfer, communication between teacher and student and organization the LMS provides could be a stimulus.

Benefits for alumni:

Alumni are bound to the school through integrative actions, information and events. They generally have a certain emotional link to the school. This link will be a good lever to have them to participate as they will gain additional access to the schools information and can be integrated further into the schools community.

Benefits for companies with a close relationship to the school:

As those companies and the schools graduates have a high mutual interest in each other the companies can gain a platform to present themselves to the students as well as a resource of public relation. Furthermore in collaboration with the school means of online training for these companies could be devised.

Appendix J Reference Architecture

(Electronic Version on Data-CD root/Master Thesis/02a Reference Architecture.pdf)

1 Introduction

This document is designed to present a structured basis for the LMS definition, and implementation into a polytechnic school. The checklists, matrices and processes are designed as a guide line to gain the necessary information from site surveys, surveys, workshops and stakeholder-interviews to determine the requirement specifications for the Learning Management System LMS selection, implementation, operation and the necessary change management processes. The document is only a guide line and raises no claim for completeness. The user may feel free to adapt the framework as considered necessary.
In general the LMS project should be treated as such which requires **stakeholder management** including a stakeholder portfolio (this is also important criterion quantifying), **risk management** including a risk occurrence chart and "**What If" plans** as well as a **time management** including the **work breakdown** structure. *(An example can be found on the accessory data CD.)*

2 Business Requirement Specification Framework (BRSF)

The first major task is the data elicitation to gain not only information for the Business Requirement Specification but also to develop the necessary guidelines and concepts for the selection-, implementation and operation processes. This task accompanies the complete selection and implementation phase. A guideline of important questions can be found in the tables below (or in the "Leitfaden" by Kerres). *(An example can be found on the accessory data CD.)*
For a better estimation when to ask those questions the main data elicitation process was broke down into seven phases which can partly overlap.

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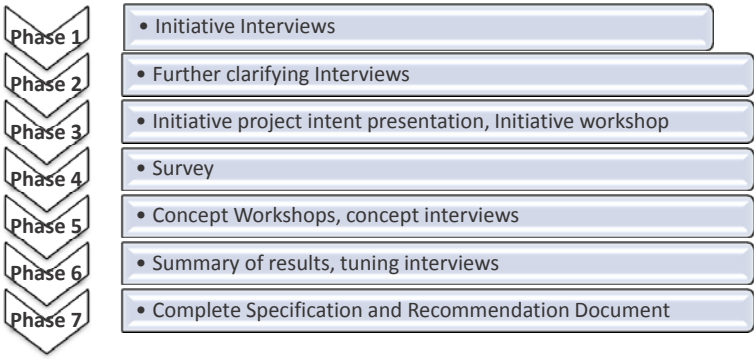


The Answers should be noted free (use extra sheets) and prioritized (by the interviewed stakeholder): 1 = must have/ important input, 2 = should have/ notable input, 3 = nice to have but no high priority/ disregard for first concept and 4 = disregard completely. Some Questions are already prioritized as their outcome may have a significant impact on the LMS concept. In the second step the prioritization will be important for the weight the respective criterions will have.

Company/ Business Profile					
No	**Answer**	**Prio**	**When**	**Who**	**How to elicit**
1.	**What is the institute's vision?**	1	Phase 1	School Management	Interview
2.	**What is the institute's mission?**	1	Phase 1	School Management	Interview
3.	**Which business structure is the LMS supposed to support?**	1	Phase 1	School Management	Interview
4.	**Who are the stakeholders? How important are the respective groups? ➔ Stakeholder Portfolio**	1	Phase 1	School Management	Interview
5.	**What are goals and objectives in implementing the LMS? ➔ Business Specification Scope**	1	Phase 1	School Management	Interview
6.	**Which ideas/ concepts regarding the LMS utilization already exist?**	1-2	Phase 1, 2, 3 and 5	School Management, Administration	Interview, workshops
7.	**Which restrictions for the LMS concept are already known? (technical, organizational, conceptual)**		Phase 1, 2, 3 and 5	School Management, Administration	Interview, workshops
8.	**How high is the project budget?**		Phase 1	School Management	Interview
9.	**What is the project timeframe?**		Phase 1	School Management	Interview
10.	**Define the hardware equipment available for the project.**		Phase 1, 2, 3 and 5	School Management, Administration	Interview, workshops
11.	**Which PR effect is the LMS expected to generate?**		Phase 1	School Management	Interview
➔	**Institute Classification/ Framework conditions**				

Online Learning Perspective					
No	**Answer**	**Prio**	**When**	**Who**	**How to elicit**
1.	**What are the teaching group's size, heterogeneity and educational background?**		Phase 2, 5	School Management, Teacher	Interview, workshops
2.	**Which kinds of online learning have to be supported? (Autodidactic, Blended Learning, online learning)**		Phase 2, 5	School Management, Teacher	Interview, workshops
3.	**Which kind of assistance shall the online learners gain/ need from the instructors? (close supervision, open design)**		Phase 2, 5	School Management, Teacher	Interview, workshops
4.	**Which kind of learning motivation can be mainly expected? (intrinsic/ extrinsic)**		Phase 2, 5	School Management, Teacher	Interview, work-

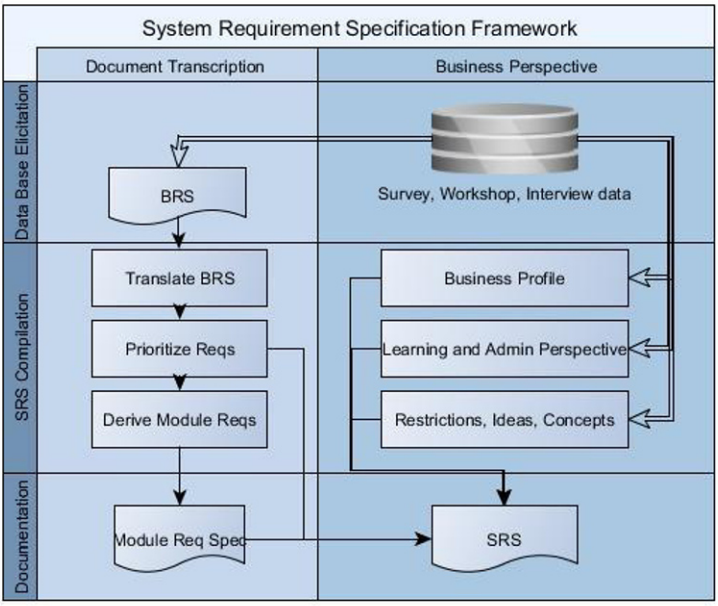
					shops
5.	**Which kind of learning environment shall be mostly supported? (open vs. expository teaching environment)**		Phase 2, 5	School Management, Teacher	Interview, workshops
6.	**How shall the online learning evaluation be designed? (Automated, manual, open design)**		Phase 2, 5	School Management, Teacher	Interview, workshops
7.	**What structure shall content and group management have?**		Phase 2, 5, 6	School Management, Teacher	Interview, workshops
8.	**How can the educational objectives be supported by the LMS?**		Phase 2, 5, 6	School Management, Teacher	Interview, workshops
9.	**How should the data-, group and organization structure be designed to support the institute's business structure and the educational objectives?**		Phase 2, 5, 6	School Management, Teacher	Interview, workshops
➔	**Online Learning Perspective Vision**				

LMS capability/module elicitation					
No	**Answer**	**Prio**	**When**	**Who**	**How to elicit**
1.	**Which communicational modules should be supported? (chat, forum, direct messages, dashboard, blog, wiki)**		Phase 1, 2, 4	Main target groups	Survey, Interview
2.	**Which administrative modules should be supported? (info board, email blast, email info, subject menu bar)**		Phase 1, 2, 4	Main target groups	Survey, Interview
3.	**How should the collaboration management be structured?**		Phase 1, 2, 4	Main target groups	Survey, Interview
4.	**Which organizational modules should be supported? (schedules, calendars, online organization structure, personal profiles, grade overview, substitute plans)**		Phase 1, 2, 4	Main target groups	Survey, Interview
5.	**Which media/data types must be/ should be/ must not be supported?**		Phase 1, 2, 4	Main target groups	Survey, Interview
6.	**How should media, information be distributed communicated and administrated?**		Phase 1, 2, 4	Main target groups	Survey, Interview
7.	**How should the system and the media in particular be accessible?**		Phase 1, 2, 4	Main target groups	Survey, Interview
8.	**Should the UI be personally adjustable or a fix standard?**		Phase 1, 2, 4	Main target groups	Survey, Interview
➔	**LMS Module Requirements**				

LMS feature elicitation					
No	**Answer**	**Prio**	**When**	**Who**	**How to elicit**
1.	**What previous knowledge of/ operating experience can be expected?**		Phase 2, 3, 4, 5	Main target groups	Survey, workshop, interview
2.	**How can the stakeholders be activated to use the LMS?**		Phase 2, 3, 5	Main target groups	workshop, interview
3.	**How can the LMS be made intuitive?**		Phase 2, 3, 4, 5	Main target groups	Survey, workshop, interview
4.	**How can LMS robustness be achieved?**		Phase 2, 3, 5	Main target groups	workshop, interview
5.	**Should the LMS be accessible through a company website?**		Phase 4, 5	Main target groups	Survey, workshop
6.	**Will the profile creation be free for visitors or will it be exclusively for company members?**		Phase 2, 3, 4, 5	Main target groups	Survey, workshop, interview
7.	**Should the LMS be accessible from smartphones via an app?**		Phase 2, 3, 4, 5	Main target groups	Survey, workshop,
➔	**LMS Feature Requirements**				

3 System Requirement Specification Framework (SRSF)

The second task is the translation of BRS into the SRS with re-assessed inclusion of the determining business- and mission related perspective. This task can consequently only be started when the gross of the survey and workshop data is collected and the BRS is completed.

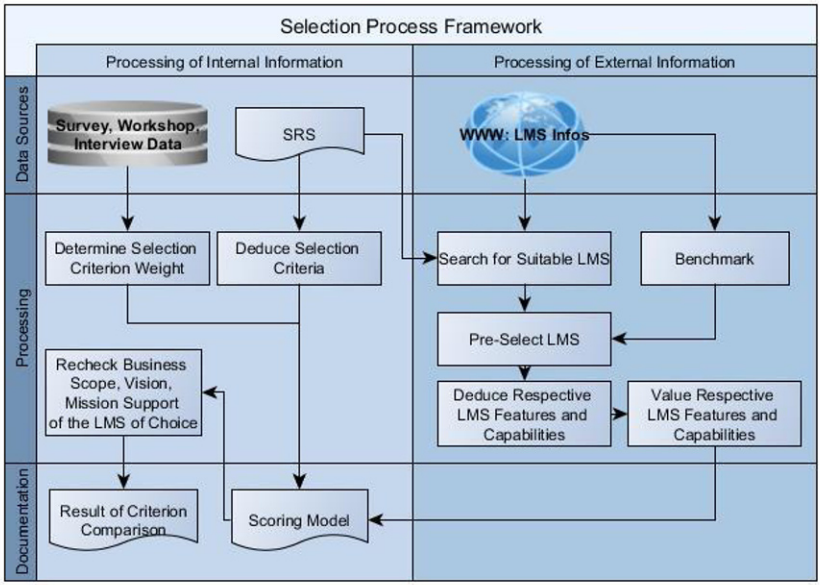


Steps to gain the System Requirement Specification:

1. SMART, well structured, well communication able and understandable translation of the BRS into required LMS' modules and elements, features and capabilities.
2. Consider prioritization and differentiators:
   1 = must have/ important input,
   2 = should have/ notable input,
   3 = nice to have but no high priority/ disregard for first concept and
   4 = disregard completely
   Prioritization is reasoned from survey, workshops and one-on-one discussions
3. Derive the necessary modules form steps 1 and 2
4. Formulate the Module Requirement Specification
5. Consider how to support the business vision, mission and organizational structure.
6. Consider learning- and administrational perspective.
7. Consideration of restrictions (business and technical) and developed ideas and concepts developed in workshops and one-on-one discussions
8. Derive a rough concept of the LMS' necessary modules, features and capabilities from the steps 1 to 7
9. Formulate the System Requirement Specification *(A selection of widely used Example forms can be found on the accessory data CD. Volere Template is recommended)*

4 Selection Process Framework

The selection process already requires a good understanding of the intended implementation and operation concepts and the completed SRS. Via research for suitable LMS a pre-selection must be compared and valuated according to defined criterions.

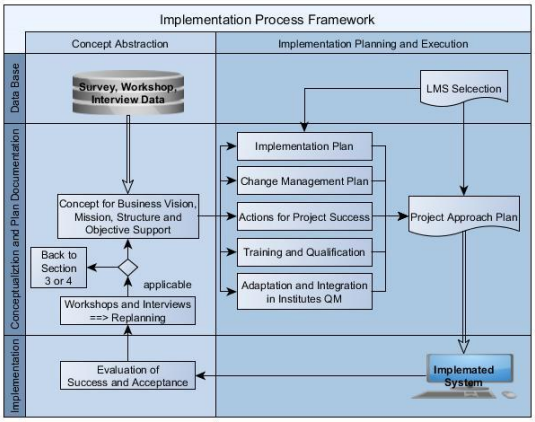


Steps to preselect the LMS of choice:

1. Searching the internet and other sources for suitable LMS according to the SRS.
2. If possible benchmarking via the internet or direct contact to LMS using institutes.
3. Create a Matrix *(an Excel Scoring Model can be found on the accessory data CD)* to compare suitable LMS according to the acceptability criteria gained from the SRS, prioritization and restrictions.
   - Prioritization/ weight:
     - ⇨ Surveys, workshops and one-on-one discussions deliver a stakeholder specific weight.
     - ⇨ Quantifying this weight by stakeholder importance (deduced from the Stakeholder Portfolio) the respective weight can further be qualified.
   - The LMS rating for each criterion can be 1 to 4 *(see Scoring Model)*
   - Formulate “Reject Criteria” (e.g. if criterion with weight > 3,1 not met)
4. Consider which LMS on the market supports business vision, mission and organizational structure the best.
5. Consider which LMS fits the Didactic Concept the best.
6. Consider which LMS fits the desired Module Requirements the best.
7. Consider which LMS fits the desired characteristics the best.
8. Chose and rank two to three LMS.

5 Framework for Implementation- and Change Management

As the Implementation- and Change Management may vary vastly between institutions the following process model and the checklist shall merely provide examples of important points to include in the planning. Generally it is always important to consider all inputs the stakeholders and especially the destined users provide thoroughly and try to include them in the concepts.



The following points should be considered in the Implementation process:

□	Align LMS structure to business vision, mission and organizational structure. Concepts can be developed in workshops with designated users.	
□	The stakeholders define the problem statements and objectives.	
□	Follow up on current IT-infrastructure when setting up the LMS (if possible)	
□	Deliberate and plan staff training and qualification arrangements (for support staff, admin staff, teaching staff)	
□	Plan the necessary adaptions to the companies Quality Management System and the LMS' compliance to it	
	Change Management Plan:	
	□	Stress system value for stakeholder and the system being implemented for the user's sake.
	□	Make the selection result, based on the employee, publicly official including all of the employees inputs included in the system to create acceptance.
	□	Constant stakeholder inclusion- and participation through: workshops, survey, presentations, brainstorming, training terminal and suggestion possibilities
	□	Talk the Talk" ➔ PR for system along the phases of change
	□	Gaining acceptance through the features ➔ support for the daily business and further
	□	Create acceptance through mandatory utilization (reactive and participative) (➔ administration and information through system only)

	□	Use open communication a culture for constructive criticism and confidence
	□	Find a balance in communication to the stakeholders: Do not overload them with information but keep them in the loop so they maintain the feeling of control over project and LMS.
□	Design a project approach plan (with stakeholder management, phases, work breakdown structure, timeframe incl. due dates, project monitoring KPIs and work packages for third parties)	
□	Constant evaluation of project success and LMS acceptance.	
□	User friendliness is an important selling point!	
□	Successive implementation in small parts. But consider future extension as early as possible ➔ "Think big start small!"	
□	"A fool with a tool is still a fool" ➔ The tool is chosen by the problem at hand! ⇨ The LMS suitability hast to be reevaluated and the LMS adjusted if necessary ⇨ Modules are only to be implemented if desired and sensible but not for it's own sake only.	
□	KISS ➔ Keep it smart and simple.	

6 Operational Concept Framework

As with the Implementation- and Change Management Process the Operational Concepts may be extremely diverse. So the following checklist shall provide assorted points from the best practice research to consider in an operational concept. For the operational concept it is also very important to include the stakeholder's inputs.
The following points should be considered for the operational concept:

□	Develop a concept for LMS inclusion into business vision, mission and organizational structure
□	Develop a concept for LMS utilization and the necessary business- and LMS-structure that make this utilization possible
□	Clearly structure and differentiate responsibilities within the LMS utilization. (Who is responsible for content, administration, IT)
□	Consider and plan technical support, help desk, teacher support, manuals and wikis to operate the system successfully
	Plan regular instruction and training for the designated users.
□	Consider and plan data care (who, when which data)
□	Avoid extra effort and expenditure through over-redundant Information channels ➔ Use channel with best information-quality only!
□	Use distinct information-/ communication-channels to avoid data and information overhead
□	Use and regularly adjust the content-structure concept. Use a content management concept. (Who, when, which content)
□	Use and regularly adjust the group-structure concept. Use a group management concept.
□	Start small and leave options for expansion. (Content accumulates over time)
□	Avoid creating much overhead for the administration and teaching personnel. Provide the initial additional time needed to work the LMS and to create the content within the normal working hours. A high additional workload will discourage the LMS utilization.

□	Make the LMS use mandatory through reducing information redundancy.
□	Restrict the procedure possibilities as little as possible to maintain motivation for system progress and new ideas.
□	Design rules for student/ teacher communication (forum and chat enable student/student help, teacher is not obliged to spent much time online and accessible)

7 Cost-Effectiveness Assessment Framework

The following table depicts the most commonly used costs and benefits found throughout the "best-practice" literature for LMS implementation and operation. They should be regarded as an initial collection for the Cost Effectiveness Assessment.

Costs	**Benefits**
Costs of introducing and implementing an LMS at the school	Benefits of additional services
Cost for resources, personnel	Benefits of saving time and labor
Costs for change management and continuing motivation processes	Benefits as marketing platform and qualifying element in the competition
Costs for continuous use, maintenance and service	Benefits through communication gain
Cost for marketing utilization and QM	Acceptance though modern media usage
Cost for adaption and further programming	Expected service, Benefit of Image
Cost for additional work in restructuring and re-preparing content	Customer satisfaction, employee satisfaction
	Benefits though enhanced business quality
	Optimized data-/ contend-structure ➔ faster access

The Assessment can be broken down into the following steps:
Define Costs and benefits using the bullets above as an initial collection.

1. Mark which cost are internal and which are external (assign to third parties)
2. Reason costs and benefits, and assign them a time of effectiveness (short-, mid- and long-term).
3. Asses Cost-Effectiveness-Ratio.

(An Excel Cost-Effectiveness Assessment Form can be found on the accessory data CD)

8 Appraisal Framework

The appraisal contains the summary of the LMS selection (2 choices max) with a short statement about the LMS' suitability in regard to:

1. Business structure
2. Vision, mission and business objectives
3. LMS utilization objectives
4. Planned LMS utilization concepts
5. Didactic application
6. Cost-Efficiency Considerations
7. Further prominent points and reasons

The Appraisal should compact conclusion and should not span more than one page.

(An Example Appraisal can be found on the accessory data CD)

Appendix K Scoring Model

(See Electronic Version on Data-CD root/Master Thesis/02b Scoring Model.xlsm)

Appendix L Cost-Effectiveness Analysis

(See Electronic Version on Data-CD root/Master Thesis/02c Cost-Effectiveness-Analysis.xlsx)

Appendix M System Requirement Specification - TA

(See Electronic Version on Data-CD root/Data TA (Restricted)/LMS Pflichtenheft TA.pdf) ➔ German

Appendix N Scoring Model - TA

(See Electronic Version on Data-CD root/Data TA (Restricted)/LMS Scoring Model TA.pdf)

Appendix O Cost-Effectiveness Analysis - TA

(See Electronic Version on Data-CD root/Data TA (Restricted)/LMS Kosten Betrachtung TA.pdf)

Appendix P Survey Results TA

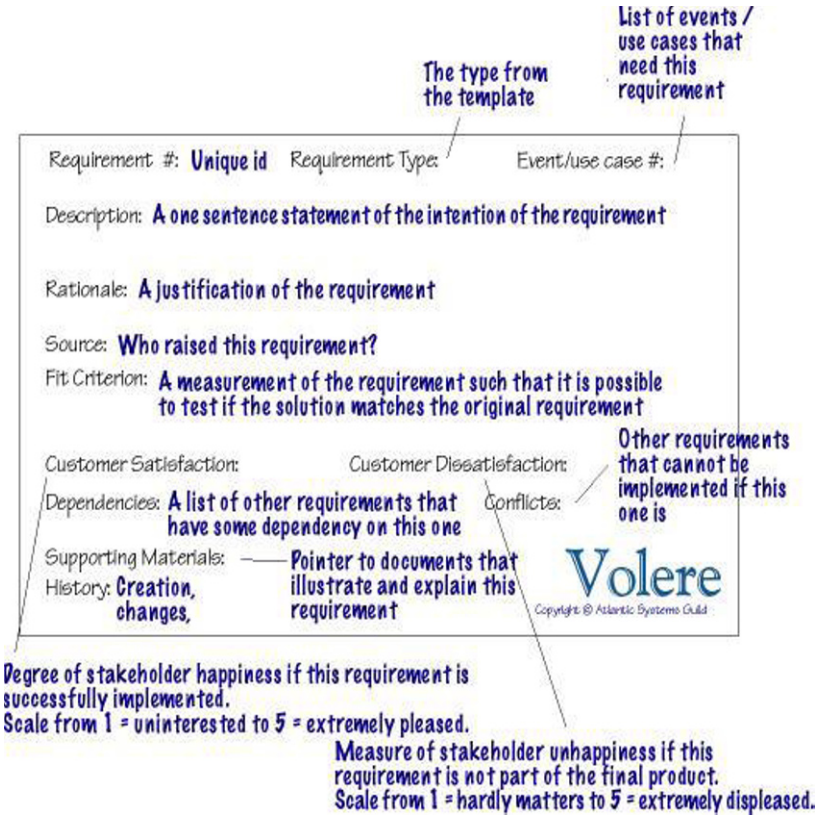
(See Electronic Version on Data-CD root/Data TA (Restricted)/Survey Results TA)

Appendix Q Examples and Templates for RSD-Creation

(See Electronic Version on Data-CD root/Templates and Examples/RSD)

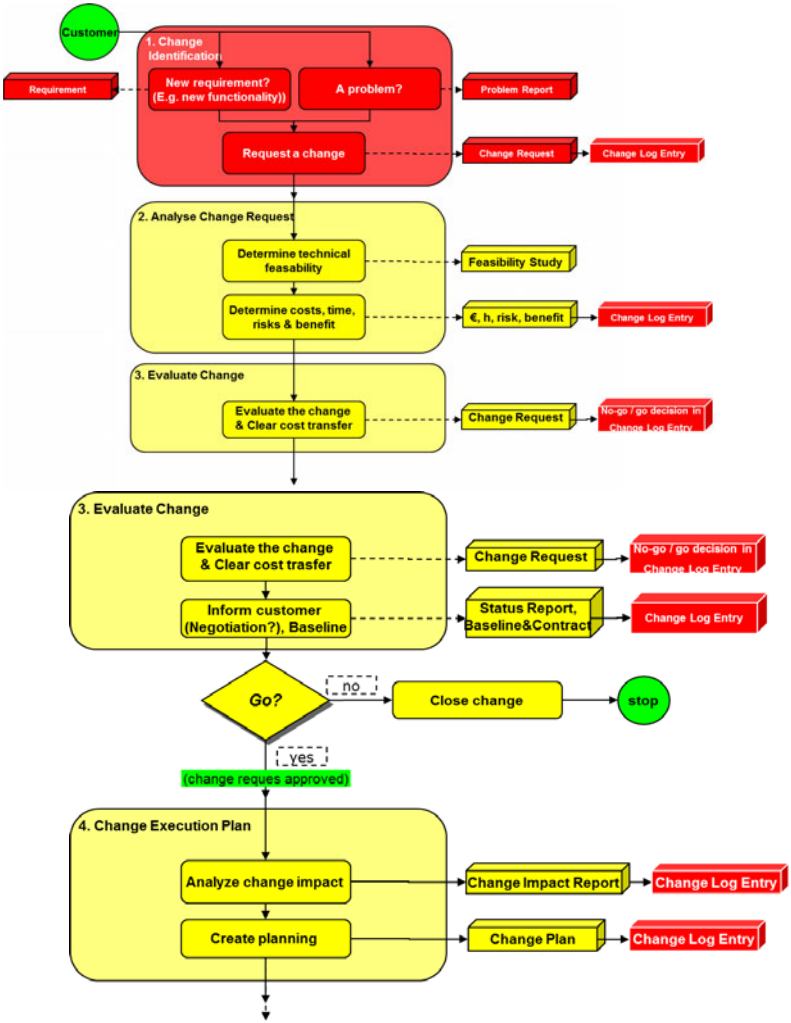
Appendix R Requirement Shell – Volere

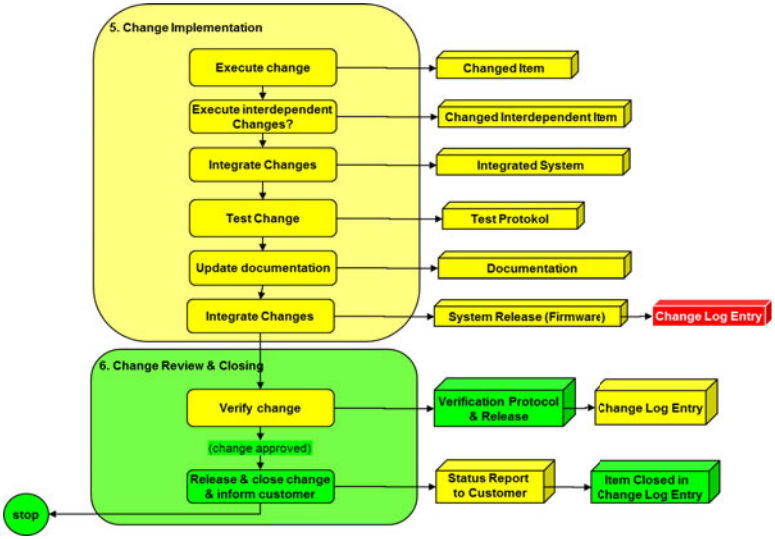
By Robertson & Robertson (2003):



Appendix S Requirement Change Management Process

In concordance with Schelle et al. (2008)



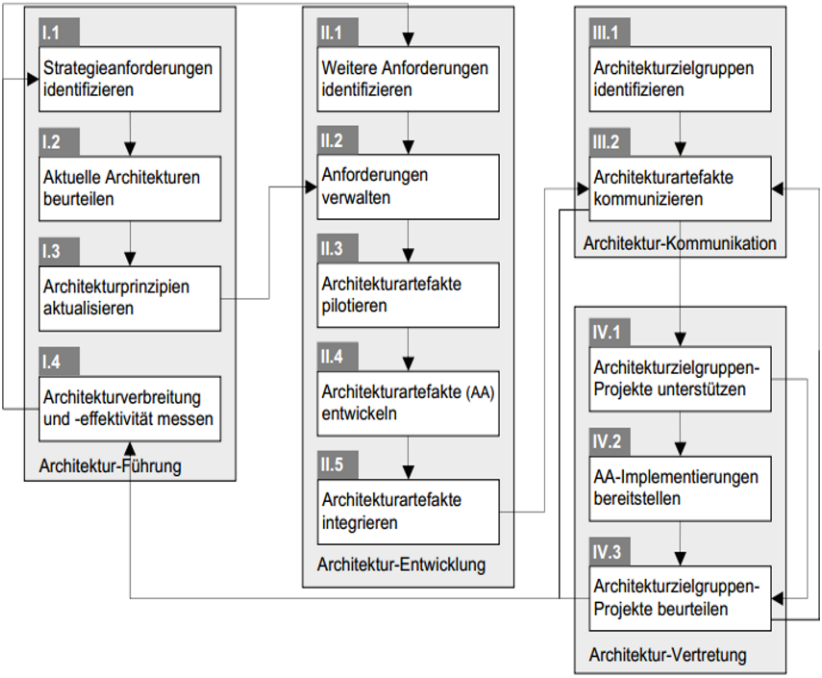

5. Change Implementation
Execute change
Changed Item
Execute interdependent Changes?
Changed Interdependent Item
Integrate Changes
Integrated System
Test Change
Test Protokol
Update documentation
Documentation
Integrate Changes
System Release (Firmware)
Change Log Entry
6. Change Review & Closing
Verify change
Verification Protocol & Release
Change Log Entry
(change approved)
Release & close change & inform customer
Status Report to Customer
Item Closed in Change Log Entry
stop

Appendix T Change Management - CSFs

By Government of Queensland (2008)

Appendix U Architecture Management Approach

By Hafner & Winter (2005):



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Allen, I. E., & Seaman, J. (2007). *Online nation: Five years of growth in online learning*. *October* (p. 25). Sloan Consortium.

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