Modeling Coherent Social Systems for Learning

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Abstract

This work proposes a modeling approach applicable in the field of technology enhanced learning and describes its implementation. Proposing a modeling approach goes beyond specifying a discrete set of categories or structural elements to describe learning resources and processes, as it investigates the meta-level of modeling. This work is based on work done by Guarino, Carrara, & Giaretta, which distinguishes the meta-level categories role type from natural type, and the work of Steimann, which recommends to introduce these meta-level categories into object-oriented modeling and the Unified Modeling Language UML. The work presented here adopts these concepts and proposes a modeling approach applicable in the field of technology enhanced learning. This is founded in analyzing concepts of learning and their epistemological foundation and in investigating instructional meta-models. This work integrates research in computer science and the learning sciences. Distinguishing types from roles allows to separate an entity from its instructional purpose. Specifying the instructional role an activity, information asset, or person fills, allows to realize functional equivalences in the course of planning and during run time. Realizing functional equivalences allows to foster situated and generative learning. Based on the context and situation the learner is confronted with, the learner himself, a coach, and any agent which regulates the learning process is able to integrate an entity, which is able to fill the role within the system, at any time. The main achievements of this thesis are: Specifying the modeling approach of Learning Roles which provides a functional-structural view on social systems and which works as a basis for contextualized and pedagogically enriched metadata. Implementing this modeling approach in a specification for describing learning designs and instructional models (PAS 1032-2, Deutsches Institut für Normung e.V., 2004). Defining the concept of Second-Order Learning Objects (SOLOs), which is based in the approach of Learning Roles. SOLOs are shared schemes and mediating artifacts which support processes of generative learning.

Keywords

Technology enhanced learning, metadata, modeling.

Zusammenfassung

Diese Arbeit befasst sich mit dem Entwurf und der Implementierung eines Modellierungsansatzes im Bereich des technologiegestützten Lernens. Der Entwurf dieses Ansatzes geht über die Spezifikation eines Sets von Kategorien und Strukturelementen im didaktischen Feld hinaus, da er die Meta-Ebene der Modellierung untersucht. Die Arbeit basiert auf der Arbeit von Guarino, Carrara, & Giaretta, die die formalen Konzepte *Typ* und *Rolle* unterscheidet, und der Arbeit von Steimann, die einen Vorschlag zur Integration dieser formalen Konzepte in die objektorientierte Programmierung und die Modellierungssprache UML (Unified Modelling Language) erarbeitet. Die vorliegende Arbeit integriert diese Konzepte in einen Modellierungsansatz im Bereich der Didaktik, bzw. des technologiegestützten Lernens. Fundiert wird der Ansatz in der Analyse verschiedener Lernbegriffe und ihrer epistemologischen Fundierung sowie Modellen der Allgemeinen Didaktik und Systematischen Pädagogik. Die Arbeit ist interdisziplinär angelegt und bezieht sich auf die Erziehungswissenschaft und die Informatik, da sich beide Wissensgebiete intensiv mit dem Thema Modellierung befassen. Die Unterscheidung der formalen Konzepte Typ und Rolle ermöglicht es, zwischen einer Entität und ihrer didaktischen Funktion zu unterscheiden und funktionale Äquivalenzen zu beschreiben. Die Planung funktionaler Äquivalenzen erlaubt es, den Lernprozess nicht strikt vorher zu planen, sondern den situativen Bedingungen anzupassen. Der Modellierungsansatz ist pädagogisch flexibel und hat insbesondere auch das situierte Lernen im Blick. Er bietet einen funktional-strukturellen Blick auf soziale Systeme. Die vorliegende Arbeit leistet folgendes: Den Entwurf eines rollenbasierten Modellierungsansatzes zur Beschreibung von Lernszenarien als kohärente soziale Systeme (Learning Roles). Basierend darauf, ein Konzept zur Spezifikation von kontextualisierten, pädagogisch angereicherten Metadaten. Die Implementierung des rollenbasierten Ansatzes, bzw. seine Integration in die Spezifikation PAS 1032-2:2004 (Deutsches Institut für Normung e.V.), die ein Beschreibungsmodell zur einheitlichen Darstellung und Vergleichbarkeit didaktischer Konzepte, Szenarien und Methoden unter besonderer Berücksichtigung e-Learning spezifischer Gesichtspunkte, bereitstellt. Weiterhin beschreibt diese Arbeit die Anwendung des Modellierungsansatz im Konzept der Second-Order Learning Objects (SOLOs). SOLOs sind geteilte Schemata die nicht-determinierbare generative Lernprozesse unterstützen.

Schlagworte

Lerntechnologien, Metadaten, Modellierung.

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Contents

List of Figures

List of Tables

Chapter 1

Introduction

Within the last decade schemes, descriptive frameworks, and modeling languages to describe educational resources and processes have become a major concern in the field of educational technology. A formal description of learning resources and processes of learning is a key prerequisite for the widespread use of computer-supported and web-based learning. Educational technologist argue that descriptive frameworks are crucial for exploiting the economic as well as technical potentials arising from information and communication technologies. Furthermore, educational modeling languages and descriptive frameworks support the development of innovative instructional models and pedagogical approaches (cp. Hummel, Manderveld, Tattersall, & Koper, 2004).

This work proposes a modeling approach and describes its implementation. Proposing a modeling approach goes beyond specifying a discrete set of categories or structural elements to describe learning resources and processes, as it means to investigate the meta-level of modeling. This work is based on work done by Guarino, Carrara, and Giaretta (1994), who distinguish the meta-level categories role type from natural type, and the work of Steimann (2000b), who proposes to introduce these meta-level categories into object-oriented modeling and the Unified Modeling Language. The work presented here, adopts these concepts and proposes a modeling approach, applicable in the field of learning. This is founded in analyzing concepts of learning and their epistemological foundation and in insights gained from the scientific field of Instructional Design, which defines instructional meta-models. The work builds upon research in both fields, computer sciences and the learning sciences, as both fields are concerned with modeling. The modeling approach is implemented in a specification for describing learning designs and instructional models (DIN DOM, Deutsches Institut für Normung e.V., 2004) and in the concept of Second-Order Learning Objects (SOLOs). SOLOs are shared schemes and mediating artifacts which support processes of generative learning.

In the remainder of this chapter, I will first give the motivation for this work and explore the problem in some detail (chapter 1.1). Then I will provide an overview and the structure of the following chapters (chapter 1.2).

1.1 Motivation

Recent developments in both, the field of information and communication technology (ICT) as well as the learning sciences have an impact on the field of educational technology. Innovations in ICT led to far-reaching change in many spheres of life. Besides network based technologies, which allow using heterogeneous information and services, the new approaching vision of a semantic web, semantic technologies, and corresponding infrastructure becomes more and more significant. The semantic web is envisioned to extend the current world wide web by systematic use of machine readable information, which specifies the semantics of the content in a formal way (cp. Berners-Lee, Hendler, & Lassila, 2001). As computer-based applications require a formal description of available resources and specifications of how to process requests, machine readable information becomes an indispensable prerequisite for semantic web technologies. In parallel and closely related to this technological development, we face a profound transformation in the domain of the learning sciences. Besides the increasing recognition of constructivistic theories of learning, the notion of learning as a fundamentally social and situated process gained significance. Whereas for a long time, learning theories and concepts have merely focused on the individual learner, there is a shift towards the social group and the co-construction of knowledge, now. Further development was triggered by the increasing importance of knowledge-based work and the rapidly growing amount of available information. These trends, which are often subsumed under the acronym of a knowledge-based society, call for approaches to support lifelong learning.

Research and development in the field of educational technology is a multidisciplinary endeavor. The terms educational technology and learning technology, often used synonymously, are only loosely defined (cp. Oliver, 2000). They comprise computer- and web-based learning scenarios, educational multimedia, computer-supported collaborative learning, adaptive hypermedia-systems for learning, etc. In its broadest sense, educational technology can be defined as *"the use of technology to support innovations in teaching and learning"* (Oliver, 2000, p. 22). To draw on the advantages of information and communication technologies, educational technology benefits from the development and application of formal specifications. Accordingly, Hummel et al. (2004, p. 113) define educational technology just as these *"specifications of methods and techniques which support the realization of e-Learning"*.

Specifications relevant for educational technology include (but are not limited to): learner and competency profiles to provide means for personalization, formats to describe educational resources and their aggregation, as well as metamodels to describe learning models and pedagogical approaches. In general, a specification is a unified and formal description of a product, service, or process. Specifications have to be standardized (i.e. broadly accepted and implemented) in order to assure interoperability across context, systems and platforms. Current specifications in the field of educational technology primarily provide descriptive frameworks and modeling languages to describe educational resources and processes.

Schemes like the Standard for Learning Objects Metadata (IEEE LOM, 2002) specify sets of metadata to label, catalogue and describe educational resources. Metadata is machine readable information about information on the web, that allows resources to be properly searched and processed (W3C, 2002). Modeling languages provide notational systems to describe educational processes. The structural elements and relations these modeling languages provide, have to be formally defined in order to be used and processed by machines.

While the need for specifications and standards is broadly accepted in the field of educational technology, the literature reveals a variety of intentions underlying the use of specifications. Accordingly, specifications in the field of computer-supported learning are meant to fulfill different purposes and objectives. From a technical point of view standards ensure technical interoperability across platforms such as Learning Management Systems. The availability of machine readable information is a basic requirement for adaptation, personalization, and automatization. From an economical perspective specifications are a prerequisite for exchange, reuse, efficient production and management of educational resources (cp. Klebl, 2003). The recent interest in the design and development of reusable learning objects as self-contained educational resources, reflects this economical perspective. Specifications are an important requirement for the universal and efficient use of educational content. From an educational perspective specifications fulfill a communicative function, as they allow to share experience and coordinate activities among those involved in the design and development of learning scenarios. Well-specified descriptions of learning processes allow to discuss and evaluate a learning scenario without necessarily implementing it (cp. Scheunpflug, 2001). Furthermore, a specification can be used as an explicit contract between those involved in the learning process, e.g. the teacher and the group of students (cp. Dillenbourg, 2002).

Representation of information especially gained importance in the context of the semantic web. Currently, web content is formatted for human readers rather than programs. The content of an html-page is presented in an satisfactory way for being processed by people, but cannot be processed by machines. *"The Semantic Web approach to solving these problems is not the development of superintelligent agents. Instead it proposes to attack the problem from the Web page side. If HTML is replaced by more appropriate languages, than the Web page could carry their content on their sleeve. (. . .) they could contain information about their content. (. . .) The term metadata refers to such information: data about data. Metadata capture part of the meaning of data, thus the term semantic in Semantic Web."* (Antoniou & van Harmelen, 2004). The endeavor is to represent information in a way which is more easily processable by machines. Antoniou and van Harmelen (2004) summarize: *"the goal of the Semantic Web is to assist human users in their day-to-day online activities."* Key semantic web technologies are:

- Explicit metadata to identify and extract information from web sources;
- ontologies to assist in web searches, to interpret retrieved information, and to communicate with other agents;
- logic and inferencing for processing retrieved information and for drawing conclusions;
- intelligent agents (Antoniou & van Harmelen, 2004, p. 7).

The notion of the semantic web evokes a wide range of associations and visions. Scenarios envisioning the future of the semantic web, are presented for example by Berners-Lee et al. (2001); Antoniou and van Harmelen (2004). In the field of learning some of them go far beyond the idea of search, exchange, and re-use of learning material, e.g. Simon, Dolog, Miklós, Olmedilla, and Sintek (2004); Allert, Richter, and Nejdl (2002). Scenarios which reflect the concept of receptive learning and the acquisition metaphor of learning (Sfard, 1998) are well addressed in the current discussion on educational metadata and standards. A typical scenario looks as follows: Learning material is produced by an author, sampled to courses by a course designer, classified according to skill taxonomies, and finally distributed to a learner. A learner, who owns a learning passport, which lists skills and prior knowledge, is offered specific courses based on his learning portfolio and preferred learning style. A learning flow management guides the learning process, samples personalized sequences based on learners action, coordinates tracking functionalities and presents the learning material. Scenarios, which currently are intended, are mainly those of instruction, separating a provider side (authors and course designers) from a consumer side (the learners). The IEEE Standard for Learning Metadata proposes a corresponding vision: *"To enable computer agents to automatically and dynamically compose personalized lessons for an individual learner"* (IEEE LOM, 2002).

But in modern knowledge-based societies, which are characterized by fundamental change and continuous transformation, there is also need for scenarios which focus on generative processes of creating innovative knowledge. This concept of learning is referred to as innovative and knowledge-creation learning (Bereiter, 1985; Engeström, 1999; Paavola, Lipponen, & Hakkarainen, 2002). It comprises open, ill-structured, productive, and long lasting processes of problem solving in individual and organizational learning, it focuses on communication and cooperation, and engages different forms of knowledge: tacit, procedural and declarative knowledge alike. *Metadata may support learners to find a relevant Community of Practice and a tandem partner to communicate with towards a shared goal; a group of learners might look for a coach who is experienced in co-ordinating processes of ill-structured problem solving; learners might search for support regarding strategies of solving problems and generating innovative solutions; semantic web agents might support group formation; mediating artifacts might help to share knowledge within an organization and foster organizational learning; learners might search for support regarding strategies rather than content.*

According to Antoniou and van Harmelen (2004), at present, the greatest needs to realize scenarios like these *"are in the areas of integration, standardization, development of tools, and adoption by users"*. To gain acceptance among all stakeholders schemes and specifications must allow adequately describing the domain in question. This is a prerequisite for integration, standardization, and adoption by users.

1.2 Overview and Structure

To adequately represent information in the field of learning, schemes, descriptive frameworks, and specifications must be able to describe any educational resource and learning process. This requirement is mentioned in relevant literature on learning technology specifications (cp. Koper, 2001; Pawlowski, 2001; IMS Global Learning Consortium, 2003b) and is referred to as *Pedagogical Flexibility*: The specification must be able to describe educational resources and processes that are based on different pedagogical approaches and models of learning. The specification must not prescribe a specific pedagogical approach. Pedagogical flexibility plays an important role from an instructional point of view and caused a lot of debate. While this requirement is taken into account by all initiatives which publish schemes and specifications in the field of educational technology, the question whether they actually meet this requirement, is still not answered. If current standards and specifications fail to meet pedagogical flexibility, they will foster educational monoculture instead of valuable diversity.

This work identifies the range of approaches, pedagogical flexibility has to take into account. In order to not prescribe any discrete pedagogical approach, it contrasts concepts of learning and their underlying epistemological foundation. It states, that descriptive frameworks in the field of learning must take into account concepts of learning which refer to learning as generative process of knowledge creation as well as concept of learning which refer to learning as receptive process of knowledge acquisition. It must take into account productive and reproductive aspects of learning alike. Furthermore, it must take into account integrated and isolated forms of learning: learning which is embedded in its context of use as well as scenarios of classroom-based learning. Regarding the requirement of pedagogical flexibility, this work states, that schemes inevitably reflect specific concepts of learning.

To investigate, whether descriptive frameworks actually allow describing any process of learning, this work draws on research done in the field of Instructional Design, which is concerned with modeling. Descriptive frameworks are based on *instructional meta-models*. Instructional meta-models specify, what is in common with any discrete learning design and learning model. In order to allow pedagogical flexibility, meta-models must take into account models which describe learning as determinable as well as models which describe learning processes as non-determinable.

Based on this foundational work, this thesis proposes a generic modeling approach based on Learning Roles. The modeling approach of *Learning Roles* allows to specify context specific educational metadata which addresses the valuable diversity in the field of learning. Instead of being neutral with regard to diverse concepts of learning, it advises to define schemes, which explicitly reflect specific concepts of learning. Guiding principle of this modeling approach is to model coherent social systems.

The modeling approach is implemented:

- In a specification for describing learning designs and learning models (PAS 1032-2, Deutsches Institut für Normung e.V., 2004) and
- in the concept of Second-Order Learning Objects (SOLOs). SOLOs are shared schemes and mediating artifacts which support generative processes of learning (Allert, Richter, & Nejdl, 2004).

This work focuses on the pedagogical attributes in schemes and specifications.

Chapter 2 gives a broad overview of current learning technology specifications and standards. Chapter 2.1 focuses on general aspects of learning technology specifications. Besides introducing the terminology used, it describes typical requirements for learning technology specifications and names the initiatives which publish these specifications and standards. Chapter 2.2 categorizes specifications according to their function regarding the educational process. It provides an overview of functions addressed by current standards and presents representatives. Chapter 2.3 and 2.4 focus on content- and process-oriented specifications, respectively and describe representatives in some detail.

Chapter 3 presents different concepts of learning and their epistemological foundation. Chapter 3.1 contrasts reproductive learning with generative learning. Furthermore it states, that learning does not only take place on an individual, but also on an organizational and societal level. Chapter 3.2 focuses on the aspect of contextualization and contrasts isolated with integrated learning. Chapter 3.3 reflects current learning technology specifications and the notion of de-contextualization.

Chapter 4 is concerned with modeling in Instructional Design. It presents prominent instructional meta-models, which represent descriptive frameworks, and presents activity-centered as well as system-centered meta-models. Chapter 4.4 reflects current learning technology specifications, based on this background.

Chapter 5 introduces the formal categories *natural type* and *role type* and presents the modeling approach of *Learning Roles*.

Chapter 6 shows current implementations of Learning Roles based on the definition given in chapter 5. First, the work presents the integration of Learning Roles in a specification used for describing learning scenarios and models, published as PAS 1032-2 (Deutsches Institut für Normung e.V., 2004). Then, the modeling approach of Learning Roles is applied to model Second-Order Learning Objects. Second-Order Learning Objects complement the current concept of learning objects. They are shared schemes representing mediating artifacts which support processes of generative learning. Metadata and semantic technologies are used as means for planning, structuring, reflection, and communication in generative learning processes. According to the notion of individual and collaborative learning as a process of reflective action, the role of schematically represented strategies and media for learning, reflection, and inquiry is stressed.

The conclusion presents thesis statements resulting from this work and defines further work.

Chapter 2

Learning Technology Specifications

This chapter provides a brief introduction to currently available learning technology specifications. With regard to the focus of this work, the landscape of current learning technology specifications is mapped, focusing on content- and process-oriented specifications. It describes selected representatives in some detail.

Chapter 2.1 is concerned with general aspects of learning technology specifications. Besides introducing the terminology used, it describes typical requirements for learning technology specifications and names the initiatives which publish these specifications and standards. Chapter 2.2 classifies current specifications according to their intention. Finally, chapter 2.3 and 2.4 introduce selected representatives of content- and process-oriented specifications.

2.1 Specifications and Standards

Throughout this work the term *specification* is used to refer to any kind of standard, irrespective if it is formally approved by an official organization for standardization or not. While officially approved standards (*norms*) have to be developed in a public and consensus oriented process involving all stakeholders, specifications do not require consensus and may reflect particular interests of a specific group of stakeholders. In general a specification is a unified and formal description of a product, service or process. A specification has to be complete in the sense that it describes all relevant features of a product, service, or process. Furthermore, an officially approved standard has to be compatible with other existing standards and has to be neutral with respect to commercial products.

Currently, the development of learning technology specifications is driven by several initiatives, including industrial consortia like the *IMS Global Learning Consortium, Inc.* (IMS stands for *Instructional Management Systems*), expert based initiatives like the *IEEE LTSC (Institute of Electrical and Electronics Engineers, Inc. - Learning Technology Standards Committee)* and *ADL (Advanced*

Distributed Learning) initiative, as well as national and international organizations for standardization such as the International Organization for Standardization (ISO), the European Committee for Standardization (CEN), and the German Institute for Standardization (DIN). While the ISO Joint Technical Committees (JT1), Subcommittee 36 (SC36) is working on officially approved standards on learning technology, there are no norms available, yet (cf. Hummel et al., 2004).

Irrespective of the particular functionality a given specification is meant to fulfill a set of general requirements for learning technology specifications has been specified. According to the diversity of intentions underlying the use of educational technology these requirements reflect technical, economic, organizational, as well as pedagogical rationales. While there is no common agreement on the minimal set of requirements, there is a high degree of correspondence. The following list summarizes typical requirements mentioned in the literature on learning technology specifications (cf. Koper, 2001; Pawlowski, 2001; IMS Global Learning Consortium, 2003b):

- **Formalization.** The specification must describe objects, services or processes in a formal way.
- **Completeness.** The specification must be able to fully describe the object, service or process including all relevant characteristics and elements.
- **Compatibility.** The specification must fit in with other relevant standards.
- **Interoperability.** The specification must be independent of any particular technical system, platform or application.
- **Adaptability.** The specification must take into account the fact that educational resources or processes sometimes have to be adapted to specific characteristics of the learner or situational circumstances.
- **Reproducibility.** The specification must describe an educational resource or process in such a way, that the intended learning process can be repeated in different situations with different persons.
- **Reusability.** The specification must support re-use of educational resources or processes in other contexts.
- **Pedagogical Flexibility.** The specification must be able to describe educational resources or processes that are based on different pedagogical approaches and models of learning. The specification must not prescribe any specific pedagogical approach.

These requirements are meant to ensure effectiveness, efficiency, attractiveness and accessibility of educational technology (cp. Koper, 2001). While the first three requirements (formalization, completeness, and compatibility) reflect definitional criteria of a standard the latter ones are rooted in technical, economic, organizational, and pedagogical considerations.

Function	Explanation	Representatives
search and selection	describing educational resources in order to support search and selection	IEEE-LOM
aggregation	combining and organizing resources into larger units	IMS Content-Packaging
personalization	specifying person-related data for personalization during the educational process	Public and Private Information (PAPI); Learner Information Profile (LIP)
regulation	describing rule-based regulation of educational processes	IMS Simple Sequencing; Question and Text Interoperability (QTI)
activity description	describing educational processes by describing structural elements and relations in the field of learning and teaching	Educational Modelling Language (EML); Essener-Lern-Modell (ELM)

Table 2.1: Learning Technology Specifications and their Functions (Extended Version of the Classification Scheme Proposed by Klebl, 2004).

2.2 Functions of Learning Technology Specifications

The increasing popularity of computer-based learning and the use of learning- and content-management systems led to a need for standards in order to assure the interoperability between different technological systems. The development of more and more sophisticated systems, providing a growing set of functionalities, comes along with the request for specific standards that address and support these functionalities. While in the beginning, the discussion on standards in the field of educational technology focused on the description of learning resources and their aggregation, the description of educational processes became more and more important in the meantime. Current specifications in the field of learning technology address a broad range of aspects relevant for the design, management, and implementation of educational scenarios. Different specifications can be categorized according to their function regarding the educational process. Table 2.1 provides an overview of functions addressed by current standards and presents representatives (cp. Klebl, 2004).

In the following, the functions mentioned are explained in some detail. Representative specifications are mentioned briefly. Specifications that are of direct relevance for this work are described in more detail in chapters 2.3 and 2.4.

Searching and Selecting. In order to be able to search and select learning resources in distributed repositories like the internet, resources have to be described in an appropriate way. Similar to bibliographic and archival systems the information used to describe a particular resource is encoded as metadata.

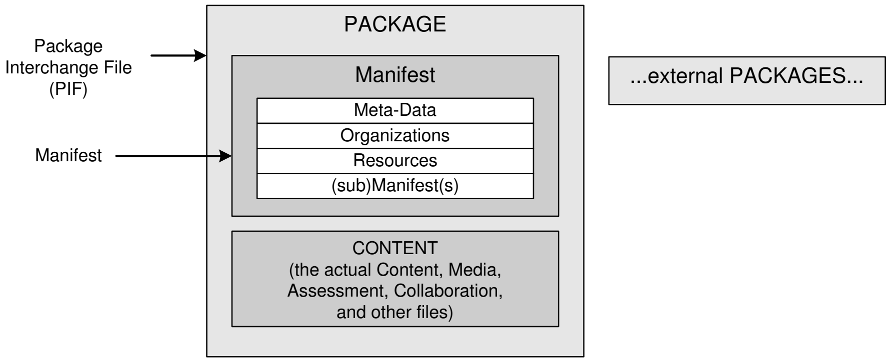

Figure 2.1: IMS Content Packaging (IMS Global Learning Consortium, 2004).

Metadata is used to classify, catalog and describe educational resources. Learning technology standards focusing on search and selection, specify an appropriate set of data to describe the educational resource in a way that is meaningful to the intended user. The most important standard in this respect is the *Standard for Learning Objects Metadata (LOM, 1484.12.1)*, approved by the Learning Technology Standards Committee of the IEEE LOM (2002). LOM and further specifications in this field are based on *Dublin Core, DC* (Dublin Core Metadata Initiative, 2004)), which provides a set of metadata to describe resources providing general information on categories such as title, subject, and author. DC is used in bibliographic and archival systems.

Aggregation. In order to be able to exchange entire units between Learning Management Systems, learning resources are aggregated. Aggregating learning resources requires to describe any element as well as its relations, and thus the intern structure of the unit. This procedure is called *Content Packaging.* Corresponding standards define how to describe resources and relations contained in the package. The most relevant standard for describing units of aggregated learning resources is the *IMS Content Packaging Specification* (IMS Global Learning Consortium, 2004b). Its basic structure is presented in figure 2.1: Describing packages which are reusable and distributable is essential in IMS Content Packaging. A package contains the learning resources itself as well as the manifest. The manifest comprises metadata, the structure of how the resources are organized, and the reference to these resources.

Personalization and Adaptation. In order to personalize learning resources to a learner's preferences, objectives, and prior-knowledge, information about the learner is needed. Specifications define a standard format for the representation and communication of student profiles. The purpose of specifications in the context of personalization is to allow the creation of learner records which can be communicated between educational systems (such as Adaptive Hypermedia Systems) over the lifetime of a learner. The *IEEE Public and Private Information Specification (PAPI)* and the *IMS Learner Information Package (LIP)* are representatives with regard to personalization and adaptation.

Guiding and Controlling Learning Sequences. Specifications define methods which instruct learning technology systems to sequence discrete learning activities in a consistent way. Learning resources are not presented statically, but the presentation of content is affected and controlled by the learner's behavior. The IMS Simple Sequencing Specification *"incorporates rules that describe the branching or flow of instruction through content according to the outcomes of a learner's interaction with content"* (IMS Global Learning Consortium, 2003c). In addition to specifying methods to control the presentation of resources due to the learner's behavior, specifications provide frameworks to describe processes of assessment. Guiding principle of these specifications is to adapt the learning sequence to the learner's competences, detected in an assessment activity. Outcome and result of an assessment activity determines the starting point for further learning sequences. A representative for these specifications is the *Question and Test Interoperability (QTI) Specification* (IMS Global Learning Consortium, 2004a).

Describing Processes of Learning and Teaching. Specifications such as *IMS Learning Design*, IMS LD (IMS Global Learning Consortium, 2003b), the *DIN Didaktisches Objektmodell* (Deutsches Institut für Normung e.V., 2004), and the *Essener-Lern-Modell, ELM* (Pawlowski, 2001) provide frameworks to describe the entire field of learning and teaching, including social interaction and learning activities. They provide descriptive frameworks which specify structural elements and their relations in a learning scenario. To give an example: IMS Learning Design relates structural elements such as *persons*, which fill *roles*, performing an *activity* by using an *environment*. The persons, filling roles, work towards a learning objective. As any learning scenario is based on a model of learning, the specification must allow describing any model of learning, learning method, and pedagogical approach which exists and will exist in future.

Learning technology specifications aim to capture instructional and educational information. According to different objectives, purposes, and lines of reasoning, they can be assigned to two main groups. On the one hand there are those specifications that focus on the description of content and its aggregation. On the other hand there are those specifications that focus on describing learning activities and their sequencing. Both strands are discussed in chapter 2.3 and 2.4.

2.3 Content-Oriented Specifications

Content-oriented specifications focus on the description of resources that are used in the context of learning and instruction. In order to find and select a resource that is appropriate in a specific educational situation, called Learning Object (LO), the description also has to capture its educational characteristics. Content-oriented specifications are build on the premise that an educational resource is a self-contained entity, that can be described without reference to other resources. The concept of educational resources as self-contained entities resembles the paradigm of object-oriented programming, which draws on the concept of components or 'objects' that can be reused on a variety of platforms and in different contexts (cf. Hummel et al., 2004; Wiley, 2003).

Content-oriented specifications can be divided into two subgroups. While some specifications like the Standard for Learning Objects Metadata and the Didaktischen Ontologien provide a framework to describe discrete educational resources, other specifications like IMS content packaging focus on the aggregation of educational resources into larger units.

2.3.1 Learning Objects Metadata (LOM)

The Standard for Learning Objects Metadata, LOM (Learning Technology Standards Committee of the IEEE (IEEE LOM, 2002) defines a structure of a metadata instance for the interoperable description of LOs. The standard is developed by the IEEE Learning Technology Standards Committee and has its origins in both the ARIADNE and the IMS project. It builds on the Dublin Core Standard which provides a framework to describe information and service resources. The Standard for Learning Objects Metadata aims at facilitating search, exchange, evaluation, acquisition, and use of LOs by learners, instructors, and automated software processes. Thereby, a LO is defined as *any entity, digital or non-digital, that may be used for learning, education or training* (IEEE LOM, 2002). The specification defines a set of data elements to describe the relevant characteristics of a learning object. The data elements are grouped into nine categories. Table 2.2 lists the nine categories of the basic schema and their upper-level data elements.

The LOM standard defines vocabularies for some of the data elements. Nevertheless, data elements, vocabularies, and categories are meant to be extensible as needed.

2.3.2 'Didaktische Ontologien'

Meder (2000) specifies the Didaktischen Ontologien, in order to define the educational characteristics of a learning resource in five categories. Meder explains, that the term ontology is originate in philosophy, where it names the study of the nature of existence (in contrast to epistemology as the theory of cognition). In computer science the term has been adopted with different meaning. According to Studer, Benjamins, and Fensel (2005), based on Gruber (2004), *an ontology is a formal, explicit specification of a shared conceptualization.* An ontology describes an domain, specifying a finite list of terms (denoting relevant concepts in the domain of discourse) and the relationships between these terms (Antoniou & van Harmelen, 2004).

Guiding principle of the Didaktischen Ontologien is to make learning resources accessible to learners themselves in order to foster explorative and self-organized learning. According to Meder (2000), learning takes place in the context of solving problems. Having access to a well-defined organization of knowledge allows to find the knowledge needed to solve the problem and supports a self-organized knowledge management. Furthermore, the Didaktischen Ontologien support authors to develop optimal paths of learning and instruction. To define an educational resource, Meder specifies five categories:

- The category of semantics: any object is assigned to a thematically defined problem;
- the category of pragmatics: any object is assigned to a competence, which is needed to solve a problem;

Category	**Explanation**	**Data Elements**
General	The General Information that describes the Learning Object as a whole.	Identifier, Title, Language, Description, Keyword, Coverage, Structure, Aggregation Level
Life Cycle	The history and current state of this learning object and those entities that have affected this learning object during its evolution.	Version, Status, Contribute
Meta-Metadata	A description of the metadata record itself.	Identifier, Contribute, Metadata Schema, Language
Technical	The technical requirements and characteristics of this learning object.	Format, Size, Location, Requirement, Installation Remarks, Other Platform Requirements, Duration
Educational	The key educational or pedagogic characteristics of this learning object.	Interactivity Type, Learning Resource Type, Interactivity Level, Semantic Density, Intended End User Role, Context, Typical Age Range, Difficulty, Typical Learning Time, Description, Language
Rights	The intellectual property rights and conditions of use for this learning object.	Cost, Copyright and Other Restrictions, Description
Relation	This category defines the relationship between this learning object and other learning objects, if any.	Kind, Resource
Annotation	This category provides comments on the educational use of this learning object, and information on when and by whom the comments were created.	Entity, Date, Description
Classification	Describes where this learning object falls within a particular classification system.	Purpose, TaxonPath, Description, Keyword

Table 2.2: Categories and Data Elements of the Standard for Learning Object Metadata (IEEE LOM, 2002).

- the category of knowledge-types, answering questions of know-what, know-why, know-how, know-where (knowledge-types are: orientation, action, explanation, reference/source);
- the category of presentation media, defining the media in which the content is presented (text, table, picture, image, sound, movie, interactive transaction);
- the category of relations (hierarchy relations and associative relations).

Any of these ontologies is organized in hierarchies. The categories of semantics and pragmatics are to be defined according to job specifications, describing activities, functions, and results specific to an organization and institution. The cetagories of knowledge-types, presentation media, and relations is defined by Meder's ontologies.

Beyond these categories, any object is defined in its level of interaction: receptive (the learner's activity is reduced to selection, sequencing learning resources, and determining the duration of stay), interactive (the learner is integrated in a human-machine interaction), and cooperative (the learner is integrated in a human-human interaction).

Further ontologies have been specified in the field of computer-supported collaborative learning (CSCL), called CSCL-ontologies. Their emphases is placed on aspects such as: learning goals and group information (Inaba et al. 2000), communication models and problem solving methods (Ikeda, Hoppe, & Mizoguchi, 1995), and learning tasks (Mizogushi & Sinitsa, 1996). The entities these ontologies describe, are not learning resources conveying content to be acquired, but entities such as an discrete activity of leaner-to-learner interaction. These ontologies specify entities in order to foster collaborative processes rather than describing content-oriented resources.

2.3.3 IMS Content Packaging

The IMS Content Packaging Specification (IMS Global Learning Consortium, 2004b) describes a mechanism to represent content structures in order to exchange content between different technological systems. The Content Packaging Specification has been developed by IMS and is part of the Sharable Content Objects Reference Model, SCORM (Advanced Distributed Learning, 2004a). The Content Packaging Specification primarily addresses the needs of developers and implementers of learning materials and learning management systems.

An IMS Content Package comprises the learning resources itself as well as a manifest which describes the contained content in a meaningful way (see Fig. 2.1). A package represents a unit of (re-)usable content and includes all the information needed to use this content for learning. The top-level manifest of a package describes the package itself. This description comprises general metadata, possible organizations of the content, references to all resources needed, as well a one or more optional, logically nested manifests. The organizations section contains zero, one or more structures for the content in this package. The specification only supports hierarchical organizations of the content. According to this specification, resources are defined as pieces of data in a file-format, such as web pages, media files, text files, assessment objects. These resources form the building blocks for any kind of content.

2.4 Process-Oriented Specifications

In contrast to content-oriented specifications, described above, process-oriented specifications focus on the description of a sequence of learning activities. Process-oriented specifications stress the importance of organizing resources and activities in order to foster learning. Instead of describing isolated resources they aim to provide information models capable to describe the entire field of learning and instruction in an interoperable way.

Process-oriented specifications can be grouped into two main types. While some specifications like IMS Simple Sequencing concentrate on the rule-based presentation of resources to the learner (the learning activity is only implicitly modeled) other specifications like IMS Learning Design and the DIN Didaktisches Objektmodell (DIN-DOM) explicitly describe instructional scenarios and learning processes, comprising activities and social interaction. While some of the specifications presented here are conceptualized as organizing content in the sense of IMS Content Packaging, it is important to note that they describe qualitatively different aspects of learning.

2.4.1 IMS Simple Sequencing

The IMS Simple Sequencing Specification (IMS Global Learning Consortium, 2003c) defines a mechanism to sequence content and to deliver and exchange these sequences between different technological systems. The Simple Sequencing Specification has been developed by IMS and is part of the Sharable Content Objects Reference Model, SCORM (Advanced Distributed Learning, 2004b). The Simple Sequencing Specification is primarily meant as a mechanism for learning designers and content developers to declare *the relative order in which content is presented to the learner and the conditions under which a piece of content is selected, delivered, or skipped during presentation* (IMS Global Learning Consortium, 2003c). The Simple Sequencing Specification defines the functionality a conformant system must implement in order to present the content in the specified way. The specification also supports the rule-based flow of learning activities according to a user's interaction with the content.

IMS Simple Sequencing conceptualizes a learning activity as an integral part of a content resource. The learner's reaction to a content resource triggers the corresponding set of sequenced activities. The specification only provides learning activities for single learners and is restricted to a limited number of sequenced activities.

The Simple Sequencing Specification allows to represent simple instructional designs, common to CBTs and WBTs. Figure 2.2 depicts the relation between IMS Content Packaging and IMS Simple Sequencing.

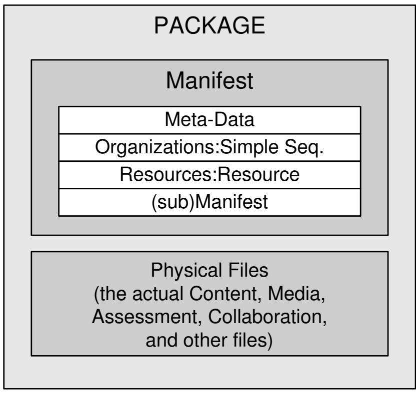

Figure 2.2: Simple Sequencing as an organization within a content package.

2.4.2 IMS Learning Design

The IMS Learning Design Specification, IMS LD (IMS Global Learning Consortium, 2003b), provides a descriptive framework for describing a pedagogical method as an integral part of an *unit of learning*. The descriptive framework is depicted in the information model in figure 2.3. The Learning Design information model is based on the Educational Modelling Language (EML), which has been developed by the Open University of the Netherlands (Koper, 2001). The IMS Learning Design Specification extends the IMS Content Packaging Specification and provides placeholders for other IMS specifications like Meta-Data and Simple Sequencing. IMS LD aims to provide a notational system that allows to *describe any design of a teaching-learning process in a formal way* (IMS Global Learning Consortium, 2003b).

Both, the IMS Learning Design Specification as well as the Educational Modelling Language are based on the assumption that the mere aggregation of learning objects is insufficient to promote learning. Therefore, these specifications focus on modeling instructional strategies and learning methods (cp. Hummel et al., 2004; Koper, 2001). In order to be able to describe any learning design, regardless of its pedagogical approach, the Educational Modelling Language is build on a pedagogical meta-model. The pedagogical meta-model is defined as a model that allows to describe any specific pedagogical model. The pedagogical meta-model proposed by (Koper, 2001) is derived from an analysis of pedagogical approaches described in literature. The pedagogical meta-model comprises four packages described in table 2.3.

IMS LD as well as the Educational Modelling Language provide a notational system to describe a unit of study. Both, EML and IMS LD are build on the assumption that, in essence, every learning design can be broken down to a method that prescribes a sequence of activities to be performed by persons with certain roles in an environment. Persons filling the roles learner and staff work towards certain learning objectives. The environment consists of objects and services needed to perform the activity. The different activities to be performed by learners and staff are organized by the element *method*. A method consists of one or more concurrent *play(s)*. Each play consists of one or more sequen-

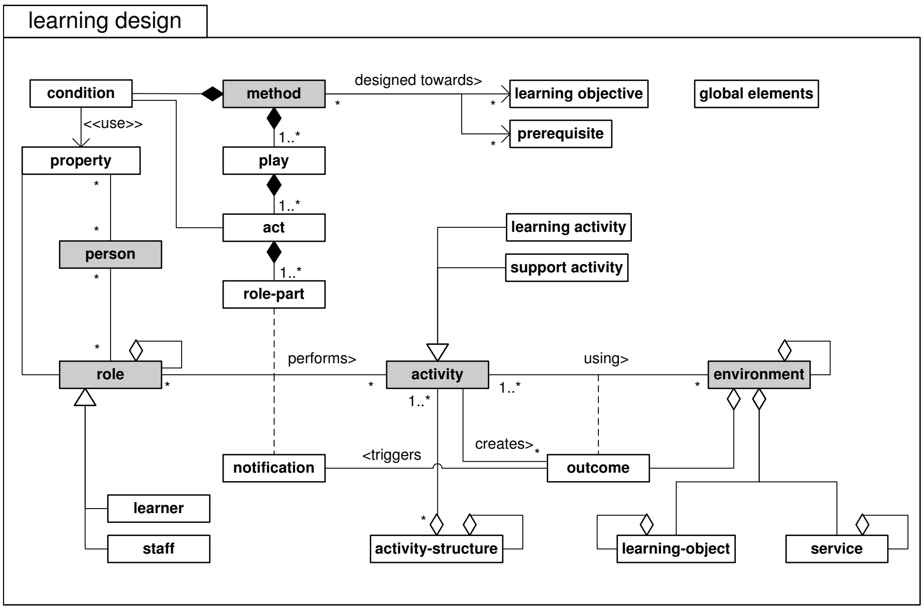

Figure 2.3: Conceptual model of the overall learning design (IMS Global Learning Consortium, 2003).

Package	**Explanation**
learning model	Describes how learners learn based on commonalities (consensus) in learning theories.
unit of study model	Describes how units of studies which are applicable in real practice are modeled, given the learning model and given the instruction model.
domain model	describes the type of content and the organization of that content. For example, the domain of economics, law, biology, etc.
theories of learning and instruction	describe the theories, principles and models of instruction as they are described in literature or as they are conceived in the head of practitioners.

Table 2.3: Packages in the pedagogical meta-model (Koper, 2001).

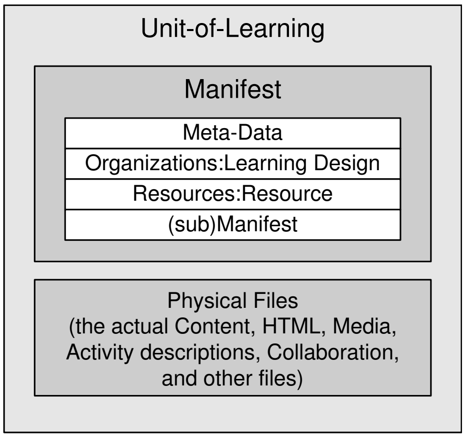

Figure 2.4: The structure of a Unit of Learning (IMS Global Learning Consortium, 2003).

tial *act(s)* whereby every act includes one or more concurrent *role-part(s)*. A role-part assigns a specific activity or activity-structure to a specific role. Any activity refers to an environment which comprises objects and services needed to perform the activity. Further elements like learner Properties, Conditions and Notifications are defined to support the description of individualized learning. Figure 2.3 describes the conceptual model of the overall learning design.

IMS Learning Design separates the description of learning objects and services from the description of educational methods and learning activities. Only the latter are modeled in IMS Learning Design. Figure 2.4 depicts the model of a *unit of learning*.

Further specifications and modeling languages, such as the Essener-Lern-Modell, ELM (Pawlowski, 2001) and the DIN DOM (Deutsches Institut für Normung e.V., 2004) provide descriptive frameworks which allow describing learning processes and learning scenarios. The Publicly Available Specification DIN DOM, which focuses on describing learning scenarios and models, and which integrates the modeling approach of Learning Roles, is presented in detail in chapter 6.1.

Chapter 3

Concepts of Learning

Among relevant standardization initiatives there is common agreement that the diversity of learning theories and pedagogical approaches is of great value. Therefore, standardization in the field of learning and learning technology has to take into account any existing and evolving learning model. This means that not a specific learning theory, learning model, or pedagogical approach becomes a standard, but that specifications and standards must allow to describe any approach, theory and model. This work contrasts concepts of learning. Concepts of learning reflect an epistemological foundation and found learning models and pedagogical approaches. Based on this outline of concepts of learning, this chapter reflects whether current learning technology specifications address any of these concepts.

Koper (2001) illustrates the diversity of learning theories in his outline on the Pedagogical Meta-Model, which forms the basis of the Educational Modelling Language (EML), by a citation from Duffy and Cunningham (1996):

> "As the quote from Skinner suggests, everyone agrees that learning involves activity and a context, including the availability of information in some content domain. Traditionally, in instruction, we have focused on the information presented or available for learning and have seen the activity of the learner as a vehicle for moving that information into the head. Hence, the activity is a matter of processing the information. The constructivists, however, view the learning as the activity in context. The situation as a whole must be examined and understood in order to understand the learning. Rather than the content domain sitting as central, with activity and the 'rest' of the context serving a supporting role, the entire gestalt is integral to what is learned." (As cited in Koper, 2001, p.11)

Often different learning theories are referred to as behavioristic, cognitivistic, or constructivistic. From a cognitive point of view, information processing theories are contrasted with theories of situated cognition. While these typologies reflect some of the most prominent paradigms in psychology, which deal with the investigation and explanation of human learning, this taxonomy is problematic when used to classify actual learning designs. While behavioristic, cognitivistic,

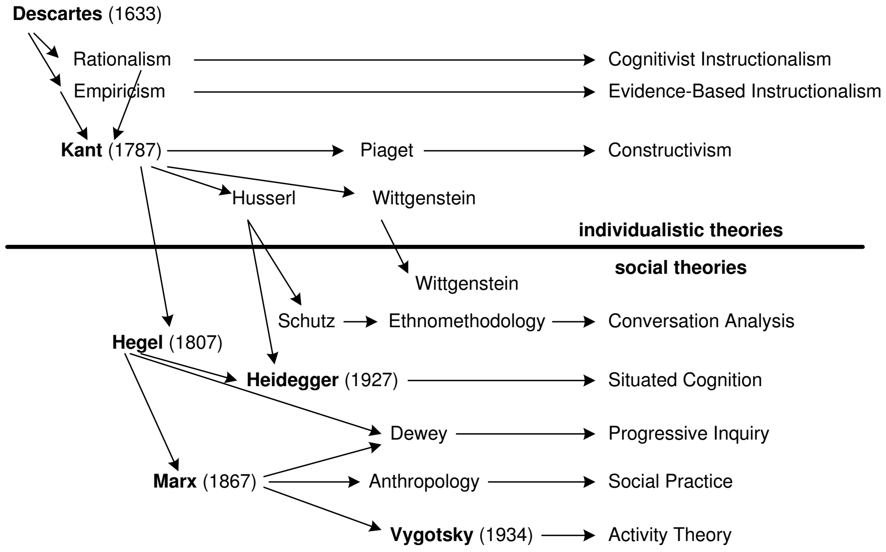

Figure 3.1: Philosophic influences on individual and social theories of learning (Stahl, 2003).

and constructivistic learning theories provide a framework for the investigation and explanation of human learning they don't lend themselves directly to a concrete pedagogical approach. Even so, a range of models of learning and instruction have been derived from psychological learning theories, each learning scenario can be viewed and analyzed from any of these positions. In contrast to the afore mentioned classification this work draws on concepts of learning which are rooted in different philosophical positions of epistemology and ontology. Each concept of learning incorporates a specific concept of knowledge. The relationship between philosophies and learning theories have been discussed e.g. by Packer and Goicoechea (2000). Stahl (2003) visualizes the relationship in a diagram (figure 3.1). A history of philosophy which is relevant for the learning sciences can be viewed from different perspectives. The figure focuses on the aspect of individualistic and social theories.

Concepts of learning as well as the assumptions and epistemological foundation they are based on, play a prominent role in the design of learning scenarios. Every learning design, educational technology, and research methodology explicitly or implicitly reflects a specific concept of learning and epistemological foundation. *"Contemporary learning theories reflect implicit (often unacknowledged) philosophic commitments defined at different stages in the history of philosophy, representing different responses to this dualism."* (Stahl, 2003, on the mind-body dualism introduced by Descartes).

The following sections outline concepts of learning and knowledge and their epistemological and theoretical foundation. This outline of different concepts of learning illustrates the wide range of scenarios and the valuable diversity specifications and standards must take into account.

Chapter 3.1 contrasts different concepts of learning regarding reproductive and productive aspects of learning. This is important as learning is commonly understood as acquisition and reproduction of knowledge rather than creation and generation of knowledge. This work states that the acquisition metaphor of learning is well addressed by current specifications and standards for technology enhanced learning. Therefore, the outline mainly focuses on concepts which go beyond the acquisition metaphor and towards the knowledge-creation metaphor of learning. Based on this more comprehensive view on learning, the relation between individual, organizational, and societal learning is sketched.

Chapter 3.2 focuses on issues rising from conceptualizing the context of learning. It contrasts individual with isolated learning. Furthermore, it discusses limitations of pre-planned learning activities and draws consequences for modeling.

Chapter 3.3 reflects current learning technology specifications with regard to the question whether they actually address any concept of learning. It states, that the modeling approach a specification is based on, is never neutral regarding the concepts of learning.

3.1 Contrasting Concepts of Learning: Reproduction and Generation of Knowledge

This section contrasts the acquisition metaphor of learning (receptive and reproductive learning) with the knowledge-creation metaphor of learning (generative and productive learning).

3.1.1 Acquisition Metaphor of Learning and Reproductive Learning

Sfard (1998) distinguishes the *acquisition metaphor* from the *participation metaphor* for learning. The *acquisition metaphor* refers to learning as a matter of individual acquisition and construction of knowledge. The goal of learning is individual enrichment. Learners are consuming recipients and (re-)constructors. Teachers are providers, facilitators and mediators. Outcomes are realized in the process of transfer and are conceptualized as a person's capability to use and apply knowledge in new situations. Knowledge is seen as property and possession of an individual mind and as public commodity. A typical acquisition scenario delivers information the learner is supposed to acquire or reconstruct. Ausubel's model of Expository Teaching (1963), which guides the learner, and Bruner's model of Discovery Learning (1966), which allows to explore the learning material, represent prototypical examples. In scenarios of knowledge acquisition and receptive learning, exercises typically fill the role of repeating and applying the concepts just learned (e.g. solving a well-structured problem, which provides a clear problem statement and aims at a solution which can be assessed as right or wrong).

The *participation metaphor* of learning refers to learning as a process of participation in shared learning activities and social processes of knowledge construction. One major goal of learning is community building. Cognition and knowing are distributed over both individuals and their environment. Learning is 'located' in networks of distributed activities of participation. The focus is on activities such as *knowing* and not so much on outcomes and products such as *knowledge.*

The participation metaphor of learning is based on Lave and Wenger's concept of *situated learning* (Lave & Wenger, 1991). The term situated learning is an umbrella term many concepts refer to. It locates learning in the process of co-participation and in social interaction, not in the head of individuals. Learning is referred to as meaning production. Lave and Wenger (1991) define learning as moving from peripheral participation to full membership within a knowledge community. Relevant roles in a community are peripheral member, full/active member, and expert/core member. Peripheral participants do not simply accumulate knowledge and skills but are introduced to processes, routines, methods networks, relevant issues, and approaches within the community. *"The individual learner is not gaining a discrete body of abstract knowledge which (s)he will then transport and reapply in later contexts. (. . .) There is no necessary implication that a learner acquires mental representations that remain fixed thereafter, not that the 'lesson' taught consists itself in a set of abstract representations"* (Hanks, 1991, p. 14). An example: According to the concept of situated learning, students are not only taught how to conduct scientific work, but students are also introduced to scientific communities, i.e. to the procedures of how to publish on conferences relevant in the community, to controversial discussions in the field, to the everyday work of experts, which find current and promising issues of research within the community (cp. Allert & Richter, 2002).

3.1.2 Knowledge-Creation Metaphor of Learning and Generative Learning

Paavola et al. (2002) extend Sfard's participation metaphor of learning and introduce the *knowledge-creation metaphor* of learning. They extend the participation metaphor as it was originally used to characterize learning in traditional cultures which are relatively stable. The knowledge-creation metaphor is used to characterize learning in modern knowledge societies and communities where fundamental changes and transformations take place. Bereiter and Scardamalia (1993) argue that in innovative knowledge communities, which constitute the knowledge society, there are no clear-cut roles for newcomers and old-timers as not only old-timers have access to the most valuable knowledge and skills. Newcomers develop competencies, generate and advance knowledge that is innovative and valuable.

The knowledge-creation metaphor of learning focuses on innovative and generative learning, and conceptualizes learning *"as analogous to processes of inquiry, especially to innovative processes of inquiry where something new is created and the initial knowledge is either substantially enriched or significantly transformed during the process"* (Paavola et al., 2002, p. 24). The knowledge-creation metaphor of learning is seen as epistemological foundation of many concepts of CSCL and knowledge communities. Models which are based on this concept of learning are developed and applied in in the field of knowledge management and education alike.

Paavola et al. (2002) identify the knowledge-creation metaphor of learning by analyzing models of innovative knowledge communities and knowledge advancement, i.e. Nonaka and Takeuchi's model of knowledge-creating organizations (1995), Engeström's model of expansive learning (1999), and Bereiter's theory of knowledge building and innovative learning (1993). The knowledge-creation metaphor goes beyond the acquisition metaphor of learning where knowledge is taken more or less as such:

> "We have argued that in these models learning and knowledge advancement is understood through a knowledge-creation metaphor that emphasizes the importance of going beyond the information given. All of them are trying to answer to the challenge of the 'learning paradox' by focusing on processes of innovation. The learning paradox (or the 'Meno paradox') is the classical problem of explaining how something more complex is created using existing knowledge (see Bereiter 1985). These three models of innovation take the learning paradox to be a basic epistemological question by highlighting the importance of explaining how something new is created" (Paavola et al., 2002, p. 31)

Models of innovative and generative learning (learning which generates innovative knowledge) avoid mentalism and an exclusively individualistic approach by criticizing the classical conception of knowledge as conceptual, declarative, and propositional knowledge only. The *"models of innovative learning criticize the traditional view according to which human cognition is a symbolic system that mainly relies on explicit propositional knowledge and functions according to explicit formed production rules"* (Paavola et al., 2002, p. 28). To understand processes of innovation as externalization of declarative knowledge, which already resides in an individual's head, is referred to as simplistic view.

Innovative learning is seen as dialectical interaction between different forms of knowledge: tacit, procedural and declarative knowledge. *Procedural knowledge* (know-how) is based on the idea that activities and skills are not guided by explicit rules and propositional knowledge. Rather, rule-like behavior emerges as an outcome of knowledgeable action (Paavola et al., 2002, p. 28). *Tacit/implicit knowledge* is based on the idea that creative experts have extensive experience in solving problems in their field. Based on their tacit knowledge they have some sort of sense what is promising in their field, the know how to solve new problems and try to find out new and more promising ways of doing things in their field. Shared conceptualization and shared construction of conceptual artifacts arise from dialectical interaction of tacit, procedural and declarative knowledge within processes of solving problems, questioning objectives and existing problem solutions, originating new thoughts and advancing communal knowledge. Knowledge advancement means to collaboratively transform ideas, practices, and conceptual artifacts.

Knowledge creation is seen as a fundamentally social process as people collectively improve their understanding through social interaction. *"New ideas and innovations emerge among rather than within people"* (Paavola et al., 2002, p. 29). This means that knowledge is not considered to reside and being created in an individual's mind. The assumption that knowledge consists of objects, which can systematically be produced, transferred and accumulated, is referred to as mentalistic concept of knowledge. In contrast to this view, the socio-cultural theory of learning stresses, that meaning and knowledge are not only represented as cognitive artifacts in individual minds, but also in linguistic, conceptual and material artifacts in the inter-subjective world (see Stahl, 2003). Learning and meaning-making is not just a psychological process taking place in individuals' minds, but is constructed by social activities.

> "Mediating artifacts, which are created and changed in the course of human activity, represent socially shared values, procedures, rules, theories as well as epistemic and ontological beliefs. Socio-cultural theory holds that cognitive artifacts result from the internalization of culturally developed artifacts which are themselves a result of human activity. From this perspective, learning is an ongoing adaptation and transformation of mediating artifacts in collectively organized activity systems. Learning can be seen as a process of inquiry, which either enriches or transforms the initial knowledge and procedures." (Richter, Allert, & Nejdl, 2005)

The concept of innovative and generative learning is not only relevant in the context of scientific research but also in knowledge management (Nonaka & Takeuchi, 1995) and school education (Bereiter, 1993; Engeström, 1999). In the following, innovative and knowledge-creation learning is referred to as *generative learning*. Generative learning goes beyond the acquisition of what is already known and extends or transforms the socially shared knowledge including its artifacts and practices.

As learning is not limited to reproductive forms of learning but also includes productive and generative activities, the twofold nature of learning means that the individual has to adapt to ongoing change due to technological, social, and cultural transformations and at the same time has to make active contributions to these developments (cp. Allert et al., 2004). Learning-on-demand, which predefines learning objectives and delivers learning content according to demands resulting from job-specifications and current tasks, covers the reproductive aspects of learning, whereas generative learning focuses on the productive aspects of active citizenship, participation in innovation, knowledge creation, and ongoing change. Learning is not limited to professional development or vocational training but affects any aspect of life. Innovative technologies and business processes require the acquisition of new skills. Changing social structures and norms calls for the creation of different types of relationships. Cultural transformation alters ones beliefs and attitudes. In contrast to concepts which solely focus on institutionalized and organized forms of education, a notion of learning as a core condition of human life is stressed.

At this stage one may claim that the term learning is used in an inflationary manner as it goes beyond reproductive learning and formal education towards informal and productive learning. But, broadening the scope of learning towards informal and productive learning does not equate any activity with learning. Indeed not every process of change, generation, and innovation is a process of learning, as change does not always mean learning. But as soon as these processes are made accessible to reflection they have the power to change and enhance understanding, knowledge, and skills. Not only diverse concepts of learning (Scardamalia & Bereiter, 1996; Paavola et al., 2002)), but also pedagogical meta-models take into account productive aspects of learning (cp. Scheunpflug, 2001; Treml, 2000, and chapter 4). To extend the scope of learning is also in line with the EC Memorandum on Lifelong Learning (Commission of the European Communities, 2000) which considers employability and active citizenship as equally important aims of lifelong learning.

Broadening the scope of learning towards productive aspects of learning raises crucial questions on the design, implementation, and use of learning technology. In fact many applications that are useful to support productive learning have not been developed for learning purposes but for knowledge management, scientific visualization, and cooperative work. But, the current notion of learning objects solely focuses on reproductive learning. In order to address both, reproductive and generative concepts of learning, this work extends the current concept of learning objects: Chapter 6.2 delineates the idea to use semantically rich descriptions, such as shared metadata schemes, in order to foster generative learning, reflection and active citizenship. According to this extended concept, learning objects work as mediating artifacts in processes of generative learning.

3.1.3 Learning on an Individual, Organizational, and Societal Level

A concept of learning which comprises both reproductive and generative aspects, also implies that learning does not only mean individual change but inevitably is an organizational and social process. This section, which is based on the work of Allert et al. (2004), states that learning takes place on an individual, organizational and societal level.

Individual learning changes organizations, culture and the socially constructed objective world. Generative learning leads beyond what is already known and extends or transforms the socially shared knowledge including its artifacts and practices. The generation of new knowledge by means of scientific inquiry, artistic work, investigative journalism, personal experience, and even by accidental discovery brings about learning on the individual as well as organizational and social level. On the other hand, the increasing amount of innovative knowledge makes demands on the individual. Individual learning takes place in the context of organizational and societal learning and development, calling for the adaptation of the individual.

The notion of learning as a fundamentally social process has been acknowledged with regard to organizational learning as well as learning in the context of culture. The change of organizational structures and the implementation of new practices do not only appeal on employees' skill and knowledge, but also results in improvements and innovations in work organization, tools and products.Argyris and Schön's concept of *double-loop learning* conceptualizes the intertwined relationship between individual and organizational learning (e.g. Argyris & Schön, 1978). Beyond the organizational level, Oerter describes - referring to the cultural-historical activity theory (Leont'ev, 1978) - the mutual-dynamic adaptation of culture and the individual. By means of activity, the individual successively opens itself to the scope of options provided by culture. Culture, again, is created by individuals' activities. This mutual-dynamic process accounts for an isomorphism between culture as an objective structure and the individual as a subjective structure. While culture usually evolves slower than individuals, recent cultural trends indicate that even within one generation substantial cultural change can occur. Rapid cultural change requires permanent learning (cp. Oerter, 1994, p. 143)[1]. Both, the concept of double loop learning as well as the notion of isomorphism between the objective and subjective structure of the world by means of mediated action reflect the dynamic interrelationship of productive and reproductive learning.

As soon as the scope of learning is broadened and productive learning is acknowledged as important complement to reproductive learning processes, a huge variety of additional activities of individual as well as collaborative learning comes to the fore. Endeavors such as change management and organizational learning, scientific inquiry, the creation of innovative technologies, the design and evaluation of social interventions and programs, and conflict resolution become part of a more comprehensive understanding of learning.

Whereas some current concepts of learning solely focus on aspects of reproduction of culture and on reconstruction of existing knowledge and thus on learning as qualification, other concepts broaden the scope beyond the learner-centered reproductive aspects towards societal-transformative and generative aspects of learning. Broadening the scope towards both aspects of learning raises crucial questions on the design, implementation, and use of technology to enhance learning. While there are diverse endeavors to support productive, generative, and transformative processes of learning by technology (Scardamalia, 2004; Paavola et al., 2002; Suthers, Weiner, Connelly, & Paolucci, 1995), the discussion about learning objects as well as specifications and standards for technology enhanced learning have merely concentrated on the reproductive side of learning and knowledge acquisition.

3.2 Contrasting Concepts of Learning: Contextualization

This section focuses on issues arising from conceptualizing the context of learning. It contrasts isolated with integrated learning and discusses limitations of pre-planned learning activities and consequences for modeling.

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[1] The notion of knowledge-based societies also comprises both aspects, the reproductive as well as productive. Moving into the Knowledge Age is an acronym for being confronted with far-reaching change in cultural, social, and economic life. Current cultural, social, and economic trends challenge traditional concepts of learning. The character of knowledge-based societies and learning is twofold: individuals, organizations, and societies are both reproductive and productive. On the one hand, living and working within a knowledge-based society requires continuous development of individuals and groups in order to adapt to ongoing change and to improve employability and adaptability (i.e., the reproductive character of learning). On the other hand individuals and groups form and create innovation and change, which again constitutes and characterizes the knowledge-based society (i.e., the productive character of learning). Being able to contribute to and co-determine the complex cultural, social, and political spheres fosters active citizenship.

3.2.1 Isolated Learning

From the point of view of modeling it is relevant to contrast concepts of *isolated learning* with concepts of *integrated learning.* Isolated learning refers to learning which typically takes place in a classroom, separated by time and place from the context where the learned comes into practice, e.g. the context of work processes. Brown, Collins, and Duguid (1989) state that *"many teaching practices implicitly assume that conceptual knowledge can be abstracted from the situations in which it is learned and used".*

Isolated learning refers to learning as context independent. It refers to its context only in the means of preconditions (prior knowledge) and post-conditions (outcomes). Within the program a learner works towards a predefined learning objective. Typically, a modularized learning unit is delivered - a workflow, described by a process model, guides the learning process. The learning activities are pre-planned and the unit of study is prescribed. Learning processes are optimized in order to reach the learning objective in the most efficient way. Learning processes of isolated learning are conceptualized as well-structured and hence can be pre-structured and pre-planned.

3.2.2 Integrated Learning

Integrated concepts are concerned with learning which is contextualized. Learning is embedded in its context of use. It means not only to learn at a work place (just co-located), but to integrate learning in work processes. Learning processes are situated and crucially embedded within a dynamically changing context. Learners are actively engaged within the context. Beyond being embedded, learning changes its context (e.g. in organizational learning). Often these processes are long lasting, do not take place within a well-defined period of time, and mean continuous improvement - they can not be described with attributes such as: "typical learning time". Furthermore, integrated concepts assume learning processes and learners to actively change the context they are embedded in. Learning processes and its context interact, which means that not only the individual learner learns (which means change), but also the context learns and changes. A typical context is an organization. The concept of learning organizations addresses the intertwined process of change. Organizations experience dynamic, complex environments that call to question the traditional strategic management and organizational hierarchy paradigm. Organizational processes, procedures, and policies are altered in response or anticipation of environmental change. This again forms the complex and dynamic context for organizational and individual learning. Moreover, the relation from learning to its context is reciprocal, e.g. learning is initiated by demands resulting from change management and at the same time learning supports, enables, and demands change management. Learning aims at both, dealing with organizational change and actively creating organizational change. Organizational culture and learning also interact reciprocally and co-referentially. Learning is a constitutive element of knowledge management and gains strategic relevance (see de Viney, 2004).

Learning processes of integrated learning are conceptualized as ill-structured and situated. As teaching and instruction can not determine learning, learning processes can not be pre-planned (Scheunpflug, 2001). To illustrate integrated learning, two scenarios are presented (see: scenario 1 and 2).

Scenario 1: Communities of Practice in Product- and Process-Oriented Processes

The Chrysler Corporation in 1988 was facing increasing competition as the Japanese competition was threatening to put the Chrysler Corporation out of business. Restructuring the organization aimed at dramatically reducing the typical product-development cycle. Functional units such as design, engineering, manufacturing, and sales where radically reorganized, as there was only little interaction between the units. *"Engineers would now belong to 'car platforms'. These platforms were product-oriented, cross-functional structures that focused on a type of vehicle: large cars, small cars, minivans, trucks, and Jeeps. Each platform was responsible for all phases of development associated with the hole vehicle. (...) For example, if you were a brakes engineer, your main allegiance, your reporting relationships, and your performance evaluation were no longer with the brakes department, but with a platform, such as small cars or minivans."* (Wenger, McDermott, & Snyder, 2002, p. 2). Restructuring from process-oriented to product-oriented processes succeeded in reducing the product-development cycle and costs, but did not come without its own costs:

> "A host of new problems started to appear: multiple versions, uncoordinated relationships with suppliers, innovations that did not travel, and repeated mistakes. The company had gained the advantage of product focus, but comprised its ability to learn from its own experiences. Something had to be done to save the platform idea. With a clear need for communication across platforms, former colleagues from functional areas started to meet informally. Managers recognized the value of these informal meetings in fostering learning processes that cut across all platforms. Still, they wanted to keep the primary allegiance and formal reporting relationships of engineers within the platforms. Rather than formalizing these emerging knowledge-based groups into a new matrix structure, they decided to keep them somewhat informal but to sanction and support them. The Tech Clubs were born."(Wenger et al., 2002, p. 2)

This scenario illustrates that issues such as strategic intent, organizational structures and processes of innovative learning are intertwined. The starting point of restructuring is a critical competitive situation. Learning is integrated in organizational and innovative processes. Furthermore, innovative learning is also required for successfully implementing the strategic plan. Organizational requirements form the context for learning and vice versa. Learning is situated and contextualized.

From the point of view of learning the matrix of product- and process-oriented workflows reflects knowledge-creation within problem solving teams (car platforms) and communities of practice (Tech Clubs), cp. figure 3.2. The demand for forming these teams and communities as well as for knowledge-creation and learning within these teams and communities directly derive from actual organizational needs and work-practices. Persons, knowledge assets, and technologies form the interfaces between process- and product-oriented processes within the matrix.

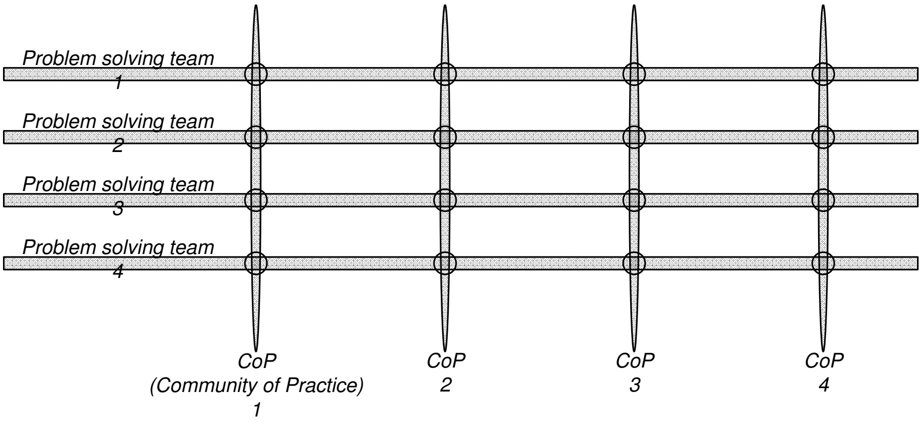

Figure 3.2: Innovative knowledge systems based on communities of practice within an organization. Product-oriented workflows are complemented by process-oriented knowledge communities (according to Wenger, McDermott, and Snyder, 2002, p. 2).

Scenario 2: Workflow Embedded Learning

Workflow embedded learning is a well-elaborated methodology, applied in infirm and trainings and vocational education leading to a certified degree. It is based on the assumption that 70 to 90 percent of knowledge is generated informally within processes of problem solving, in which learning was not explicitly intended (cp. Rohs, 2002). Work-related activities are increasingly characterized by complex and ill-structured problems. Learners gain experience by solving complex, ill-structured problems and generate know-how and expert-knowledge. Predefined units of learning do only play a minor role in workflow embedded learning.

Workplace learning is integrated in an organizational culture and in situational conditions. Regarding the workflow the learner is integrated into an operational department and is accompanied by a coach, who provides advice regarding the learning process. The workflow provides informal learning opportunities and facilitates a wide variety of experiences. The learner is responsible for achieving technical and vocational skills and competences himself. Within the organization the learner contacts his supervisor and team colleagues regarding work organization and work-plans. Beyond this, the learner contacts his coach in order to receive support with regard to learning activities such as reflecting learning process. Furthermore, there is a pool of experts, the learner may contact regarding specific technical issues.

Some programs also support learners in organizing networks and teams of fellow-learners and experts as soon as confronted with specific problems. The context (workflow and organizational structures) again does not only provide learning opportunities to the learner, but is also shaped and changed by learning processes: Often the organizational structures within a department must be reorganized to allow workflow embedded learning. Furthermore, a learner - who at the same time is an employee within the department - creates innovative solutions and may modify processes within the organization.

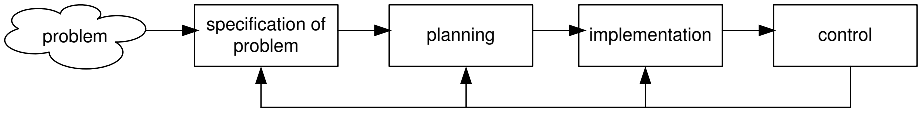

Figure 3.3: Process-model of well-structured problem solving (Richter, Allert, and Nejdl, 2003).

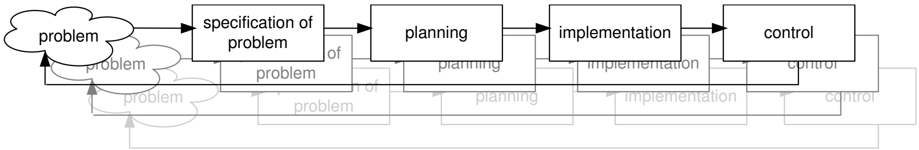

Figure 3.4: Process-model of ill-structured problem solving (Richter, Allert, and Nejdl, 2003).

The scenarios presented, illustrate that integrated learning is contextualized and situated. Solving real-world problems is central in integrated learning. Jonassen (1997) and Shin Hong (1998) have distinguished well-structured from ill-structured problem solving from an instructional point of view. In well-structured problem solving the problem is given and well-defined. For example: A robot, which allows to transport a 50 kilo artifact from A to B, is to be constructed. The students have to specify the problem, plan a solution, implement and control their solution. The solution can be assessed as right or wrong: either the robot is able to transport the artifact from A to B or it is not (figure 3.3).

Ill-structured problems are situated and embedded within a dynamically changing context. Furthermore, solving a situated problem requires the change of the context itself. Neither the problem situation nor the solution is clearly defined. Knowledge, skills, activities, and processes which allow solving the problem can not be predefined precisely. Furthermore, there are divergent solutions, which can not be assessed objectively as right or wrong, as each solution has its PROs and CONs (figure 3.4). While some approaches in cognitive science state that ill-structured problems can be transferred to well-structured problems (e.g. Zimbardo, 1995), some newer approaches stress, that solving ill-structured problems requires cognitive processes which are qualitatively different from those needed to solve well-structured problems. This qualitative difference does not allow mapping them or transferring the one to the other without ignoring crucial elements of the problem (cp. Jonassen, 1997). The intertwined relation between a program and its context is a crucial element in models of generative learning, as these models assume that:

- Learning takes place in dynamically changing environments and
- learning continuously changes its environment.

A prominent model of generative learning works as example to illustrate the bidirectional relation between a program and its context: Engeström's model of expansive learning (figure 3.5). This model represents an ideal learning cycle, but does not determine learning processes to exactly follow this cycle. With

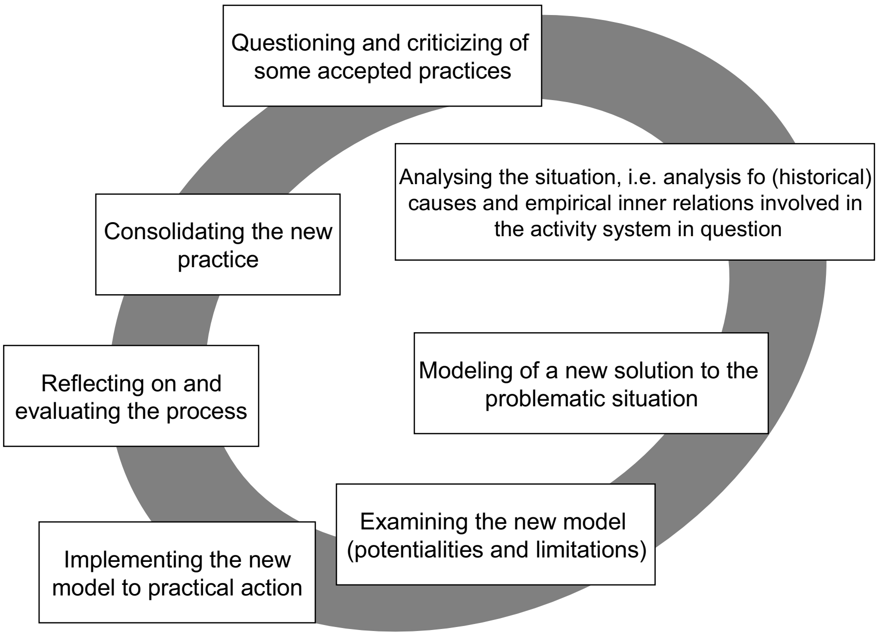

Figure 3.5: Engeström's model of Expansive Learning (Engesröm, 1999).

regard to the issue of contextualization and situatedness, phase one (*Questioning and criticizing accepted practices*), two (*Analyzing the situation, i.e. analysis of historical causes and empirical inner relations involved in the activity system in question*), five (*Implementing the new model to practical action*) and seven (*Consolidating the new practice*) are most relevant. They actually require a socio-historical context and intervene with its context.

Societies or organizations typically provide ill-structured problems and work as context. Integrative learning demands a context which allows and appreciates change initiated by learning. The concept of learning organizations refers to the interrelation of individual learning and organizational learning. Learning organizations allow change initiated by individual and cooperative learning processes. Argyris and Schön (1978) conceptualize this by the concept of double-loop and single-loop learning (figure 3.6).

- Single-loop learning only allows to co-determine the action strategy (i.e. the learning design/unit-of-study, which is designed towards a predefined learning objective). Scardamalia and Bereiter (1996) refer to learning which approximates a learning objective or the optimal solution as learning which is asymptotic. The learner is not supposed to transform the learning objective. Learning is optimized within the loop of single-loop learning.

- Double-loop learning allows questioning goals and predefined objectives, such as learning objectives and governing variables. It goes beyond work-

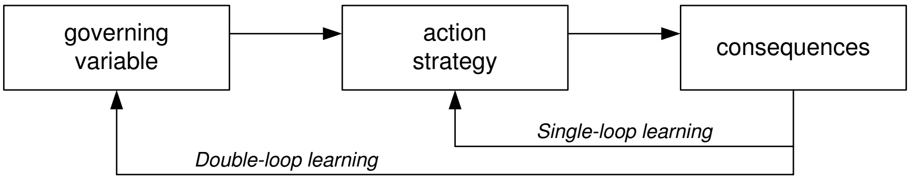

Figure 3.6: Single-loop and double-loop learning (Argyris, and Schön, 1978).

ing towards a predefined learning objective.

Double loop learning and expansive learning focus on knowledge generation, as these concepts facilitate the complex process of internalization and externalization of knowledge and allow to transform objectives. This is assumed an important prerequisite for innovation. As integrated learning is embedded in organizational processes and workflows, it is a key issue of knowledge management, organizational and strategic management. It accompanies and catalyzes processes of innovation and re-organization. On the one hand the organization specifies requirements for learning endeavors, on the other hand organizational learning makes demands and interacts with the organizational culture. Handling these as isolated processes would increase complexity and decrease viability within the organization.

In the context of technology enhanced learning Mühlhäuser (2004) refers to process-integrated learning as ambient learning, i.e. learning and teaching disappears in everyday (work-related) processes, tasks, and activities.

It is important to mention that isolated units of learning often are encapsuled in processes of integrative learning - e.g. an instructional unit is made available to the learners in order to provide background knowledge, needed to solve an ill-structured problem.

3.3 Reflecting Current Learning Technology Specifications

3.3.1 The Notion of De-Contextualization

Organizing different concepts of learning on a continuum of contextualization illustrates that context is more crucial in some concepts of learning than in others. Figure 3.7 arranges the concepts of reproductive and generative learning as well as humanistic approaches on a continuum of contextualization. The notion of *de-contextualized learning objects* and *de-contextualized units-of-learning*, which is a core assumption of many current learning technology specifications and standards, addresses concepts of reproductive learning rather than concepts of generative learning, and concepts of isolated rather than integrated learning.

The content-driven concept of learning objects and object-oriented approaches of modeling implicitly reflect the acquisition metaphor of learning and the concept of reproductive learning. Learning and instruction are seen as processes of delivering, transferring and reproducing information. The learning objective is

Reproductive Learning	**Generative Learning**	**Humanistic Approaches**
▪ Acquisition metaphor ▪ Concepts based on theory of information processing ▪ Receptive learning ▪ Transmission model ▪ Delivery of knowledge pieces ▪ Textual references to context, e.g. in Problem-Based Learning: solving well-structured problems with a clear problem description given (Shin Hong, 1998; Allert & Richter, 2002)	▪ Knowledge-creation metaphor ▪ Concepts based on theory of situated cognition ▪ Learning as meaning making ▪ Co-construction of knowledge within an socio-cultural and situational context ▪ The activity is the context. Meaning exists as activities (Stahl, 2003) ▪ Dealing with real world and ill-structured problems, e.g. in Problem-Based Learning: solving ill-structured problems (Jonassen, 1997)	▪ Focus on self-reflection, self-knowledge and personal insight ▪ Learner is part of the context ▪ Development of personality

learning as decontextualized

learning as contextualized

Figure 3.7: Concepts of learning on a continuum of contextualization.

predefined and embedded in the learning object respectively the unit-of-learning. The learner works towards a pre-defined learning objective, which he asymptotically adapts to. The learning process is pre-planned.

According to the current concept of learning objects, meaning is fully enclosed in the learning object and acquired by the learner. IEEE LOM (2002) reflects this concept by specifying attributes such as Typical Learning Time and Semantic Density within its category Educational. LOM assumes that the semantic density of an object is determined by the characteristics of the resource itself. Hence, it is enclosed in the learning object and transferred to the user, but not constructed by the user himself. Effect studies within the science of communication refer to this position as transmission model of information, which assumes a passive recipient and asks what *''media do to people''*. The transmission model assumes a homogeneous mass audience, a hypodermic view of media, and an unidirectional effect. In contrast to this the Uses and Gratification Approach assumes an active recipient and asks *"what people do with media"* (cp. Blumler & Katz, 1974). This approach reflects a shift of paradigms which has taken place in the science of communication in the 70s. As a result, the semantic density of a resource is constructed by the user according to his former experience, individual relevance, actual interests and needs (cp. Charlton & Neumann-Braun, 1992) and can hardly be assigned to the resource.

The position referred to as transmission model in the science of communication, is reflected by LOM: *"This standard will specify the syntax and semantics of Learning Object Metadata, defined as the attributes required to fully/adequately describe a Learning Object"* (IEEE LOM, 2003). It aims at an absolute and complete description of an object. Meaning is completely deducable from the object itself, which means that the entire meaning lies within the object. LOM's concept of semantics is based on epistemological and ontological assumptions comparable to those underlying the concept of reproductive learning.

The modeling approach of IMS LD (IMS Global Learning Consortium, 2003b) describes how an object is used within a unit-of-study. Therefore, the approach differs from that of LOM, as an object is not described per se, but in its relation to other structural elements within a unit-of-study. But in principle the approach of modeling is the same - only the root element is different: While LOM's root element is a learning object the root element in IMS LD is a unit-of-study. The unit-of-study again is assumed to be de-contextualized and completely described, according to requirement R1: *"Completeness: The specification must be able to fully describe the teaching-learning process in a unit of learning, including references to the digital and non-digital learning objects and services needed during the process."* (IMS Global Learning Consortium, 2003b). As a consequence a unit-of-study is a closed unit. IMS LD can't describe an open system (the notion of *open systems* refers to Willke (2000): It can not describe a program (e.g. a unit-of-study) in its relation to its context, i.e. in its relation to organizational change and organizational learning (which is not a simple *"is part of"* relation). Contextualization in processes of organizational learning and organizational change is crucial e.g. in Engeström's model of expansive learning or Bereiter's model of innovative learning. The context here is a dynamically changing context, as explained in chapter 3.2.2 (integrated learning) on solving ill-structured problems. There is a conflict between the need for contextualization in some concepts of learning (cp. generative and integrated learning) and the attempt at de-contextualization in the current discussion on learning technology specifications.

The predisposition of current learning technology specifications and standards towards reproductive and isolated learning is at least partly due to the idea of learning objects as self-contained and de-contextualized resources that convey the information that is to be acquired by the learner. This conceptualization of learning objects separates the creation and design of learning objects from its use and hence restricts the learner's role to that of a consumer. The separation of design and execution (runtime) of educational activities also characterizes modeling approaches for learning activities such as IMS Learning Design (IMS Global Learning Consortium, 2003b). The notion of pre-planned learning activities contradicts the character of innovative processes of generation, which can not be predetermined. Accordingly, current modeling approaches are of limited value in this respect. In order to utilize the potential of metadata, modeling languages, and semantic technologies to support generative learning it is not sufficient to look for innovative and appropriate modeling languages, but to answer the question, what the purpose and the raison d'être of these approaches is in the light of a more comprehensive concept of learning (cp. chapter 5 and 6).

3.3.2 Learning and Semantics: Shared Meaning Making

The *IEEE Standard for Learning Object Metadata* (IEEE LOM, 2002) claims to be *neutral* with regard to learning models and pedagogical approaches and thus addresses the valuable diversity in the field of learning. But any descriptive framework and specification inevitably reflects a specific underlying concept of semantics and knowledge. In contrast to positions which assume meaning completely enclosed within the object itself (e.g. the naturalistic position in philosophy, the transmission model in communication sciences, and the concept of reproductive learning) and positions, which assume that meaning is exclusively constructed by the individual recipient, Stahl's approach of learning as meaning making neither assigns attributes exclusively to the object nor exclusively to the user but assumes a dynamic relationship as well as situatedness and contextualization within culture. This section presents Stahl's approach of shared meaning making and states, that processes of *learning* and *semantics* are related. It is argued that semantics and meaning-making is based on communities. This concept of learning and semantics founds basic assumptions of the approach of role-based modeling, which is introduced in chapter 5.

Stahl (2003) strengthens the collaborative character of learning and semantics, and refers to learning as shared meaning making. Meaning making is not understood as a psychological process which takes place in individuals' minds but as an *"essentially social activity that is conducted jointly - collaboratively - by a community, rather than by individuals who happen to be co-located"* (Stahl, 2003, p. 523). Stahl grounds the collaborative character of meaning making in the philosophical tradition of Heidegger, Hegel, and in Vygotsky's concept of mediated cognition which shows how meaning is socially produced and situationally interpreted. His concept goes beyond the exclusive focus on the individual as thinker.

> "That is to say, the meaning-making practices do not merely take place within a 'context of joint activity', as actions might take place within the four walls of a room. Rather, the context of joint activity is those practices - the practices form the context. Similarly, the meaning is not merely transferred from mind to mind by the activities, but the meaning is constructed by and exists as those activities. Similarly, artifacts are not simply instruments for conveying independent meanings, but are themselves embodiments of meaning" (Stahl, 2003, p. 524).

Stahl proposes the concept of a dynamic relationship between shared meaning and individual interpretation. This perspective refers to knowledge as acculturated and situated and cognition as situated and mediated: meaning is created in the inter-subjective world and is only then incorporated (internalized) in a persons own sense-making repertoire. Meaning persists in physical and semantic artifacts within a socio-cultural context. People interpret this meaning from their own perspective. The relationship between embodied meaning and interpretation is dynamic. This relationship overcomes the body-mind dualism which was introduced by Descartes *"where meaning, as something purely mental, is ontologically distinguished from and epistemologically divorced from the physical world"* (cp. Stahl, 2003). Kant and Hegel worked to overcome this dualism (Stahl, 2003; Kant, 1868/1990). Hegel (1807/1967) showed how consciousness emerges through activity in the social and physical world, and Vygotsky (1930/1978) worked out the collaborative character of meaning making. Comparable to Bereiter's concept of conceptual artifacts, meaning is collaboratively produced in a socio-cultural context, embodied in a physical or semantic artifact, and situationally interpreted within a community (or social system). Meaning is both: incorporated in a conceptual artifact as well as inter-subjectively interpreted and shared (Stahl, 2003, p. 524, referring to Vygotsky, 1930/1978). This position holds that meaning is neither purely deducable from the object itself nor exclusively constructed by the audience (by consensus), but that there is a dynamic relationship. From this point of view, describing an artifact a priori (per se) is not possible. It is only possible to interpret meaning situationally.

Any position and concept of learning reflects an underlying fundamental epistemology and ontology. As semantics is concerned with meaning, the field of learning may work as an example for modeling within the Semantic Web.

Irrespective of the concept of learning chosen, learning scenarios are coherent social systems. Any concept of learning forms expectations towards roles, activities, resources, and the learning culture. This means, within a learning scenario concepts of learning, concepts of knowledge and persons' roles are related and correspond. For example: When learning is assumed to be acquisition, the teacher will understand himself as a provider of knowledge and the learner as a consumer or re-constructor - if one of them will not fill the corresponding role the system would not work well.

Chapter 4

Instructional Meta-Models

This chapter provides an overview on activity-centered and system-centered instructional meta-models and draws consequences for modeling. Chapter 4.1 states that instructional meta-models model what is in common with any specific learning design and pedagogical approach. Chapter 4.2 provides an overview over prominent activity-centered instructional meta-models. Chapter 4.3 describes the shift from activity-centered process models to system-centered descriptive frameworks. Chapter 4.4 critically reflects current learning technology specifications.

4.1 Modeling in Instructional Design

Modeling languages such as IMS Learning Design (IMS Global Learning Consortium, 2003b) and the DIN-Didaktisches Objektmodell PAS 1032-2 (Deutsches Institut für Normung e.V., 2004) aim at describing learning and teaching designs (called *units-of-study* in IMS Learning Design) and specifying how learning resources are used within a process of learning and teaching. IMS Learning Design is based on the Educational Modelling Language EML (Koper, 2001) which forms a *pedagogical meta-model*. A pedagogical meta-model specifies structural elements and relations which are in common with any specific model of learning:

> "What is a pedagogical meta-model? In our view it is a model which models pedagogical models. This means that pedagogical models could be described (or derived) in terms of the meta-model. This is of importance when you want to express semantic relationships between pedagogical entities and want to be pedagogical neutral." (Koper, 2001)

The Educational Modelling Language (EML) specifies a semantic framework for describing any unit-of-study. Koper states that there are a lot of commonalities in the instances of learning designs.

> "There are still a lot of different stances when answering questions about learning, but there are also a lot of commonalities. These

> commonalities are the focus of a meta-model, the differences are made by parameterization of the meta-model. This idea has led us to the work on the meta-model behind EML." (Koper, 2001)

Comparable to IMS Learning Design (IMS LD) the DIN-Didaktisches Objektmodell (PAS 1032-2, DIN DOM) is a descriptive framework. Both are meta-models which allow describing any existing and potentially emerging learning design and model of learning. The question whether a meta-model actually represents any existing or potential model of learning and instruction is crucial and definitely not new. Modeling pedagogical meta-models is a core and classic field in Instructional Design. The *Allgemeine Didaktik* (Peterßen, 1994; Scheunpflug, 2001; Treml, 2000) or *Systematische Pädagogik* (Beck, 1993) systematizes and reflects theory development and the conceptualization of meta-models in Instructional Design. This scientific field is particularly and deeply rooted in the German and European tradition of the educational sciences (Peterßen, 1994; Beck, 1993). Pedagogical models and Instructional Design (ID) can not be equated with learning theories and psychology, as learning theories ask how people learn from a cognitive and psychological point of view. Pedagogical meta-models are concerned with organizing, planning, analyzing, comparing and describing instruction and education (Scheunpflug, 2001). Different from IMS LD and EML, this work calls meta-models in Instructional Design *instructional meta-models*, rather than pedagogical meta-models.

As this part of the work mainly refers to German literature the German term *Didaktik*, which has a very broad scope, must be translated. There is no definite and precise translation of this word to English, as the word *didactics* has different denotation and connotation. In this work *Didaktik* is translated by *Instructional Design* (referring to Scheunpflug, 2001; Merrill, 2002) and filled with Dolch's definition of Didaktik, which is very broad:

> "Didaktik ist die Wissenschaft (und Lehre) vom Lernen und Lehren überhaupt. Sie befasst sich mit dem Lernen in allen Formen und dem Lehren aller Art auf allen Stufen ohne Besonderung auf den Lerninhalt" (Dolch, 1965, p. 45)

Didaktik is the science of learning and teaching. It is concerned with learning in all its forms and with teaching of any kind and all grades regardless of any specific content. This definition is equivalent with Merrill's definition of Instructional Design (Merrill, 2002). The term *Bildung* is not translated as there is common agreement in philosophy and education not to translate the term *Bildung*, because there is no equivalence in English (cp. Westbury, Hopmann, & Riquarts, 2000; Klafki, 2000; Lyotard, 1979). Some other terms are not translated as well (e.g. *Berliner Modell* is not translated to *Model of Berlin.*).

Instructional Design is concerned with modeling. Instructional meta-models (*Didaktische Modelle*) aim at systematic representation of learning models, pedagogical and instructional models. Models of learning and instruction define a particular approach and procedure of learning and instruction, such as problem-based learning (PBL) and case-based learning (Flechsig, 1996). Meta-models provide categories to detect and analyze requirements, to consider conditions, to make decisions, to plan, to analyze and describe learning designs and models of learning.

Describing learning designs requires to address complexity. Instructional meta-models structure the field of learning and instruction by providing structural elements and categories. On the one hand meta-models reduce complexity by reflecting instruction along specified criteria, on the other hand they enable to reflect instruction in a more complex way.

> "Von daher reduziert didaktische Theoriebildung die Komplexität der schulischen Umwelt kriteriengeleitet. (. . .) Gleichzeitig schafft jede Theoriebildung eine Binnenkomplexität durch die Relationsmöglichkeiten ihrer verwendeten Begriffe und Modelle." (Scheunpflug, 2001)

Distinguishing models from meta-models is important as instructional meta-models do not give instructions of how to teach, but assist to structure the field of learning and teaching, to plan instruction, to systematize decisions, and to analyse conditions. Instructional meta-models are meta-theories: As general (*allgemeine*) theory they abstract from specific domains and subjects.

> "Nun sind aber die bei uns als didaktische Theorien gehandelten bekannten Systeme und Modelle in der Regel über weite Strecken hinweg (wenn nicht gar gesamt) nicht theoretischer, sondern metatheoretischer Art. Sie sollen gar nicht unmittelbar auf die Praxis von Lehrern Einfluß nehmen, sondern die vom Lehrer geforderte Theoriebildung beeinflussen." (Peterßen, 1994, p. 26)

The *Lerntheoretische Didaktik* (Heimann, 1962), an instructional meta-model, has articulated the difference between a model and a meta-model itself. Heimann states that it is inadequate to teach teachers instructional models. Instead, Heimann develops the *Berliner Modell*, in order to provide teachers with a framework to structure the field of learning and teaching. Due to its complexity and situatedness, the practice of teaching and instruction is always changing. The meta-model enables teachers to plan adequate and situated learning designs, to reflect decisions, and to consider relevant conditions.

> "Besonders deutlich sagt dies Heimann für das von ihm entwickelte 'Berliner Modell' der lerntheoretischen Didaktik. Aufgrund seiner Einsicht, dass didaktische Praxis wegen ihrer Komplexität und Situationsabhängigkeit immer in Bewegung ist, kommt er zu dem Schluss, dass es grundsätzlich unangemessen ist, Lehrern didaktische Theorien zu vermitteln. Um sie zu befähigen, ihre Praxis bewältigen zu können, müssen sie vielmehr zu eigener, situationsadäquater Theoriebildung instand gesetzt werden, so dass sie, wie Heimann es ausdrückt, immer die der Praxis entsprechenden ,theoretischen Äquivalente' bilden können. Deshalb verzichtet Heimann darauf, in der Lehrerausbildung ein starres didaktisches Theorem weiterzugeben. Statt dessen entwickelt er mit dem ,Berliner Modell' eine metatheoretische Hilfe für Lehrer, nämlich eine Strukturierungshilfe

> für situationsadäquate Theoriebildung durch Lehrer. Statt ihnen vorzugeben, was sie genau zu tun haben, zeigt ihnen dieses Modell, wo sie etwas zu haben und was dabei zu beachten ist, konkret: Welche Entscheidungen von ihnen verlangt sind und wie diese voneinander und von vorgegebenen Bedingungen abhängig zu machen sind." (Peterßen, 1994, p. 26)

This intention is identical to the intention of IMS LD, which aims at pedagogical flexibility: *"The specification must be able to express the pedagogical meaning and functionality of the different data elements within the context of a unit of learning. It must be flexible in the description of all different kinds of pedagogies and not prescribe any specific pedagogical approach."* (IMS Global Learning Consortium, 2003b). Heimann's Berliner Modell and IMS LD have the same rationale. A major difference between IMS LD and meta-models in ID is its mode of representation. Whereas IMS LD is modeled in the Unified Modelling Language (UML) which stems from software engineering, the Berliner Modell and other instructional meta-models are graphical representations, which are not represented in a specific standardized modeling language.

This work outlines prominent instructional meta-models and discusses issues related with the conceptualization of meta-models and descriptive frameworks in Instructional Design (ID). The most prominent positions in ID are the *Lerntheoretische Didaktik* (Heimann (1962): *Berliner Modell*, Schulz (1980): *Hamburger Modell*) and the *Bildungstheoretische Didaktik* (Dilthey, 1924; Klafki, 1964, 1993, : *Kritisch Konstruktive Didaktik*). Less prominent meta-models such as the *Informationstheoretisch-kybernetische Didaktik* (Frank, 1967, 1969; von Cube, 1965, 1972)) and the *Kommunikative Didaktik* (Schäfer & Schaller, 1973) have significantly influenced these positions. Within the last years the design of meta-models has experienced a substantial shift (Treml, 2000). It is the shift from activity-centered cause-and-effect models to system-centered models (Treml, 2000; Scheunpflug, 2001) which provide a functional-structural view on social systems (Luhmann, 1984/1995). Within this work, the system-centered models are represented by the *Evolutionäre Didaktik* (Scheunpflug, 2001) and the *Konstruktivistische Erwachsenenbildung* (Arnold & Siebert, 1995). The *Curriculum Theory* (*Curriculare Bewegung/ Lernzielorientierter Unterricht*), which is originated in the Anglo-American and Swedish tradition, is not outlined in this work as it is (at least as absorbed in the German literature in ID (Peterßen, 1994)) a pragmatic-instrumental model, which aims at rigorous verifiability of learning objectives, rather than at specifying an instructional meta-model. It provides a strategy for constructing curricula and planning instruction by operationalizing learning objectives. Strictly operationalizing learning objectives has been criticized for being restricted in terms of the following issues: Not any learning objective can be operationalized; operationalizing learning objectives results in only specifying simple learning objectives and in focusing on predefined objectives; any deviating interest and objective learners come up with in the process is specified as disturbance and must be ignored.

The question whether an instructional meta-model is able to serve as integrative theory, i.e. able to represent any model of learning and not prescribing any specific pedagogical approach, is crucial and well known in ID. Nevertheless, instructional meta-models are never neutral with regard to some foundational issues (Peterßen, 1994). Some of these foundational issues are relevant in the context of this work and are outlined here:

The Interest of Knowledge. The Interest of Knowledge *(Erkenntnisleitendes Interesse)* the meta-model reflects. Habermas identifies three different kinds of Interests of Knowledge in research: A practical (hermeneutic), a technical (empirical research) and an emancipatory interest (critical theory) (Habermas, 1968). Blankertz provides evidence, that also any instructional meta-model reflects specific Interests of Knowledge (Blankertz, 1969).

The central category. Blankertz distinguishes several central categories instructional meta-models are built around: The category of Bildung, the category of learning, the category of information, and the categories of communication and interaction (Blankertz, 1969).

The underlying rationale and ultimate intention. Any learning design is based on an underlying rationale. A rationale implicitly or explicitly describes how a design is supposed to work. Furthermore, Klafki and Schulz state, that any pedagogical meta-model has to prescribe an ultimate intention.

Instructional meta-models inevitably reflect the socio-historical context they are embedded in, as well as overall concepts, such as the *idea of man*, which depend on society and the foundational epistemology. For example, the Enlightenment strongly influenced these concepts and envisioned the concept of an intelligent, rationally thinking and autonomous subject (*vernunftbegabtes Subjekt*), which works as an ultimate intention and overall concept for many meta-models.

Any instructional meta-model faces further issues, which often were a matter of dispute. The most prominent issues are (Peterßen, 1994):

- The position of the learning objective;
- The primacy of one of the structural elements (any primacy and priority has to be explicitly legitimated).

As this chapter refers to German literature (mainly to (Peterßen, 1994; Blankertz, 1969; Treml, 2000; Scheunpflug, 2001)), chapter 4.2 and 4.3 outline the most prominent activity-centered and system-centered meta-models in some detail. Based on the issues listed above, chapter 4.4 reflects current learning technology specifications and their underlying assumptions, focusing on the notion of *pedagogical neutrality*, i.e. the notion that a pedagogical meta-model *"(...) must be flexible in the description of all different kinds of pedagogies and not prescribe any specific pedagogical approaches"* (IMS Global Learning Consortium, 2003b). The chapter critically reflects, whether IMS LD actually is a pedagogical meta-model and states, that IMS LD is a model which describes planned activities, regardless whether they are pedagogically meaningful and reasonable and or not. Its central category is *learning as adaptation* (in the context of qualification), rather than Bildung.

Based on this discussion this work states that standardization activities defining such specifications should take into account the long tradition of ID in order to learn from existing meta-models and the related discussions. The Essener-Lern-Modell ELM (Pawlowski, 2001), a learning technology specification, is based on a prominent instructional meta-model: the Berliner Modell. But the *Berliner Modell*, which was developed in the 1960th, has been enhanced and significantly changed since, due to some severe criticism.

Before starting the outline, an overview on instructional meta-models is given in table 4.1. Blankertz categorizes different positions and presents a terminology (Blankertz, 1969). The table is based on Blankertz's terminology and adds positions, which are developed after the 1960's, and IMS LD.

4.2 Activity-Centered Models

This chapter presents activity-centered instructional meta-models and identifies significant differences between them.

4.2.1 Bildungstheoretische Didaktik

The Bildungstheoretische Didaktik and its central categories are rooted in the Age of Enlightenment (Klafki, 1993) and refer to Humboldt's concept of *Bildung* (Humboldt, 1956).

The Central Category of Bildung. The category of Bildung and the concept of *the Subject* are central in the Bildungstheoretische Didaktik. The Subject is an intelligent, responsible, critically reflecting, mature, and autonomous person, responsible within society and culture (*Subjekt-Begriff: ein vernunftbegabtes Subjekt, eine über sich selbst verfügende Person, ein verantwortlich handelndes Individuum ist Idealbild des gebildeten Menschen*). In defining the concept of *the Subject*, the Bildungstheoretische Didaktik prescribes an ultimate intention of education and instruction. The concept of the Subject and the category of Bildung work as theoretical foundation of any learning design.

The Thesis of the Primacy-of-Content. In the beginning of the 20th century, the Bildungstheoretische Didaktik concentrated on issues such as selecting, organizing, and concentrating the *Object-of-Bildung* (*Bildungsinhalte*) along pedagogical principles. The Object-of-Bildung is not just a subset of domain specific content, but is specified in a complex and well-defined process along pedagogical criteria (Dilthey, 1924). The Object-of-Bildung comprises aspects regarding intention, content, anthropological-individual and socio-cultural requirements. The Bildungstheoretische Didaktik states the thesis of the *Primacy-of-Content (Primat der Inhalte)*, which means that the task of selecting and developing adequate methods of instruction is subsumed the task of selecting and organizing the Object-of-Bildung (Dilthey, 1924). Modeling the Primacy-of-Content using the notation of UML is shown in figure 4.1.

Over the last two centuries, the meaning of the concept of Bildung has been diluted and reconstructed several times. Klafki reconstructs the concept of Bildung in the 1960's and again in the 1990's (Klafki, 1993). He states that

Bildungs-theoretische Didaktik	**Lerntheoretische Didaktik ‚Berliner Modell'**	**Informations-theoretisch-kybernetisch Didaktik**	**Kritisch-kommunikative Didaktik**	**Kritisch-konstruktive Didaktik**	**Lern-theoretische Didaktik ‚Hamburger Modell'**	**IMS LD**	**Evolutionäre Didaktik**
concept of Bildung	concept of learning	concept of Information	concept of communication and interaction	concept of Bildung	concept of engagement	concept of learning as adaptation	system/ environment difference as epistemological category
Hermeneutics	Positivism	Critical Rationalism	Critical Theory	Integrative theory	Integrative theory	--	Evolutionary Theory, Theory of Social Systems
practical interest (to understand it)	technical interest (to control it)	technical interest (to control it)	emancipatory interest	practical, technical, and emancipatory interest	practical, technical, and emancipatory interest	technical interest	--
Hermeneutics	Empiric-analytical methods	Empiric-analytical methods	Critical research	Integrative theory	Integrative theory	--	--
primacy of content	Interdependency	Control cycle	---	primacy of intention	interdependency	primacy of learning objectives	system-centred model

Table 4.1: Instructional meta-models since 1960; according to Blankertz (1969) and continued.

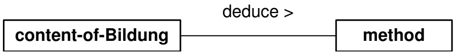

Figure 4.1: Modeling the thesis of the Primacy-of-Content in UML.

material and *formal* aspects of Bildung are not to be treated as isolated forms. Material concepts concentrate on the object-side of Bildung: the learner learns the content he is confronted with. This results in substantial and extensive volumes of knowledge. Formal concepts instead concentrate on the subject-side of Bildung: the learner acquires strategies. This results in skills and competences, which enable the learner to make knowledge accessible himself. Klafki (1963) claims that Bildung always has to be material *and* formal, and refers to it as categorial (*kategoriale Bildung*). The categorial concept of Bildung comprises formal and material aspects alike.

> “Den Bildungsvorgang umschreibt er mit der Formel der ‚doppelseitigen Erschließung’ die zu dem Ergebnis führt, ‚dass sich dem Menschen seine Wirklichkeit kategorial erschlossen hat und dass eben damit er selbst ... für diese Wirklichkeit erschlossen worden ist.’ (KLAFKI 1963, S. 298). Dabei stellt die erschlossene Wirklichkeit den materialen und der erschlossene Mensch den formalen Aspekt des einheitlichen Bildungsergebnisses dar.” (Peterßen, 1994, p. 90)

Klafki notes that only certain objects have the capacity of being *categorial*, comprising formal and material aspects of Bildung. With regard to Bildung as categorial, Klafki forms the principle of *Elementaria*: The particular object must comprise a general principle (im *Besonderen* ein *Allgemeines* enthalten). When learning a particular concept, the learner acquires a category which enables him to identify similarly structured concepts on his own. The principle of Elementaria comprises the *material aspect* as well as the *formal aspect* of Bildung.

> “Ein ‘Elementares’ ist ein Inhalt, der im Besonderen ein Allgemeines enthält.” (Klafki, 1963, p. 321)

A particular object represents the general principle beyond. The relation *particular-general* implements the principle of Elementaria. Concentrating on a particular object which represents a general principle enables learners to identify the general principle and its structural elements in *any* object that represents the general. Klafki defines a set of categories representing the principle of Elementaria (table 4.2).

The principle of *Elementaria* and the *categorial* form of Bildung work as underlying rationale of the Bildungstheoretische Didaktik. They represent the guiding principle of instruction and are supposed to ensure that a learning design is reasonable and meaningful. Being based on hermeneutical research, the Bildungstheoretische Didaktik reflects the practical Interest of Knowledge.

Form of Elementaria	Fundamental (*Fundamentales*)	Exemplarity (*Exemplarisches*)	Typical (*Typisches*)	Purpose (*Einfache Zweckform*)	Aesthetic (*Einfache ästhetische Form*)
Principle	Only existent as experience	The general is learned in concentrating on the particular	The general is learned in concentrating on the particular	The general is the particular	The general is the particular
Example	Learning about oneself in a critical situation	A falling stone represents the principle of gravity	A typical building represents the Gothic	Reading in order to practice reading	The picture represents the golden section

Table 4.2: Forms of Elementaria according to Klafki (1963).

4.2.2 Lerntheoretische Didaktik - Berliner Modell

The term *Lerntheoretische Didaktik* comprises many approaches. The most prominent representatives are the *Berliner Modell* (Heimann, 1962) and the *Hamburger Modell* (Schulz, 1980). Heimann (1962) aimed at specifying a formal meta-model which enables teachers generating innovative instructional models instead of only applying existing ones. The meta-model assists in systematic analysis and enables teachers to make and reflect decisions (*Entscheidungsmodell*).

The meta-model supports teachers to identify which elements are static and which ones are open to parameterization and design. It does not determine but structure decisions and assists in systematic analysis by representing structural elements which constitute processes of teaching and learning (*didaktische Vorgänge*).

The Central Category of Learning. Central category of the Berliner Modell is the *category of learning.* Heimann distinguishes the category of learning from the category of Bildung. In contrast to the category of Bildung the category of learning is assumed to be neutral, broad, and comprehensive. Being neutral, it ensures autonomy regarding decisions (Heimann, 1962). Heimann replaces the term Bildung by the term *processes of teaching and learning* (L*ehr- und Lernvorgänge*) to contrast the Lerntheoretische Didaktik from the Bildungstheoretische Didaktik. According to Heimann the concept of Bildung is ideologically overloaded and conveys normative assumptions. The category of learning and the Lerntheoretische Didaktik are neutral - they do not constitute norms, do not prescribe an ultimate intention, and do not determine an underlying rationale. They neither restrict behavior, nor determine decisions (e.g. regarding intention and content). Instead, the Berliner Modell facilitates teachers by only making explicit the range of possible decisions (Peterßen, 1994).

The Thesis of Interdependency. As any particular learning design is unique and not reproducible, the meta-model of the Lerntheoretische Didaktik represents an assumed general phenomenon. Any particular setting of learning and teaching is an instance of this phenomenon. The structural elements in this meta-model are formally static, but situationally variable (Peterßen, 1994). Six structural elements constitute instruction: four *fields of decision* and two *fields of constituting conditions* (Heimann, 1962). Fields of decision are: *intention*, *content*, *method*, *media*. Heimann provides some attributes to characterize the fields of decision (table 4.3). The fields of conditions aim to reflect the historical and situational context: the *anthropological-psychological conditions*, and the *socio-cultural conditions* (figure 4.2). Decisions can not be made arbitrarily, but according to the conditions given. The model provides orientation without providing a rigid schema. Categories and structural elements facilitate analyzes and decision making.

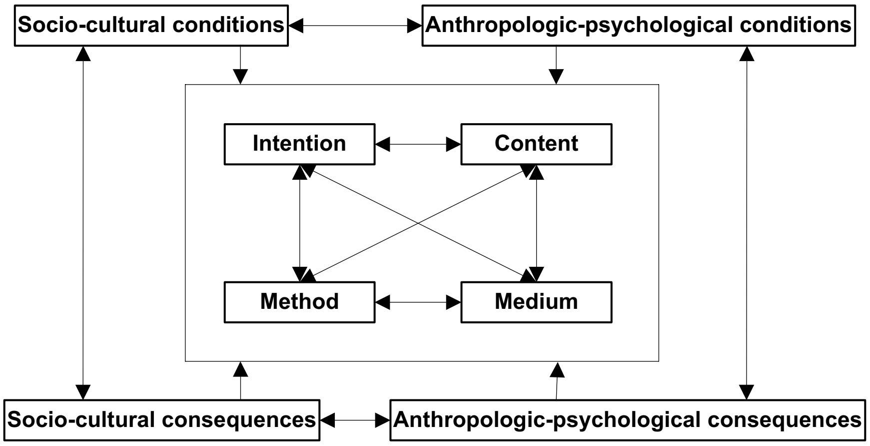

Figure 4.2: Berliner Modell - structural elements and relations (Strukturmodell des Lehrens und Lernens, Heimann, 1962).

In contrast to the thesis of the *Primacy-of-Content* in the Bildungstheoretische Didaktik (and the *Primacy-of-Intention* in Curriculum-theory and the Kritisch-konstruktive Didaktik, as shown in the following), the Berliner Modell states the thesis of *Interdependency.* Decisions are interdependent. None of the decisions determines another; none decision can be deduced from another.

> "Die methodisch notwendigen Unterrichtsentscheidungen hängen zwar voneinander ab, lassen sich aber keinenfalls auseinander deduzieren." (Peterßen, 1994, p. 128)

Heimann states, that only interdependency of all aspects of teaching and learning, results in a meta-model which is neutral. Structural elements are not isolated parts but are intertwined elements which constitute a coherent whole. They modify, foster or repress each other, but non of them has primacy per definition. Any decision depends on the context (the anthropologic-psychological and the socio-cultural conditions) and has effects (the anthropologic-psychological

Intention	Content	Method	Media
cognitive-active (knowledge)	science	articulation (the sequence of activities in a learning process)	Speech, book, picture, formula, diagram, audiotape, video, screen, natural object, model, gadget, machine.
affective-sensing (experience, attitude)	techniques	organization of groups and rooms	Ranging from *experiences* to *verbal symbols* (Dale, 1950).
pragmatic-dynamic (competences)	pragmata	pedagogical approaches and learning models	Heimann separates media from method, because of the entelechy of media.

Table 4.3: Attributes specifying the structural elements in the Berliner Modell - a brief overview (Heimann, 1962, pp. 417).

and the socio-cultural consequences). Any consequence of a unit-of-learning becomes a condition for a next unit-of-learning. Main achievement of the Berliner Modell is to describe the entire process of learning and teaching and to take into account conditions and consequences.

The Technological Character of the Meta-Model. The Berliner Modell structures instructional processes and allows to compare learning designs. Its technological character makes it a perfect basis for creating a learning technology specification (e.g. the Essener-Lern-Modell, ELM is based on the Berliner Modell (Pawlowski, 2001). The following aspects characterize the Berliner Modell:

- The category of learning is assumed to be neutral;
- the technological character of the model (Peterßen, 1994);
- the focus on the technical Interest of Knowledge and its positivistic position regarding the theory of science;
- referring to the context in the means of pre- and post-conditions (conditions and consequences);
- separating the analyzes from the constitution of norms and values (i.e. no ultimate intention is defined and prescribed).

The Lerntheoretische Didaktik broadens the scope of instructional meta-models from specifying the Object-of-Bildung to describing the entire process of learning and teaching. Concentrating on issues of content was criticized as unidirectional. The concept of Bildung was evaluated as not being neutral as it prescribes an ultimate intention (the categories of Bildung and the Subject) and defines an underlying rationale (the principle of Elementaria). Instead, the Berliner Modell separates analyzing norms from defining norms and intentions. Analyzing norms is assigned to theory, defining norms is assigned to practice, and critically reflecting norms is assigned to teachers.

The model's technological character is an asset and drawback in one. Some criticism can be found at (Peterßen, 1994): The assumed interdependency of structural elements aims at coherency. But a coherent structure and efficient teaching do not necessarily result in effective learning and reasonable teaching. There is no underlying rationale and ultimate intention, which ensures meaningful learning and responsible teaching. The clear and well-defined structure of the meta-model leads to the assumption that processes of teaching and learning are well-structured and planning is well-regulated. It raises expectations that well-structured and well-planned activities are effective and pedagogically reasonable activities.

> "Stimmigkeit didaktischer Entscheidungen mag Reibungslosigkeit des Lehrens und Lernens begründen, möglicherweise auch hohe Effizienz, aber pädagogisch wirksame Vorgänge sind dadurch allein noch nicht zu gewährleisten. Lerntheoretische Didaktik deckt also offenbar nicht alle Ebenen didaktischen Denkens und Handelns ab." (Peterßen, 1994, p. 131)

The Lerntheoretische Didaktik does not address all layers of reflection relevant in instructional design. It concentrates on a purely technological perspective. Blankertz criticizes the unilateral focus on positivism and the model's technological character.

> "Entweder wird der Unterricht rein technologisch aufgefasst und beliebigen außerpädagogischen Zwecken für die Durchsetzung ihrer Intentionen bereitgestellt, oder aber sie diktiert im Namen der Wertfreiheit dogmatisch die eigenen Werte der wie auch immer positivistisch amputierten technologischen Rationalität." (Blankertz, 1969, p. 110)

As the category of learning is neutral, the Lerntheoretische Didaktik is open to any assumption on learning, both reasonable and unreasonable. Separating analyzes and definition of norms does not mean that there are no norms. The model allows to structure decisions, but not to reflect them. According to Blankertz, decisions are never free from assumptions, norms and ideologies. Any assumption on learning is scientifically founded, politically determined, or based on personal believes.

Contrasting the Bildungstheoretische Didaktik and the Berliner Modell. The Bildungstheoretische Didaktik and the Berliner Modell already reflect the entire range of meta-models and represent the most important issues of debate in ID. Whereas the Bildungstheoretische Didaktik determines decisions prescribing an ultimate intention (the category of Bildung) and an underlying rationale (the principle of Elementaria), the Berliner Modell only structures decisions and provides support in decision making (Nipkow, 1968). Whereas the

Bildungstheoretische Didaktik proposes the Primacy-of-Content, the Berliner Modell defines interdependency of all structural elements. Whereas the concept of Bildung works as central category, theoretical foundation, and *axiom*, which legitimates and substantiates any decision regarding instruction, the Berliner Modell aims at neutrally describing structures and relations (Peterßen, 1994). Whereas the concept of Bildung refers to Humboldt and is deeply founded in the Enlightenment (Klafki, 1993), the concept of learning is assumed to be neutral and open to any intention (Heimann, 1962).

Since the 1970's, the debate on instructional meta-models has focused on the question of legitimating an ultimate intention and underlying rationale. Meanwhile, there is common agreement, that processes of teaching and learning can not be handled in a purely technological manner. There always is an underlying rationale and theoretical foundation, which can not be formalized (e.g. the principle of Elementaria and the categorial form of Bildung, which are meant to ensure reasonable instruction). These work as axioms and guide decisions on a higher level of abstraction (Peterßen, 1994). The Berliner Modell is criticized regarding this aspect, as decisions on higher levels of abstraction are neglected. The Bildungstheoretische Didaktik (and the Hamburger Modell, cp. chapter 4.2.5) argues that an ultimate intention which includes an aspect of critical reflection allows to critically reflect objectives, in order to prevent education from being disposable to any objective and intention (e.g. ideological and political). At any stage of instruction, teachers and learners must be enabled to critically reflect and transform objectives and not only to work towards a predefined objective. Since the 1970's there is agreement, that any instructional meta-model must include an aspect of critical reflection, such as the category of Bildung. Neglecting decisions on higher layers of abstraction and ignoring the need for an underlying rationale and ultimate intention which comprises an aspect of reflection means that pedagogical activities can not be separated from just any activity. Any of the following instructional meta-models ranges between these positions, proposed by the Bildungstheoretische Didaktik and the Berliner Modell.

4.2.3 Informationstheoretisch-Kybernetische Didaktik

Core concepts of the Informationstheoretisch-kybernetische Didaktik are not derived from the domain of instruction and education but from from cybernetics and information-theory.

The Central Category of Information. The central category of the Informationstheoretisch-Kybernetische Didaktik is the category of information. Processes of learning and teaching are modeled as information processes. Learning is seen as reducing information and generating redundancy. As soon as the environment no longer provides information to the learner, he learned everything. Teaching is seen as transferring information. A unit of information is called a *bit*. One bit of information represents a bit of information for one but not for the other recipient, depending on his prior knowledge. This concept of information, which is based on Shannon's theory of information and the mathematical theory of communication (Shannon & Weaver, 1949b) does not take into account the *meaning* and *relevance* of information for an individual learner.

Algorithms define the sequence of information to be learned (Frank, 1996). The theory is concerned with optimizing information strategies. The approach aims at presenting information, developing methods which generate redundancy, optimizing teaching strategies, controlling learning processes, and minimizing time and expense. Efficiency is based on the assumption that processes of learning and teaching are controllable. The guiding principle is to reach learning objectives within shortest time, lowest expense and with least side-effects. Von Cube defines Instructional Design as optimizing teaching strategies for reaching predefined learning objectives: *"Unter Didaktik verstehen wir die Aufstellung von Optimalstrategien zur Erreichung vorgegebener Erziehungsziele"* (von Cube, 1972, p. 117). Von Cube proposes a control cycle which is based on cybernetics (Shannon & Weaver, 1949a), cp. figure 4.3.

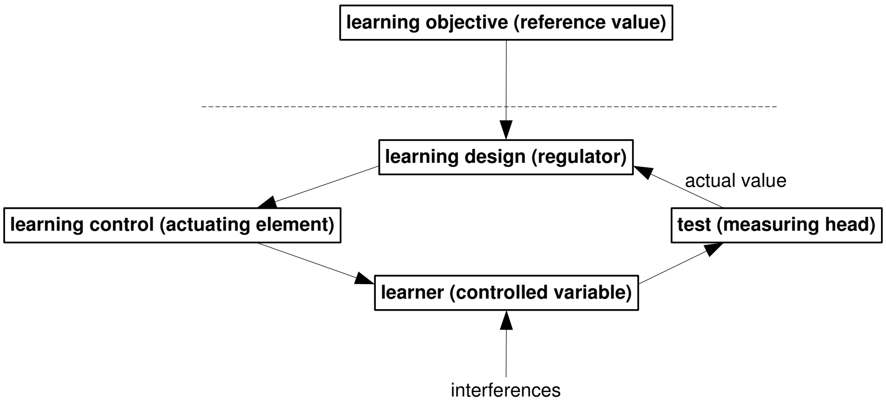

Figure 4.3: The process of learning and teaching referred to as a control cycle (von Cube, 1972).

Defining the learning objective is strictly separated from *working towards* the objective. The control cycle defines learning as adapting to a predefined learning objective. The learning objective is referred to as reference value outside the control cycle. Instructional Design generates effective instruments and teaching strategies. ID is not concerned with *defining* learning objectives as learning objectives are assumed as predefined political or personal values. A teacher has to critically reflect objectives, but in doing so he changes the role from teacher to politician or normative pedagogue. This position states that learning objectives result from interests and subjective values, they are neither false or true, but legitimated and founded. They can neither be scientifically deduced nor founded, but scientifically analyzed regarding implication, consistency, semantic clearness, empirical revisablity, and historical and social origin. This argument reflects the position within the philosophy of science the Informationstheoretisch-kybernetische Didaktik refers to. It explicitly refers to the *critical rationalism.* As a consequence of its logic-empirical concept of science, defining learning objectives is separated from ID (von Cube, 1980).

A Technological Perspective on Instruction. Ignoring the *meaning* of information made the approach useless for teaching in practice. It only gained attention in academia (Sesink, 2002) and was applied in programmed instruction. According to Peterßen (1994), this position has not been advanced since the 60th. Blankertz (1969) criticizes that defining learning objectives is excluded from ID. ID only defines a strategy to adapt to a predefined learning objective. Furthermore, Blankertz criticizes that ID is reduced to mathematically expressible facts and statements taken from behaviorism.

According to Peterßen (1994) this meta-model reflects a purely technological perspective on instruction. He criticizes the underlying assumption according to which processes of learning and instruction are calculable. He points out that learning processes are ill-structured and a-stable. Therefore, Shannon's concepts of information and cybernetics do not well describe processes of learning and teaching. The meta-model is deduced from theoretical postulates and categories, not from the practice of teaching. It refers to the critical rationalism, a position within the philosophy of science. According to Peterßen (1994), this position is reduced to technological strategies of instruction, e.g. in programmed instruction. Its design is guided by the technical interest. According to Habermas (1968), the technical Interest of Knowledge focuses on predicting and controlling the natural and the social environment.

4.2.4 Kritisch-Konstruktive Didaktik

In the 1970th and the 1980th the most prominent positions, the Bildungstheoretische Didaktik and the Lerntheoretische Didaktik, propose integrative meta-models[1]. Each position specifies a revised meta-model. The *Kritisch-konstruktive Didaktik* (Klafki, 1993) renews the Bildungstheoretische Didaktik, the *Hamburger Modell* advances the Berliner Modell.

The Central Category of Bildung. Klafki (1993) re-constructs the concept of Bildung referring to Kant (1784) and Humboldt (1956). According to Klafki, Bildung nowadays means a persons ability of *self-determination, co-determination and solidarity*: *"Bildung als Befähigung zu vernünftiger Selbstbestimmung, Mitbestimmung und Solidarität"* (Klafki, 1993). This concept of Bildung is the central category in the Kritisch-konstruktive Didaktik and works as the ultimate intention of learning and instruction. Klafki broadens the scope of the Bildungstheoretische Didaktik from specifying the Object-of-Bildung to describing the entire process of learning, teaching, and interaction[2].

> "Der Zusammenhang von Lehren und Lernen wird als Interaktionsprozess verstanden, in dem Lernende sich mit Unterstützung von

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[1] *Integrative* means, integrating all major positions within the philosophy of science: Hermeneutics, empiric-analytical research, and the critical theory (Peterßen, 1994). Before being integrative, most meta-models referred to only one position: The Bildungstheoretische Didaktik to hermeneutics, Lerntheoretische Didaktik (Berliner Modell) to the empiric-analytical position, the Kommunikative Didaktik (Schäfer & Schaller, 1973) to critical theory. An integrative meta-model is not neutral with regard to the philosophy of science and the Interests of Knowledge (Habermas, 1968), but integrates all positions and Interests of Knowledge (practical, technical, and emancipatory).

[2] Referring to the Kommunikative Didaktik (Schäfer & Schaller, 1973).

> Lehrenden zunehmend selbständiger Erkenntnisse und Erkenntnisformen, Urteils-, Wertungs- und Handlungsmöglichkeiten zur reflexiven und aktiven Auseinandersetzung mit ihrer historisch-gesellschaftlichen Wirklichkeit aneignen sollen." (Klafki, 1993, p. 32)

The Thesis of the Primacy-of-Intention. Klafki replaces the notion of primacy-of-content with the notion of primacy-of-intention: *"Primat der Intentionalität gegenüber allen anderen Dimensionen im didaktischen Feld"* (Klafki, 1978, p. 71). Ultimate intention of instruction is a person's competence of self-determination, co-determination and solidarity. These competences are developed by concentrating on typical key problems and issues the society is confronted with (*Epochaltypische Schlüsselprobleme*). These are agreed on within a society by consensus. Education is strongly embedded within its historic-cultural context and environment. Learning means to critically reflect objectives, to co-determine the societal context, and to recommend change. Klafki refers to this as *critical-constructive.* Learning does not only *use* an environment, but to responsibly *co-determine* and *change* the environment.

Klafki proposes guiding instructional principles: The principle of Exemplarity and a learner-centered approach. These methods result from the concept of Bildung. Bildung does not result from teaching, but from the learner's active and reflective action: "Bildung bezeichnet einen selbstintentionalen Vorgang" (Klafki, 1993).

The concept of Bildung guides the design of instruction and works as theoretical foundation as instruction goes beyond sequencing learning activities and learning objects. The principle of Exemplarity works as underlying rationale of meaningful and well-founded teaching.

4.2.5 Lerntheoretische Didaktik - Hamburger Modell

Based on Heimann's Berliner Modell Schulz (1980) develops the *Hamburger Modell*, cp. figure 4.4. He critically reflects the technological character of the Berliner Modell and integrates the concept of *Engagement.*

The Central Category of Engagement. Schulz refers to this revised form of the Lerntheoretische Didaktik as theory of emancipatory-relevant and professional instructional design. Emancipation in this context refers to a person's ability to dispose of oneself (*die Verfügung der Menschen über sich selbst*). The notion of Engagement represents an integral element of reflection, but differs from the concept of Bildung as Schulz states that teaching and learning are not responsible for changing the societal context itself. The notion of Engagement represents an integral element of critical reflection, which encourages learners to not only uncritically internalize and reproduce existing knowledge and objectives, but to reflect, inquire, and search for alternatives. The Hamburger Modell is not normative, which means, it does not provide specific socio-political objectives the learner works towards. In fact, the concept of Engagement works as ultimate intention which guides decisions on higher layers of abstraction. Schulz criticizes the Berliner Modell, as it ignores decisions on higher layers of abstraction. He provides categories which operationalize the ultimate intention: Competence (knowledge, skills, attitudes), self-regulation, and solidarity. A matrix helps to identify whether an object (referred to as *cognitive experience, affective experience, and social experience*) is effective with regard to these intentions and thus emancipatory-relevant (Schulz 1980a).

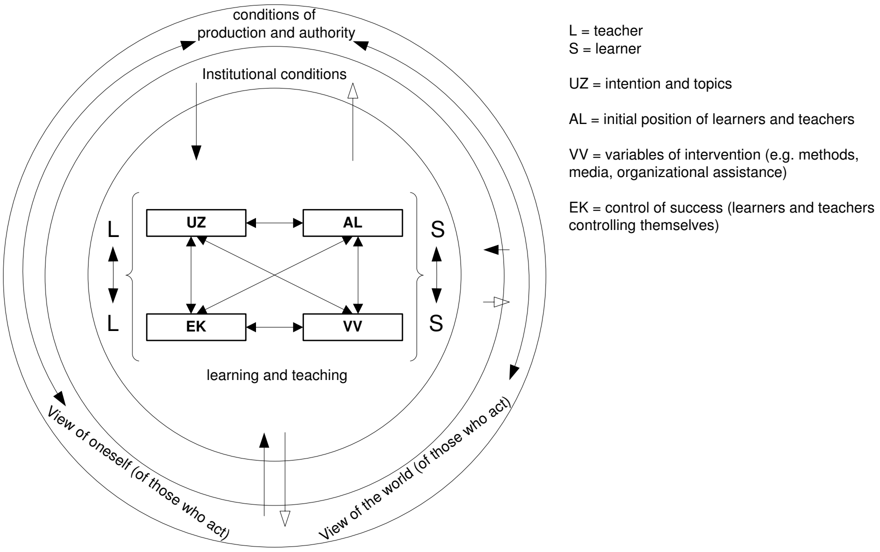

Figure 4.4: The Hamburger Modell - relevant aspects in the design of learning and teaching activities (Schulz, 1980a, p. 83).

A Learner-Centered Approach. Whereas the Berliner Modell addresses teachers only, the Hamburger Modell addresses teachers and learners alike, as Schulz respects learners to be experts referring processes of learning and instruction. The meta-model enables teachers as well as learners to plan instruction at different levels of granularity: Planning a longer period of time and scope (a year, a domain), planning a teaching unit, planning a process, and adjusting a plan during a process. Learners and teachers are related through an activity.

Whereas the Berliner Modell describes the technological feasibility of instruction, the Hamburger Modell aims to ensure responsible and professional instruction. The Hamburger Modell critically reflects the purly technological character of the Berliner Modell. Therefore, reflective action and the concept of Engagement are structural elements in the Hamburger Modell.

4.3 System-Centered Models

This chapter describes the shift from activity-centered process models to system-centered descriptive frameworks.

4.3.1 From Deterministic to Non-Deterministic Theories

Meta-models in Instructional Design are descriptive frameworks. They provide structural elements and categories which allow to describe, plan, and analyze learning designs and learning processes. But problems indicate that teaching and learning are not completely determinable, planable, and prescribable. Scheunpflug (2001) states that processes of teaching and learning are not sufficiently determined by planning, but do not succeed without planning. Both, teaching *and* learning constitute the learning process. Teaching and learning generate the learning process in terms of a dynamic interdependency rather than linear causality (Arnold & Siebert, 1995, p. 92). Processes of teaching and learning are structurally complex - they are related but separated. Learning processes are neither determined by instruction nor by intentions and objectives. Therefore, models of learning can not be deduced from models of teaching and instruction. The unity of learning and teaching is only a notionally assumed. This assumption worked as long as societies were relatively stable and characterized by homogeneity (Scheunpflug, 2001). Instruction assumes uniform schemes of life and harmonized socialization among all participants. But, social change, multiple perspectives, increasing complexity and diversity allow for and generate diverse concepts of living and learning.

> "In dem Moment, in dem sich die Lebenslagen von Schülern und Lehrkräften durch den sozialen Wandel deutlich verändern, bricht die - zumindest theoretisch unterstellte - Einheit von Lehren und Lernen spürbar auseinander. (...) Die uneinheitlichen Lern- und Lebensvoraussetzungen der Schülerinnen und Schüler sowie die unterschiedlichen gesellschaftlichen Anforderungen an Bildung sorgen dafür, dass die Trennung zwischen Lehr- und Lernprozessen immer schärfer zu Tage tritt. Mit der damit verbundenen Komplexitätssteigerung zerbrechen die Deutungsmuster, die über eine lange Zeit Unterricht vermeintlich versteh- und beherrschbar machten." (Scheunpflug, 2001, p. 11)

Activity-centered models are based on the assumption that teaching and instruction results in learning. These models have little power in explaining why a learning design was not successful. Complex structures and diverse interacting variables work as source of irritation and disturbing factors. According to Scheunpflug (2001), current instructional meta-models are not able to adequately address the increasing complexity caused by societal change and diverging processes of learning and teaching. These models do not address the flexibility and autonomy persons have, but reduce the options learners have.

> "Luhmann und Schorr sprechen deshalb davon, dass Schülerinnen und Schüler durch didaktische Theoriebildung unvermeidlich trivialisiert bzw. als ‚Trivialmaschinen' behandelt werden. Da die Lehrkraft handeln muss, unterstellt sie Reaktionen des Schülers, und trivialisiert ihn damit in Vergleich zu den Möglichkeiten, die durch individuelle Freiheit geprägt sind. Jede Didaktik wird damit auf technologische Zusammenhänge reduziert, ohne dass sie sich dessen bewusst ist (vgl. Luhmann/Schorr 1982)." (Scheunpflug, 2001, p. 14)

Activity-centered models describe processes. They relate elements such as subject, object, resources, methods and intentions (Scheunpflug, 2001). They relate cause and effect. Activities are defined as goal-oriented (Aebli, 1993) and contrasted from behavior. Instructional meta-models, which are activity-centered, have to define an ultimate pedagogical intention in order to legitimate learning objectives. Ultimate intentions contain normative aspects such as the central category of *Bildung*, *emancipation*, *empathy*, *engagement*, and *self-determination*, *co-determination*, and *solidarity*. Definition and theoretical foundation of ultimate intentions is always embedded in a socio-cultural context, implies values and conflicting interests, and often causes theoretical problems in substantiating and legitimating these normative aspects (Treml, 2000). The structure of activity-centered models is teleological, as it demands to predefine an objective[3].

According to (Luhmann & Schorr, 1979), correlating cause and effect is inadequate in planning instruction, as teaching and learning are situated. Open processes, which are not prescribable and determinable, require teleonomical rather than teleological structures. System-centered meta-models are based on the Theory of Social Systems (Luhmann, 1984/1995) and other derivations of systems theory. Luhmann's theory provides a functional-structure-centered view on social systems. Systems reduce contextual complexity in defining the difference system-environment as epistemological category. The difference is produced by the system itself and constitutes the system. The *Konstruktivitische Erwachsenenbildung* (Arnold & Siebert, 1995) refers to the Theory of Social Systems as descriptive framework. The *Evolutionäre Didaktik* (Scheunpflug, 2001) focuses on describing teleonomical structures in instruction.

4.3.2 Evolutionäre Didaktik

Describing indirect causal relations such as the only loose correlation between teaching and learning requires a paradigmatic shift from deterministic to non-deterministic theories. These theories do not necessarily come from pedagogy or the humanities. Specifying the Evolutionäre Didaktik, a descriptive framework and instructional meta-model, Scheunpflug (2001) refers to the Theory of Social Systems (Luhmann, 1984/1995), a general theory of social systems, and the Evolutionary Theory as epistemological foundation. According to Scheunpflug, the Evolutionary Theory is a universal theory, applied in multiple disciplines such as economical sciences and natural sciences. It has been misused for ideological ideas such as Social-Darwinism, Herbert Spencer's notion of *survival of the fittest*, and racism. Therefore, it is often avoided instead of studied precisely. The misunderstanding is based on the assumption that selection is intentionally controllable. Instead, the Evolutionary Theory assumes teleonomical structures. As it goes beyond the scope of this work to present basic concepts (time, meaning, communication, etc.) and an outline of the Evolutionary Theory and the Theory of Social Systems, it refers to the work of Scheunpflug (2001), Treml (2000), Willke (2000), Luhmann (1984/1995), and Krieger (1998).

The Evolutionäre Didaktik is based on assumptions such as:

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[3] Further analysis of activity-oriented models is given at (Scheunpflug, 2001).

- Teaching and instruction do not determine learning.
- Processes of learning are teleonomical, not prescribable, and not strictly planable.
- Society is characterized by contingency, continuous change, multiple perspectives, conflicting interests, inconsistency, different schemes of life, and an indetermined future.

Based on the Evolutionary Theory, the Evolutionäre Didaktik models learning as process of change and describes it by mechanisms of variation, selection and stabilization. Referring to the Theory of Social Systems, the Evolutionäre Didaktik provides a system-centered instead of an activity-centered model.

The Theory of Social Systems is a descriptive framework, based on the epistemological category of difference. The theory's guiding difference is the distinction between system and environment. "There are systems" is an ontological claim (Luhmann, 1984/1995, p. 12), systemic boundaries are empirical. Any system produces a difference which constitutes the system and its environment (e.g. the legal system is based on the difference right/wrong, the scientific systems on the difference true/false). The Theory of Social Systems provides a descriptive framework to describe systems, including their objectives.

The Theory of Social Systems specifies *personal systems* and *social systems* as meaning processing systems. Social systems are defined by demarcation from their environment and are characterized by coherence: activities of persons are significantly related (Treibel, 2000). Main task of personal and social systems is to reduce complexity. Complexity forces to select from options. Systems manage to reduce complexity by demarcation.

> "Luhmann defines complexity in terms of a threshold that marks the difference between two types of systems: those in which each element can be related to every other element and those in which this is no longer the case. In information-theoretical terms, complexity designates a lack of information that prevents a system from completely observing itself or its environment. Complexity enforces selectivity, which in turn leads to a reduction of complexity via the formation of systems that are less complex than their environment. This reduction of complexity - Luhmann refers to it as *complexity differential* (Komlexitätsgefälle) between system and environment - is essential. Without it, there would be nothing, no world consisting of discrete entities, but only undifferentiated chaos. (...) Complexity can not be observed. Any attempt to do so is already engaged in the process of reduction, of transforming unorganized into organized complexity." (Knodt, 1995, p. xvii)

Systems that operate on the basis of consciousness are personal (psychic) systems; systems that operate on the basis of communication are social systems. Both require meaning for their reproduction. They are meaning processing systems which are characterized by closure. Personal (*psychic*) as well as social systems are self-referential closed systems which process information based on their current structure and by re-organization of their structure. Meaning processing systems are not determinable. Drawing a difference means to select from the actual horizon of options.

According to Luhmann (1984/1995), persons do not belong to a social system but to its environment. This means, a person does not belong to a system for all intents and purposes but in some respect, filling a specific role. *"In systemtheoretischer Perspektive gehören die Mitglieder eines sozialen Systems als Personen zur Umwelt dieses Systems (. . .); denn sie gehören nie ‚mit Haut und Haaren', sondern nur in bestimmten Hinsichten, mit bestimmten Rollen, Motiven und Aufmerksamkeiten dem System zu"* (Willke, 2000, p. 39). This results from the closure of systems (i.e. a social systems can not determine a psychic systems and vice versa). Scheunpflug identifies and describes systems, which are involved in learning and instruction: institutions, organizations, learners, teachers, politics, society, etc. Scheunpflug (2001).

Using evolutionary mechanisms to describe *learning*, learning means to *practice* and to *produce* variation, selection, and stabilization (table 4.4). As learning, among other aspects, means to produce variation, the Evolutionäre Didaktik takes into account learning processes which are generative, non determinable and non prescribable.

	practice	**produce**
variation	To get to know contingency (multiple perspectives, cultural heterogeneity, continuous change etc.).	To articulate an own position; to create an own solution; to inquire; to make decisions; to plan processes.
selection	To concentrate on an issue; to cope with evaluation and assessment.	To take a firm stand; to assess oneself.
stabilization	To learn; to forget.	To develop an aptitude for learning.

Table 4.4: *Learning* described by the evolutionary mechanisms of variation, selection, and stabilization.

The instructional meta-model behind the Evolutionäre Didaktik also describes *instruction* by using the mechanisms of variation, selection and stabilization. Evolutionary Theory describes changes of chronological *before* and *after*. According to Scheunpflug, instructional meta-models provide categories to enable well-structured communication about instruction. Instructional meta-models reduce complexity, reflect instruction, structure decisions, and intend analyzing instruction. The more manifold instruction is observed and perceived, the more manifold options can be identified in order to allow meaningful connectivity:

> "Je differenzierter und variationsreicher die Wahrnehmung und Beobachtung von Unterricht ist, desto differenzierter werden sinnvolle Anschlussmöglichkeiten für weiteres unterrichtliches Handeln identifizierbar." (Scheunpflug, 2001, p. 121)

Scheunpflug (2001) states that any modeling approach has blind spots. Activity-centered models do not well describe the relation between a program and its

	analyzing instruction	**planning instruction**
variation	Realizing a wide variety of phenomenons and options (the horizon of options)	Producing complexity: Planning and designing options (functional equivalences) to allow and ensure connectivity.
selection	Realizing the constraints of instruction (as instruction can not realize any option, it must select options according to criteria).	Selecting options according to certain criteria.
stabilization	Maintaining instruction.	Selecting and coordinating options. Managing diversity.

Table 4.5: *Instruction* described by the evolutionary mechanisms of variation, selection, and stabilization.

context. They only refer to the context in the means of pre- and post-conditions. In contrast to this, system-centered models focus on the relation system/environment and on the question of how systems process environmental complexity. Instruction produces a horizon of options to ensure connectivity. The question of *functional equivalence* becomes crucial here: the different options planned, fill the same role within a learning process. It depends on the system (personal and social), whether an option is viable and processable (whether meaning can be processed).

4.4 Reflecting Current Learning Technology Specifications

Let us now critically reflect basic assumptions of current learning technology specifications. IMS-LD (IMS Global Learning Consortium, 2003b) works as example here. The most relevant issues for reflection are the issues, presented in section 4.1:

- The position of the learning objective;
- the central category, underlying rationale, and ultimate intention;
- the Interest of Knowledge (Habermas, 1968).

4.4.1 Ultimate Intention and Underlying Rationale - Beyond Sequencing Activities

Any instructional meta-model is situated in its socio-cultural context, reflects an underlying rationale and an Interest of Knowledge, conveys implications, and is based on an epistemological foundation. Societal trends form implications, which are inevitably reflected in a meta-model. Regarding the Interest of Knowledge, Habermas (1968) identifies three different kinds of interests: Practical (interpretative) interest, technical interest and critical (emancipatory) interest. Friesen (2005) summarizes:

> "In a frequently cited taxonomy of types of knowledge, interest and research, sociologist Jürgen Habermas (1971) lists instrumental, technical knowledge as only one of three kinds of knowledge. He sees this one type of knowledge as necessarily co-existing with two other knowledge forms that he describes as 'critical' and 'emancipatory' (on the one hand) and 'interpretative' and 'inter-subjective' (on the other) (see: MacIsaac, 1996). Significantly, for Habermas, none of these knowledge forms exist somehow beyond 'ideology' or historical contingency - instead, all are a direct result of particular human concerns or 'interests' (1971). "

Blankertz (1969) and Peterßen (1994) provide evidence, that these interests also guide the design of instructional meta-models. The following shows, that meta-models are never neutral with regard to the Interest of Knowledge.

In the Age of Enlightenment, Humboldt formed a first theory of education, founding the concept of Bildung. This concept is formed by the central idea of the Enlightenment (Kant, 1784), the guiding concept of the *Subject* as mature and autonomous person, and the political and societal movement of the modernism. The concept of Bildung integrates an aspect of critical reflection, an emancipatory interest, and the intention to foster self-determination and autonomy. The concept of Bildung works as central category and ultimate intention of instruction in the Bildungstheoretische Didaktik[4].

In the decades from 1950 to 1970, the technical interest becomes the guiding interest in Instructional Design. The concept of *programmed instruction* treated learning as technologically manageable. The Lerntheoretische Didaktik proposes the Berliner Modell, which proposes the central category of learning. In contrast to the concept of Bildung the concept of learning is assumed to be *neutral*, as it does neither convey normative aspects nor prescribe an ultimate intention. The focus of this meta-model is to technologically manage instruction.

The Berliner Modell has been criticized because of its central category of learning and the assumption that it is neutral with regard to an ultimate pedagogical intention. It was argued, that any instructional decision is motivated by a decision made on a layer beyond the purely technological (Peterßen, 1994). It is a layer of critical reflection and an ultimate intention which guides decisions referring to instruction. It is the question of why to educate, which goes beyond the question of how to educate.

Since the 1970's the prominent positions agree, that instructional meta-models require an integral element of critical reflection. It was argued that education

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[4] The concept of Bildung was de-constructed in the nineteenth century and reconstructed and re-vitalized by Dilthey in (1924) and Klafki in (1963) and (1993), substantiating the Bildungstheoretische Didaktik. Its guiding Interest of Knowledge proceeded from being purely practical and interpretative to an integration of all Interests. The current variant of the Bildungstheoretische Didaktik, called the Kritisch-konstruktive Didaktik is an integrative theory and meta-model.

and instruction are to be prevented from being disposable to any objective and interest (e.g. of radical ideologies). This is only ensured, if the instructional meta-model itself integrates an aspect of critical reflection, which allows teachers and learners to critically reflect and transform learning objectives instead of only working towards them. Habermas (1968) refers to this as critical and emancipatory interest. Integrative meta-models (such as the Kritisch-konstruktive Didaktik and the Hamburger Modell) integrate any Interest of Knowledge, the critical-emancipatory interest, the interpretative-practical interest, and the technical interest. There is need for a further layer of reflection beyond the purely technological layer. Central categories such as *Engagement*, *Bildung*, *empowerment*, *self-determination*, and *solidarity*[5], and *confidence* form an ultimate intention and represent a layer of reflection that goes beyond the technological layer. This layer separates education from just any activity, and an instructional meta-model from a meta-model which serves as descriptive framework for just any activity. Investigating education in the postmodernism, Beck (1993) states, that besides the notion of *de-constructing the concept of the Bildung* and all its implications, and besides the socio-cultural trend towards qualification which replaces Bildung, current pedagogical models nevertheless integrate an critical and emancipatory interest, resuming the concept of Bildung. They define the central category as broad as possible in order to avoid to be normative. In its revised form the Lerntheoretische Didaktik (Hamburger Modell) represents an integrative model, going beyond the purely technical interest and integrating the concept of Engagement, which reflects an critical and emancipatory interest.

Beyond an ultimate intention, activity-centered meta-models propose an underlying rationale (such as the principles of Elementaria and Exemplarity and the concept of Bildung as categorial), which reflects an assumption of why a learning design is reasonable and well-fonded with regard to its ultimate intention (i.e. why its works educational). Instead of explicitly referring to an underlying rationale and a discrete model of learning, IMS LD describes learning activities step by step, purely sequencing the activities. In order to find out, whether a learning design is based on a specific learning model (such as PBL, case-based learning, etc.), the user must investigate each step. Anyway, the design of a learning scenario is implicitly or explicitly based on an underlying rationale.

Scheunpflug (2001) argues, that activity-centered models have to define an objective, as they are means-ends models which define and relate structural elements such as subject, object and objective. Objective and ultimate intention have to be legitimated (e.g. the concept of Bildung).

Habermas' concept of Interests of Knowledge, published in 1971, reveals, that Interests of Knowledge guide the design of meta-models, with all types of interests (technical, pragmatic, and critical) *necessarily co-existing.* The Kritisch-Konstruktive Didaktik and the Hamburger Modell are conceptualized as integrative rather than purely technological frameworks, integrating practical, technical and critical interests.

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[5] The ultimate intention is not a learning objective the learner directly works towards. In a society, ultimate intentions normally are shared. They guide decisions, e.g. in a design process. For example: The ultimate intention of the ‚virtual guiding dog', handheld devices that assist in navigation, is to ensure autonomy and self-determination for blind persons. In many societies, the dignity of man comprises self-determination and autonomy. Any design decision regarding the interface, usability, etc. is made to ensure this ultimate intention.

Current learning technology specifications claim to be neutral with regard to normative aspects and pedagogical intentions. The modeling language IMS LD proposes a meta-model which reflects a purely technical interest[6]. It describes learning and instruction by sequencing activities and neglecting an underlying rationale and missing an ultimate intention. Referring to Habermas' concept of Interests of Knowledge, a meta-model which aims at a purely technological description of instruction, is *not* neutral with regard to pedagogy, culture, and societal trends, but is nevertheless embedded in its socio-cultural context and reflects an underlying rationale which goes beyond the purely technological description. The underlying rationale just remains implicit. The underlying rationale, which is implicitly addressed in IMS LD, reflects what Lyotard calls the *merchantilisation of knowledge*:

> "And it is fair to say that for the last forty years the 'leading' sciences and technologies have had to do with language: phonology and theories of linguistics, problems of communication and cybernetics, modern theories of algebra and informatics, computers and their languages, problems of translation and the search for areas of compatibility among computer languages, problems of information storage and data banks, telematics and the perfection of intelligent terminals, to paradoxology. The facts speak for themselves (and this list is not exhaustive). (...) These technological transformations can be expected to have a considerable impact on knowledge." (Lyotard, 1979/1984)

Describing learning and instruction based on an purely technical interest and handling it as purely technologically manageable, significantly transforms education and instruction. As, according to the domain of ID, an emancipatory interest (Habermas, 1968) and an ultimate intention integrating an element of critical reflection, is seen as essential in a pedagogical meta-model, IMS LD is not based on an *pedagogical* meta-model. The meta-model behind IMS LD allows to describe any activity, pedagogically relevant or not. Calling the objective of an activity a *learning objective* is not sufficient. In IMS LD, learning is not seen as *Bildung*, but as *adaptation*. The learner adapts to the predefined learning objective asymptotically, but does neither critically reflect, transform, nor question it. According to IMS LD the concept of *learning* and the *learner* underlying the Unit-of-Study-Model are neutral. IMS LD describes learning which directly works towards a predefined learning objective. It does not allow to describe learning which is emancipatory relevant, learning which allows to critically reflect, question, and transform the learning objective (addressing the emancipatory interest), e.g. double loop learning (Argyris & Schön, 1978). According to Habermas (1968) a model is never neutral, but integrative, integrating any Interest of Knowledge, the technical, the practical, and the emancipatory. IMS LD and IEEE LOM reflect a purely technical interest - the specifications are not *neutral* but partial.

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[6] A purely technical interest does not ensure learning. An example derived from the field of jurisdiction might explain this: a technically correct procedure does not result in a judgement. Only an underlying rationale such as a fundamental law (the Basic Law) founds decisions.

4.4.2 Prescribing Learning Activities

(Scheunpflug, 2001) states, that learning is not completely determinable, planable and prescribable. Processes of learning are not sufficiently determined by planning, but do not succeed without planning. Both, the processes of teaching *and* learning constitute the learning process. Teaching and learning generate the learning process in terms of a dynamic interdependency rather than linear causality (Arnold & Siebert, 1995, p. 92). Learning processes are neither determined by instruction, nor by objectives. Therefore, models of learning can not be deduced from models of instruction. The unity of learning and teaching is only a notionally assumed. (Schulmeister, 2002) states:

> “One methodological problem in instructional design exists with regard to the assignation of learning objectives to methods, with the relation between them as deductive-linear. What is intended are basically deterministic systems which directly assign certain methods to certain learning objectives, but ‘our design procedures do not always allow us to determine, with any degree of efficiency, the optimal course of action’ (Winn, 1987).”

Schulmeister identifies this as a deficit of theories of instruction. Luhmann and Schorr (1979) refers to the deficit of instructional theories (*Technologiedefizit*) as the inefficiency of instructional meta-models to prescribe learning and instruction. Just as there is no model which is able to prescribe historical processes[7], Luhmann states, that there is no instructional model which is able to prescribe learning processes.

Non-deterministic theories describe individual and organizational learning as processes of change. Change almost never proceeds as planned, even though process models assume well-structured action achieving the predefined objectives. The result of change can not be anticipated and effectively controlled by a program and intervention. Nevertheless, change often succeeds and reaches the envisioned goal:

> “Diese von Foerster (1988) für Systeme, deren Zustände sich unvorhersehbar ändern können (so genannte nicht-triviale Maschinen) abgeleitete These [Author’s note: die verbreitete Prämisse, dass es Organisationen grundsätzlich unmöglich sei, die Ergebnisse von Veränderungen vorherzusagen und durch gezielte Intervention erfolgreich zu beeinflussen] berücksichtigt aber nicht, die bereits von Foerster (1988) angesprochene Möglichkeit, dass Organisationen mit flexiblen spontanen Problemlösekompetenzen, unvorhersehbare Zustandsveränderungen durch eigenaktive zielgerichtete Problemlösungen kompensieren und z.T. trotz unvorhersehbarer Veränderungen der internen Situation und Umgebungsbedingungen einen Zielerreichungsgrad von über 90 Prozent erreichen köennen (Greif, Runde, and Seeberg, 2004).”

Instructional Design addresses an average learner and an average situation. As the knowledge society is characterized by continuous change, transformation,

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[7] Models allow to identify patterns, to analyze and reflect processes of the past.

diversity, and heterogeneity, Scheunpflug (2001) questions whether activity-centered meta-model are able to adequately address the increasing complexity caused by continuous change and diverging processes of learning and instruction. Activity-centered models are based on the assumption that planned instruction results in learning. Complex structures and diverse interacting variables work as source of irritation and disturbing factors. Facing complex phenomena in learning it is not possible to make a prescriptive plan which assures that a predetermined objective will be reached. Even though all stakeholders within the learning process have an objective, the appointed means do not inevitably lead to those ends (the envisioned objectives). Planning is not sufficient to reach an objective.

Activity-centered meta-models, including IMS LD, describe activities based on means-end relations. According to (Scheunpflug, 2001) they describe instruction comprising elements such as subject, object, resources, methods, objectives, and relations. They work on the premises of linear causality and the relation of objectives and resources[8]. They provide categories to describe situations in which teaching and learning take place and serve as models for planning and describing educational settings. Activity-centered models are based on activities as a core element. As activities are goal-oriented, activity-centered models enforce to prescribe the correlation of causes (resources) and effects (objectives). Therefore, they fail to support generative learning processes and to describe ill-structured processes of change. There is need for a meta-model which goes beyond the constraints of activity-centered approaches and is able to describe concepts of learning which assume learning to be situated, partially-determined and inherently self-referential.

4.4.3 Contextualization

Chapter 3 distinguishes isolated learning from integrated learning. Integrated learning takes place in a context of change and at the same time initiates and causes change (e.g. individual learning is integrated in organizational learning). The dynamic relationship between learning processes and complex processes of change is inadequately addressed by models that almost exclusively focus on programmatic action and predefined objectives. According to Scheunpflug (2001) a blind spot of activity-centered models is their missing ability to describe the relation between the program (a learning design) and its context. Activity-centered models basically refer to a context only in the means of pre- and post-conditions (e.g. the merit of the Berliner Modell is to make pre- and post-conditions explicit).

The IMS LD specification defines requirements (R1, R5, and R8) which focus on de-contextualized learning programs and self-contained units-of-study:

> "R1. Completeness: The specification must be able to fully describe the teaching-learning process in a unit of learning, including ref-

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[8] The notion of activity-centered theories is not equal with activity theory according to e.g. Miller, Gallanter, and Pribram (1973); Vygotsky (1930/1978, and others). Scheunpflug (2001) refers to them in German as 'Handlungstheorien', which is translated to activity-centered theories here.

> erences to the digital and non-digital learning objects and services needed during the process."
>
> "R5. Reproducibility: The specification must describe the learning design abstracted in such a way that repeated execution in different settings with different persons is possible."
>
> "R8. Reusability: The specification must make it possible to identify, isolate, de-contextualize and exchange useful learning artefacts, and to re-use these in other contexts." (IMS Global Learning Consortium, 2003b)

The modeling approach itself limits the scope of the model, as it allows to describe isolated rather than integrated forms of learning. But, learning within many concepts is conceptualized as highly contextualized and situated. The notion of de-contextualization in IMS LD and LOM is not derived from pedagogical approaches and concepts of learning. It is postulated rather than scientifically and pedagogically founded.

In contrast to activity-centered models, system-centered models explicitly describe the relation from a system to its environment. According to the Theory of Social Systems (Luhmann, 1984/1995), systems work as epistemological category. Systems process and reduce environmental complexity. The Theory of Social Systems is a descriptive framework. System-centered models and activity-centered models complement each other (Luhmann, 1978, p. 212).

> "Handlungen werden hier als Relationen von Systemen mit ihrer Umwelt mitgedacht. Evolutionäre Theorie fragt danach, wie Handlungen möglich werden und erklärt damit mit ihrem eigenen Instrumentarium handlungstheoretisch Prämissen. Konstitutive Elemente sozialer Systeme werden so beschrieben." (Scheunpflug, 2001, p. 52)

To ensure pedagogical flexibility, it is not sufficient to specify appropriate data elements, relations (IMS LD), and categories (LOM). It is essential to define an appropriate modeling approach.

Chapter 5

Learning Roles - Modeling Coherent Social Systems

This chapter outlines a modeling approach for context specific educational metadata which addresses the valuable diversity of models and concepts of learning. Describing and planning reproductive as well as generative learning makes demands on the modeling approach itself. It does not only mean to specify suitable categories and attributes, but to rethink the epistemological foundation, the underlying rationale, and the concept of modeling referring the meta-level categories. First a basic comprehension of the formal terms *natural type*, and *role type* is given. Defining these meta-level categories is based on the work of Steimann (2000b, 2000c, 2000a). Then, the modeling approach of *Learning Roles (LR)* is presented, which integrates the concept of role types. In chapter 6, the approach of Learning Roles is applied to the meta-model of *DIN DOM - Didaktisches Objekt Modell* (Deutsches Institut für Normung e.V., 2004), a conceptual model which is published as Publicly Available Specification for learning technologies by the German Institute for Standardization. Finally, the concept of Second-Order Learning Objects is introduced, which takes into account pedagogical approaches that describe learning as contextualized and generative (Allert et al., 2004).

5.1 Meta-Level Categories *Natural Type* and *Role Type*

In the context of knowledge representation, meta-level categories are categories used to model the world, such as *concepts*, *properties*, *states*, *roles*, *attributes*, and *relations* (Guarino et al., 1994). Within this work, distinguishing the categories *natural type* from *role type* is crucial.

5.1.1 Meta-Level Category *Natural Type*

Types, classes and relations are fundamental concepts in object-oriented modeling.

> "A type is a specification for a set or collection of entities that exist or may exist in some domain of discourse. (...) Mathematically, every change to a set creates a new set, but the type definition is independent of any change in its instances." (Sowa, 2000, p. 98)

The question of *What are the types in a domain?* is the question of *What exists?* in the domain. A type is an abstract specification, not a set of concrete things. Meaning and semantics of a type can be extensional or intensional. The extensional definition of a type is a list of all its entities. An intensional definition specifies the properties or criteria for identifying a type - regardless whether such an entity actually exists (e.g. the type unicorn). Organizing types in an ontology or type-hierarchy the intension of a type definition is more relevant than the extension. *"In a type hierarchy, the position of a concrete type is determined by intension rather than extension"* (Sowa, 2000, p. 99).

In the context of classifying, types are called categories. Lakoff states, that *"there is nothing more basic than categorization to our thought, perception, action, and speech. Every time we see something as a kind of thing, for example, a tree, we are categorizing. Whenever we reason about kinds of things - chairs, nations, illnesses, emotions, any kind of thing at all - we are employing categories."* (Lakoff, 1987, p. 5). In his work "What Categories Reveal about the Mind", Lakoff contrasts an objectivist view on conceptualizing categories with the so called *experiential realism.* The objectivist view assumes that categories correspond to an objective reality, whereas the experiential realism assumes that categorizing and reasoning is embodied (not independent from the organism which categorizes) and situated (not independent from the context in which categorization takes place).

Categories and types are fundamental in designing databases, knowledge bases, and object-oriented systems. *"A choice of ontological categories is the first step in designing a database, a knowledge base, or an object-oriented system. In database theory the categories are usually called domains, in AI they are called types, in object-oriented systems they are called classes, and in logic they are called types or sorts."* (Sowa, 2000, p. 51). Classes can be thought of as a set of elements. Individual objects that belong to a class are referred to as an *instance* of that class (Antoniou & van Harmelen, 2004).

Up to this, the meta-category *type* has been identified. What is a *natural type*, then? Guarino provides an ontological distinction, separating *role types* from *natural types.* This distinction is based on the meta-properties *identity* and *rigidity* (cp. chapter 5.1.2). Steimann, Siberski, and Kühne (2003) state that the definition of natural types matches the class construct of object-oriented modeling, as the definition of classes are outside the context of any relationships, and the instances keep their types for their lifetimes (identity). A type is a natural type if "*belonging to the type is independent of being engaged in a relationship (except for, perhaps, a whole-part relation) and if an object cannot leave the extension of the type without loosing its identity.*" (Steimann et al.,

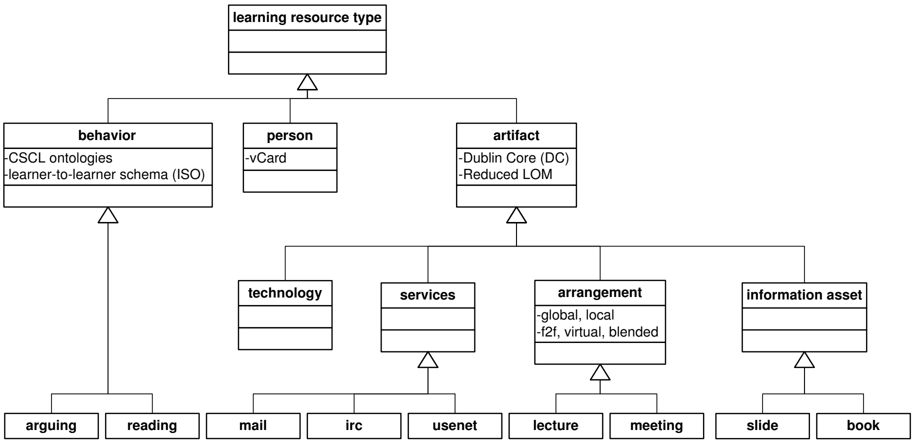


Figure 5.1: *Natural types* relevant in scenarios of learning and teaching (examples). *Person* represents any meaning processing system (e.g. a group, an organization) (Luhmann, 1984/1995).

2003). The concept of natural types becomes more definite as soon as the concept of role types is defined and roles types are distinguished from natural types (cp. chapter 5.1.2).

Learning Resource Type. Modeling learning scenarios which comprise the use of learning material and social interaction alike, requires diverse types of resources. Examples of scenarios envisioned within the domain of computer-based learning are the following:

- Teachers and learners search for learning material;
- learners search for Communities of Practice with a specific strategic intent;
- a Community of Practice creates a shared understanding by annotating information assets with *lessons learned* or *best practice*;
- learners search for a project presentation of peers;
- learners search for peers to perform peer tutoring with;
- learners search for a tutor, coach, etc.;
- mediating agents match user profiles to support group formation.

The natural types relevant in educational scenarios are not restricted to the type *information asset* but also comprise *person*, *behavior*, and *artifact* such as *technology*, *service*, and *arrangement* (figure 5.1).

5.1.2 Meta-Level Category *Role Type*

Guarino (1992; 1994) distinguishes *types* (natural types) from *roles* (role types) and Steimann (2000b, 2000c, 2000a) integrates the meta-level category role type into object-oriented modeling. Steimann states that the concept of role types is as fundamental in object-oriented modeling as the concepts of natural types, classes, and relations. Due to the fact that usually no difference is made between the concepts of natural types and role types, the concept of role types is relatively unknown. The concept of types normally represents both: natural types and role types. Actually, the difference between role types and natural types is in its contents. Syntax allows to work without distinguishing the concepts. But, semantically many problems arise from not drawing the difference between the concepts:

> "Die Rolle ist für die objektorientierte Modellierung ein so fundamentales Konzept, dass sie als auf einer Ebene mit anderen wie Klasse (oder Typ) und Relation stehend angesehen werden muss. Die Tatsache, dass sie dennoch so wenig Verbreitung gefunden hat, liegt vor allem darin begründet, dass in der Praxis gar nicht zwischen Rolle und Klasse unterschieden wird, sondern Klassen für beide Arten von Konzepten verwendet werden. Tatsächlich ist die Unterscheidung zwischen Rolle und Klasse vor allem eine inhaltliche; man kann syntaktisch recht gut ohne sie leben. Semantisch bereitet die Verschmelzung der beiden Konzepte allerdings erhebliche Probleme." (Steimann, 2000a)

Founding the concept of role types in semantics and formal languages, this work refers to Steimann (2000b, 2000c, 2000a), who gives a theoretical foundation of the concept. Steimann works out practical implications for its integration in object-oriented modeling and its representation in the modeling language UML (Unified Modelling Language).

Steimann defines the concept of role types, taking into account different perspectives: Linguistics, ontology, and formal languages. Modeling roles is originated in the philosophy of language. Eco (1994) in this context calls Lodwick (1647/1972) the first progenitor of lexical semantics. Lodwick does not start from the substantives (from nouns or names of individuals and genera, which was common in the aristotelic tradition) but from actions. Actions then are populated with actors and characters; with abstract roles, that can be connected to person's names, things, or places acting, re-acting, and being acted.

Lodwick distinguishes *appellative nouns* from *proper nouns* in linguistics. This linguistic differentiation reflects two qualities, which are specified by Husserl (1901/1922) and Guarino. Husserl introduces the quality of *Fundierung* (en: foundation), Guarino (in the context of knowledge representation and knowledge engineering) specifies *semantical* and *ontological rigidity.* A concept is founded if none of its instances can exist alone: Each instance is related to an other instance. A concept is semantically or ontologically rigid if an instance can not join and leave the extension of the concept without loosing its identity.

> "If x has the property of being an apple, it cannot lose this

> property without losing its identity (...). This observation goes back to Aristotelian essentialism (...).” (Guarino et al., 1994)

Guarino (1992) distinguishes the concept *role type* from the concept *natural type.* He founds the concept of role type as an ontological concept and gives a formal definition assigning two conditions. Role types are those concepts which are founded and not semantically rigid. Natural types are those concepts which are semantically rigid and not founded. According to Guarino et al. (1994), the meta-property rigidity means: *“A property P is rigid if, for each x, if P(x) is true in one possible world, then it is also true in all possible worlds. Person and location are rigid, while student and tall are not”.* Bram, MacDonald, and Newmarch (2004) point out that the heart of Guarino’s definition is that a role specifies behavior within a context - a behavior is a contract or relationship between two entities. A role type implies a specific relationship between instances filling the role. Role types require the instance to have an identity apart from its role type. Natural types do not imply a specific relationship with other types (except for whole-part relations). Natural types grant an instance its identity. A natural type cannot leave its type without losing its identity. A role type is not to be used in a part-whole-relation.

While the concept of role types does not play a role in most formal languages, including the logics (cp. modeling and the formal grounding of maths by Frege (1848-1925), it plays a major role in linguistics cp. Bühler (1934)). In linguistics there is a common theory of formal languages, integrating the role as fundamental concept complementing the concepts of predicates and objects:

> “In der Theorie der Sprachen, formaler wie natürlicher, taucht ein Begriff immer wieder auf: der der Rolle. Rollen komplettieren die für die Sprachtheorie so wichtigen Konzepte Prädikat (als Träger der Aussage eines Satzes) und Objekt (als Ergänzung des Prädikats) um die Beschreibung der Funktion, die das Objekt in die Aussage ausfüllt. Rollen sollten damit, genau wie Prädikate und Objekte, fundamentaler Bestandteil jeder Sprachtheorie sein. Doch während die Formalisierung von Prädikaten und Objekten heute eine Selbstverständlichkeit ist, tut man sich mit der Einordnung des Rollenbegriffs in formale (Modellierungs-)Sprachen vergleichsweise schwer.” (Steimann, 2000b)

Steimann (2000a) states that the standardization of the term “role” in modeling complements the meta-level categories type and relation. Instances of types can play roles. Correctly speaking: types *fill* roles. The classical dichotomy type/relation is extended to the trilogy type/role/relation.

Steimann recommends to introduce the concept of role types into object-oriented modeling in order to make possible dynamic modeling approaches. In contrast to the static character of natural types, the character of role types is dynamic. Roles are dependent from relations and context. Steimann et al. (2003) describe the distinction, paraphrased in object-oriented terms as follows: *“a type is a role type if for an object to belong to the extension of the type it must engage in a relationship associated with the type, and if entering or leaving the extension of the type does not alter the object’s identity.”* Roles specify the interaction

Natural Type	***Role Type***
Static.	**Dynamic**.
Semantically rigid. An instance of a class once and forever belongs to that class. It cannot change it without loosing its identity.	**Not semantically rigid**. Does not lose its identity when leaving the role (Guarino, 1992).
Not founded.	**Founded**. Has context and relations.

Table 5.1: Distinguishing the formal concepts *natural type* from *role type*.

of individuals. An instance is statically classified by its natural type and dynamically classified by the role types it fills. Each instance of a certain natural type can fill different role types, called polymorphism. According to Steimann (2001), role types and natural types (in the context of object-oriented modeling Steimann refers to natural types as classes) are interconnected by the *supports* relationship, specifying which classes support which roles. The role type specifies the behavior, instances of a natural type must provide in order to be able to fill the role. *How* the behavior is achieved is left up to the classes that support it. It depends on the classes' properties and qualities whether its instances can fill a role or not.

Summarizing the most important aspects: Guarino (1992) distinguishes the ontological concepts natural type from role type: Role types are not semantically rigid but founded. Instances of natural types can fill, adopt and leave a role without loosing their identity. Roles are defined by context and relation (table 5.1).

Integrating the concept of role types in UML, the notation for roles must be specified. Steimann (2000a) recommends to use the lollipop-notation, which in UML represents interfaces (cp. Fowler & Scott, 1997). In the following UML diagrams a rectangle indicates a natural type, a circle indicates a role type (figure 5.2). The UML diagrams specify role types the instance of a natural type can fill.

5.2 Types and Roles in Coherent Social Systems

Current work on the concept of role types is complemented by the following elaboration, which relates the concept of role types to variants of the Theory of Social Systems (Parsons, 1951; Luhmann, 1984/1995; Willke, 2000; Krieger, 1998). As discussed in chapter 4.3, the Theory of Social Systems is a descriptive framework which describes the world in terms of systems and provides a functional-structural view on systems.

5.2.1 Roles in Social Systems

In this work, the concept of role types is adapted to model coherent social systems. Whereas in object-oriented modeling *objects* and *categories* are defined,

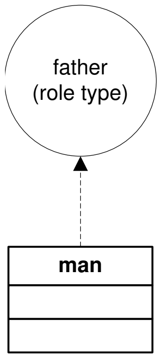


Figure 5.2: Notation in UML - a rectangle indicates a natural type, a circle indicates a role type. Here, the natural type *man* fills the role type *father*. The role father can be adopted and dropped by instances of the class man. Whereas a natural type can stand alone, role types are invariably defined in the context of relationships. Father is dependent, man is not.

the Theory of Social Systems states that the difference system/environment is constructed. *"The central paradigm of recent system theory is 'system and environment'. The concepts of function and functional analysis no longer refer to 'the system' (...) but to the relationship between system and environment."* (Luhmann, 1984/1995, p. 176). Luhmann (1984/1995) stresses, that the concept of the environment is not just a residual category, but that the relationship to the environment is constitutive in system formation. A system constitutes itself by defining the difference system/environment and by forming its boundary. It's identity is possible only by difference. The consequence of this theoretical foundation is the point of reference, which is *difference* rather than *identity*. *"This leads to a radical de-ontologizing of objects as such (...). This interpretation contains no unambiguous localization of any sort of 'items' within the world nor any unambiguous classifying relation between them. Everything that happens belongs to a system (or to many systems) and always at the same time to the environment of other systems."* (Luhmann, 1984/1995, p. 177). The difference system/environment is not ontological but an epistemological. Systems organize their inner complexity and reduce contextual (envoronmental) complexity.

According to the Theory of Social Systems, personal as well as social systems are meaning processing systems. They process environmental complexity by reducing complexity. Inner and outer complexity are different. Systems are closed and self-regulated. Meaning is processed according to the actual state and structure of the system and is defined by the system. Processes are inherently in-determined from an observers point of view (cp. Willke, 2000).

Within a system, roles and activities of persons are significantly related, e.g. when a speaker speaks, the audience listens. In listening, the audience creates the speaker and vice versa. According to Luhmann (1984/1995), persons do not belong to a social system but to its environment (cp. chapter 4). This means, a person does not belong to a system for all intents and purposes but in some respect, filling a specific role. This is obvious, as systems can not determine

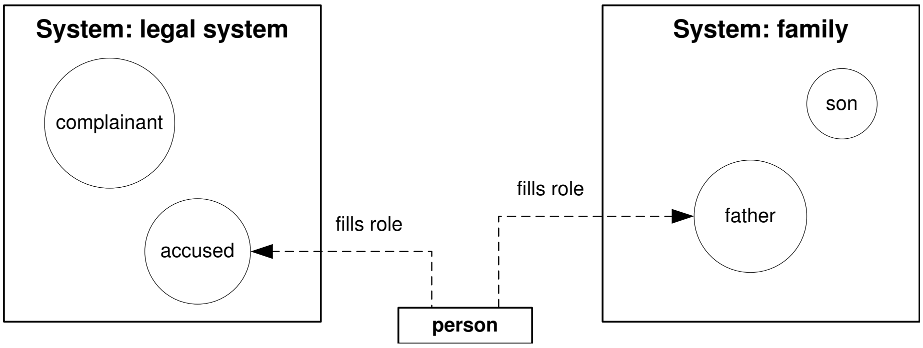


Figure 5.3: A person (natural type) filling roles within different systems.

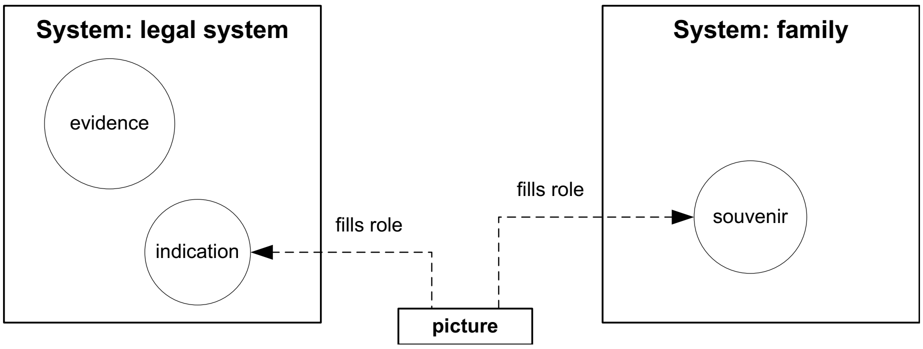


Figure 5.4: A picture (natural type) filling roles within different systems.

another. For example: The persons Peter and John belong to the environment of the system family. Only Peter filling the role son and John filling the role father, belong to the system. The legal system also belongs to the environment of the system family. The person John belongs to the environment of the legal system. Only for some intents and purposes John filling the role accused, belongs to the legal system. *"In systemtheoretischer Perspektive gehören die Mitglieder eines sozialen Systems als Personen zur Umwelt dieses Systems (. . .); denn sie gehören nie 'mit Haut und Haaren', sondern nur in bestimmten Hinsichten, mit bestimmten Rollen, Motiven und Aufmerksamkeiten dem System zu"* (Willke, 2000, p. 39).Within different systems one and the same person fills different roles.

The legal system, which is a highly formalized system, serves as an example to illustrate issues relevant for modeling social systems. There is no system without a theoretical foundation or underlying rationale. Legal systems are either based on *codified law* (e.g. the German legal system) or on *case law* (as in Anglo-Saxon countries). This foundation conceptualizes the system. Roles within the system are related. For person related roles this means for example: there is no accused without a complainant, no father without a son (or daughter). Also, the activities of the accused, complainant, attestor, and the judge are related. Persons filling a role within a system have expectations towards the other persons filling roles. The accused has specific expectations towards the

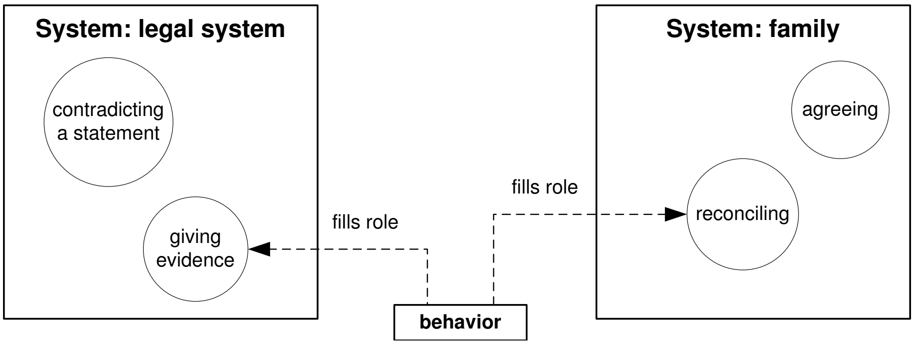


Figure 5.5: A behavior (natural type) filling a role within different systems.

judge. Instances of natural types adapt roles as soon as they move into the system. The characteristics of how an instance actually adopts a role, is based on its identity, its class properties and qualities. A role defines the qualities an instance must have in order to be able to fill the role. Within social systems expectations are tied to roles.

For the natural type *person*, the concept of role types is intuitively understood (figure 5.3). But also further natural types such as information asset (e.g. a picture), behavior, technology, service, etc. fill roles within diverse systems (see figures 5.4 and 5.5). Within the legal system the type *picture* itself does not exist. But a picture which fills the role *indication* exists in the legal system. This means: as soon as someone hands in a picture the judge will bring it into the system as indication (the picture filling the role indication) - or refuses to do so. Only filling the role indication (or another) the picture is part of the system. The same with the role *evidence*: only as the judge accepts an object as evidence it becomes part of the system. It is not part of the system per se, but filling the role evidence.

Types do not belong to a *system* but to its *environment*. One and the same person which fills the role *accused* in the legal system, fills the role *father* in the system family, each with specific intents, aspects, and purposes. Systems reduce environmental complexity. The environment is processed selectively. A judge, which is a relative to the accused in another system, is recused in the legal system.

The Theory of Social Systems (Luhmann, 1984/1995) is a descriptive framework which represents a system-centered view and is a non-deterministic and non-prescriptive meta-theory. It is a variant of General System Theory (e.g. Parsons, 1951, a functionalist in sociology). *"In 'The Social System' 1951, Parsons argued that the crucial feature of societies, as of biological organisms, is homeostasis (maintaining a stable state), and that their parts can be understood only in terms of the whole"* (http://www.hewett.norfolk.sch.uk/curric/soc/PARSONS/biog.htm). According to Scheunpflug (2001) the Theory of Social Systems works as a descriptive framework which is capable to integrate activity-centered models. Willke (2000) characterizes this theory as universal regarding domains and disciplines. Many disciplines are confronted with similar problems, e.g. the problem of increasing complexity, which can not be reduced to simple categories and principles. A comprehensive introduction into the theory of social systems is given by Willke (2000) and Krieger (1998). The foundational work is: Social Systems by Luhmann (1984/1995).

In the context of modeling coherent social systems, this work argues that roles are arbitrary n-ary relations. This is different from Guarino's statement that roles are arbitrary binary relations (Guarino, 1995). Whereas Guarino interprets a unary predicate as a concept (class) and a binary predicate as a role, this work assumes a role which is based on the system-centered view as n-ary predicate. The relation *father-son* is insufficiently described by the binary relation. In a system, the relation *father-son* is entirely affected by any other role in the system e.g. the roles mother and brother). The absence of an instance filling the role mother and the existence of the role brother entirely affects the relation father-son.

5.2.2 Modeling Coherent Social Systems for Learning

As learning takes place within a social context and as it forms a social context itself, a modeling approach which describes learning designs, must allow to describe coherent social systems. As seen above, roles are related within systems: A speaker is related to a listener (there is no listener without a speaker and vice versa), which means that the role listener constitutes the role speaker and vice versa.

Any discrete model of learning and pedagogical approach models a social system, each coherent in itself and each based on a theoretical foundation and underlying rationale. A modeling approach which models learning scenarios must allow to describe diverse concepts of learning. The approach of Learning Roles, which is introduced in the next section, defines coherent sets of categories. A set (scheme) explicitly describes a model of learning.

An example illustrates relevant roles defined by a specific model of learning: A Community of Practice (CoP) comprises the roles *core member*, *active member*, *peripheral member*, *coordinator*, and *expert* (cp. Wenger et al., 2002), which can not directly be mapped to roles such as learner and teacher in a scenario of Expository Teaching. Persons filling roles within a specific learning scenario have certain expectations concerning learning process, learning culture, social interaction, resources, etc.. In the CoP scenario information assets fill roles such as *innovative knowledge*, *best practice*, *lessons learned*. This means, information assets fill a specific role within a learning process.

A natural type can fill different roles in different learning scenarios: Peter is a person. He fills the role *coordinator* in the knowledge-creating community 'Arctic Biologists', the role *peripheral member* in the community 'GPS in Geodesy', and the role *learner* in a scenario of Expository Teaching. An information asset also fills different roles within different learning scenarios, according to the underlying concept and model of learning (figure 5.6). The foundation of roles is assigned to the concept/model of learning.

The approach of Learning Roles models learning scenarios as coherent social systems for learning. It explicitly models diverse concepts of learning. A set of roles (a scheme), which is based on a specific concept/model of learning, is

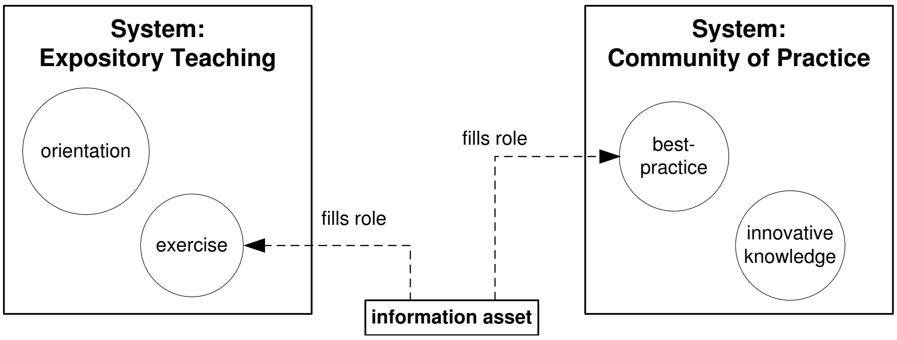


Figure 5.6: An information asset (natural type) filling roles within different scenarios of learning.

called a *Learning Role*. A side-effect of the approach of Learning Roles is expressiveness regarding the concept/model of learning the learning scenario is based on: Mature lifelong learners do not only reflect what they want to learn, but also how. This is hold for both: formal and informal learning opportunities. Rautenstrauch (2001) explains: *“Lifelong learning will be a learners own decision (. . .) the learner is mature (. . .) he will identify and define his own needs and preferred ways of learning (. . .) he will learn to learn self-organized, self-determined, and independent from predetermined curricula and institutional forms of organization.”* Therefore Learning Roles (LR) focus on expressiveness and significance regarding concepts of learning and pedagogical approaches.

Current learning technology standards and specifications implicitly integrate the meta-level categories natural type and role type, but they do not formally distinguish between them. In its value space LOM’s educational category “Learning Resource Type” lists the vocabulary: *“exercise, simulation, questionnaire, diagram, figure, graph, index, slide, table, narrative text, exam, experiment, problem statement, self assessment, lecture”* (IEEE LOM, 2002). Whereas slide is a natural type, problem statement is a role type. A slide can fill the role problem statement (figure 5.7). IMS LD specifies a structural element named *role*. Learners and teachers (staff) fill roles within a unit-of-study. But IMS LD does not explicitly distinguish the meta-level categories natural type and role type. And it does not specify roles besides the person-centered role (there is no role which can be filled by resource types such as an information asset, behavior, artifact, etc.).

Current learning technology standards and specifications (e.g. LOM) do not distinguish a *learning object* from an *object* (e.g. an information asset). One of the major problems which results from this equation is, that there is no significant and explicit distinction between an *educational resource* and a *resource*, as any resource can be used in education (e.g. the poem “The Road Not Taken” by Robert Frost was not mainly intended to be an educational resource but can be used in educational settings). The concept of context specific metadata explicitly makes this distinction. An information asset (resp. person, technology, behavior, arrangement) which fills a role within a certain learning context is a learning resource as soon as it actually fills that role (metadata of use). Learning resources are characterized and constituted by context and relations.

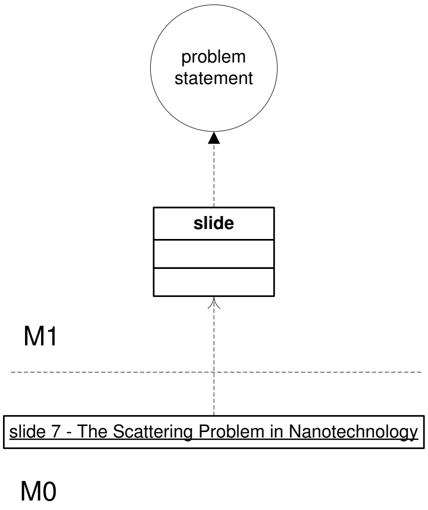


Figure 5.7: Modeling natural types and role types in LOMs category *Learning Resource Type*.

5.3 Role-Based Metadata

In specifying metadata, it is necessary to distinguish between static attributes (such as Dublin Core and vCard attributes), which are based on the *natural type* of a learning resource, and context- or role-dependent attributes which are based on the *role type* a learning resource can fill. Every learning resource can have one or more associated roles it can fill. Such a modeling approach, called *Learning Roles (LR)*, is proposed and described in detail in this section.

5.3.1 Abstraction Layers

Resources such as information assets and persons have context-independent static attributes. These static attributes are independent from the role a resource fills. Regarding an information asset, static attributes are mainly attributes taken from Dublin Core (Dublin Core Metadata Initiative, 2004) and some further LOM attributes, like dc:title, dc:creator, etc.. Persons are annotated with vCard attributes like vcard:FN (full name) and vcard:EMAIL. Besides static attributes, context-specific role-based attributes are attached to resources.

Role-based attributes are specified according to a specific concept/model of learning. In the modeling approach of Learning Roles the concept/model of learning is reflected by the Meta-Type in M2 (meta-level 2, figure 5.10). The meta-meta-level category *meta type* is crucial in modeling learning scenarios, as there always is an underlying rationale which can not be formalized. The meta type reflects central categories such as Bildung and Engagement, an epistemological foundation, and principles such Elementaria and Exemplarity, which found instructional activities (cp. chapter 4). Therefore, the approach of Learning Roles comprises three abstraction layers (figure 5.8):

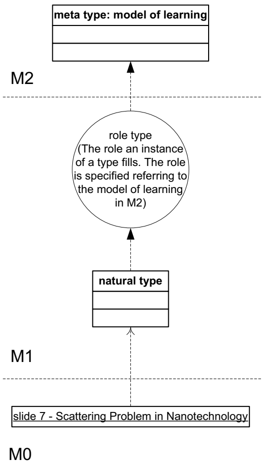


Figure 5.8: The model distinguishes natural types from role types.

Abstraction layer M0: Instances of a scenario of learning and instruction.

Abstraction layer M1: Natural types (learning resource types) and role types, which are specified by specific concepts and models of learning.

Abstraction layer M2: A meta type, which reflects the theoretical foundation the concept and model of learning is based on.

Modeling role-based metadata for the legal system, which already served as an example in section 5.2.1, illustrates key concepts of the modeling approach (figure 5.9):

Abstraction layer M0: Instances, which actually instantiate a scenario of justice: Mary Nash, Pat Higgins, Walter Miller, which are persons; a photo, which shows a damaged car; the act of speaking. All this takes place at some specific point of time and place.

Abstraction layer M1: Person, text, picture, arrangement, behavior (among others) are relevant types within a (prototypical) scenario of justice. Persons can fill the role judge, defendant, and complainant; a text can fill the role conviction, evidence, and indication, a picture can only fill the role indication; an arrangement can (among others) fill the role hearing; a behavior can fill the role *refuse-to-give-evidence* and *submit-evidence*.

Abstraction layer M2: The entire system is based on the theoretical foundation of Codified Law. This reflects relevant philosophical aspects.

5.3.2 Learning Roles

The modeling approach of Learning Roles explicitly models diversity in the field of learning. Learning Roles (LR) are sets of role types, which are specified

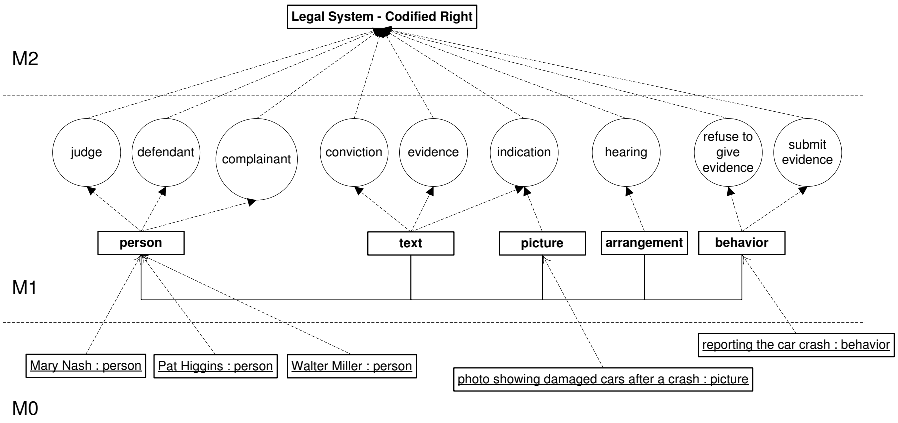


Figure 5.9: Modeling role-based metadata for the legal system works as example for illustrating key concepts of the modeling approach of Learning Roles.

according to a discrete meta type. A meta type is based on a concept/model of learning and reflects its epistemological foundation. It specifies roles, relations between roles, and qualities/properties an object must satisfy in order to be able to fill a specific role type.

A LR is a scheme which reflects a specific concept/model of learning (both, generative and reproductive). Resources can fill roles which are specified according to a meta type. Resources dynamically fill roles, which are conceptualized according to diverse concepts of learning. A resource can fill different roles in different contexts of learning and instruction. An instance of a natural type that fills a role in the context of learning is called *learning resource*.

Similarly to how ontologies are often agreed on by a community of knowledge such as ACM or IEEE, this work suggests to decide and agree on relevant Learning Roles within communities (such as scientists, practitioners, and consultants). Comparable with ontologies, a Learning Roles can be seen as shared conceptualization: *"Every ontology is a treaty - a social agreement - among people with some common motive in sharing"* (Gruber, 2004). A community agrees on a shared understanding of a specific concept/model of learning and on its relevant characteristics. The community describes a meta type, and specifies a set of roles and appropriate role-based metadata (cp. M2 and M1 in figure 5.10).

An example: A behavior (natural type) represents an activity (role type) within a learning process. Planning a learning process one asks: What function does *"debating"* have within the learning process? Or vice versa: How can we activate *"questioning accepted practices"*? Then the natural type *"debating"* fills the role type *"questioning accepted practices"* within the learning process and knowledge-creation scenario (figure 5.11).

5.3.3 Identifying Relevant Types and Roles

Each concept of learning specifies characteristic elements and is based on an underlying rationale and epistemological foundation. From these characteristic

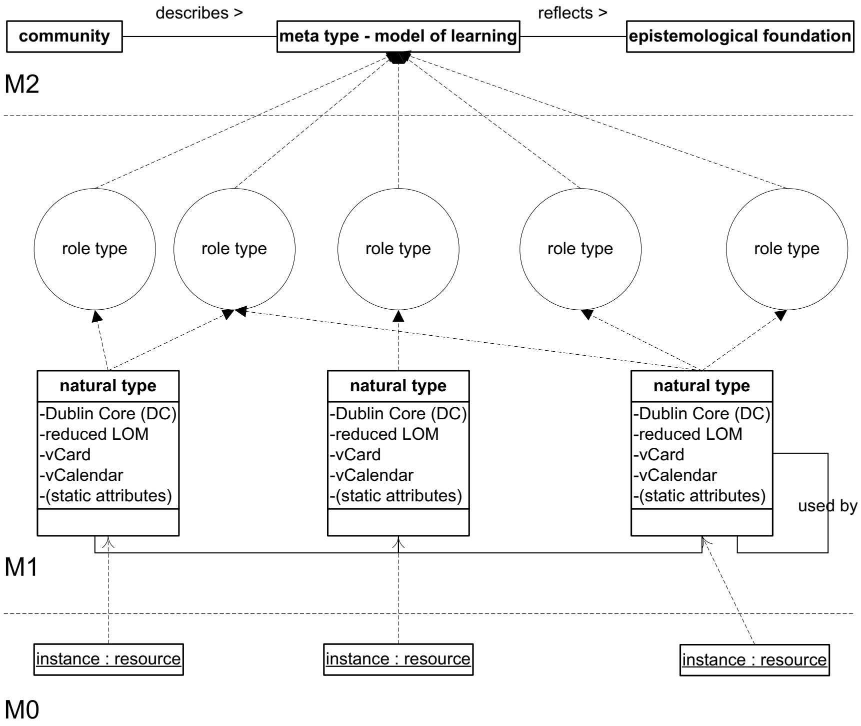


Figure 5.10: A Learning Role (LR) is a scheme. It models a meta type, which represents a specific concept/model of learning and reflects an epistemological foundation and underlying rationale, and specifies suitable role types.

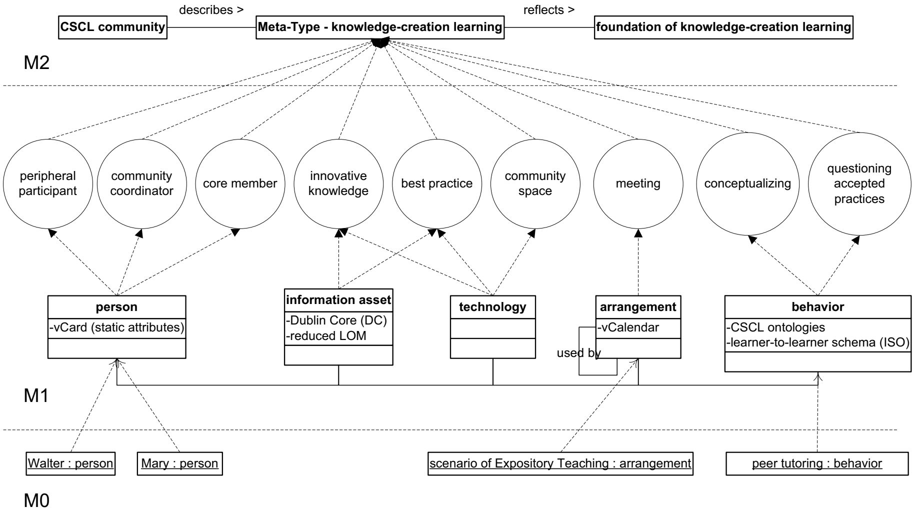


Figure 5.11: Learning Role *knowledge-creation learning* - examples of types and roles.

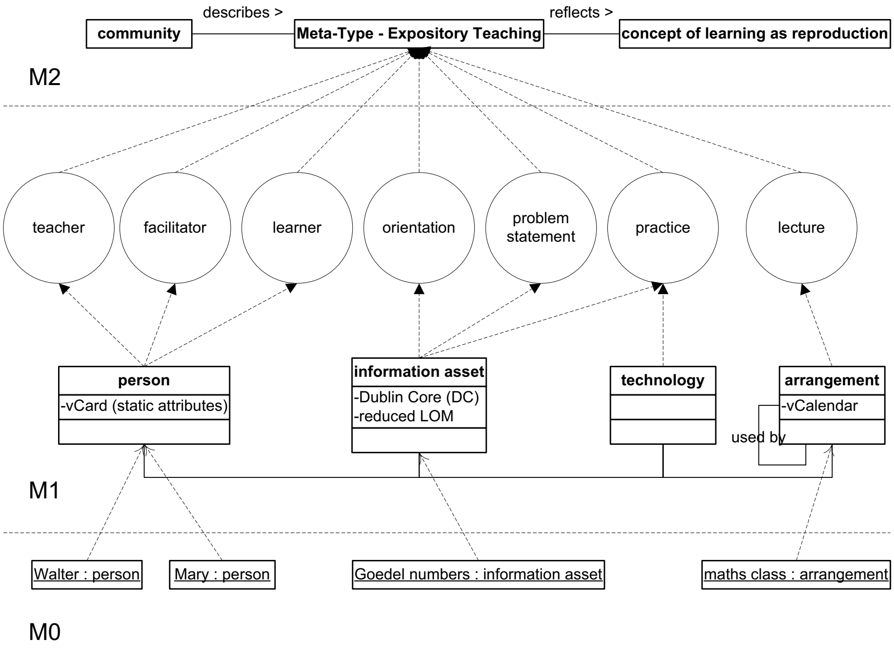


Figure 5.12: The Learning Role *acquisition learning* (examples of types and roles).

elements one can identify relevant roles and types (resources). Relevant resources can be identified by asking: What is useful to be provided and offered on the semantic web. What do users search for in the context of learning?

Two models are outlined here: the model of *knowledge-creation learning* and the model of *acquisition learning*. Within the diagram a rectangle indicates a *natural type*, a circle indicates a *role type* (figures 5.11 and 5.12).

Whatever entity is to be annotated one must ask, which natural type (resource type) it is (person, information asset, technology, behavior, arrangement) and annotate this resource with suitable metadata (vCard for persons, Dublin Core or *reduced LOM* (reduced LOM refers to LOM without the category *Educational*) for information assets e.g.). Then one must ask what roles it fills or is supposed to fill. Role-based metadata is then derived from specific Learning Roles. Any entity is annotated with static type-based attributes and context-specific role-based (dynamic) attributes.

Technical interoperability across different learning scenarios and LRs is ensured via static type-based metadata. Beyond this, the concept of Learning Roles allows perfect interoperability between learning technologies and scenarios which are based on the same concept of learning.

A crucial aspect of modeling learning scenarios is the question of how to model nesting: How to model the integration of a scenario of learning into a scenario of learning? For example: Within a scenario of *knowledge-creation learning* a scenario of *Expository Teaching*is integrated. As Learning Roles model consistent social systems, each scenario forms a coherent social system in itself. The scenario of knowledge-creation learning forms a coherent social system, represented in a LR, and the scenario of Expository Teaching forms a coherent social system, represented in a LR. A scenario is referred to as an instance of type, which fills a role within another scenario. Referring the example: The scenario of Expository Teaching is a resource (arrangement) which fills the role *resource to acquire background knowledge* in the scenario of knowledge-creation learning (figure 5.12).

Another example: there is the LR *brainstorming*, defining a scheme of roles. In a knowledge-creation scenario (figure 5.11), brainstorming is an instance of a type (behavior), which fills the role type *conceptualizing* (activity).

The next chapter presents in detail how role types and Learning Roles can be applied for describing learning scenarios (PAS 1032-2, DIN) and for specifying Second-Order Learning Objects (SOLOs). SOLOs are shared schemes which foster learning strategies.

Chapter 6

Current Implementations of Learning Roles

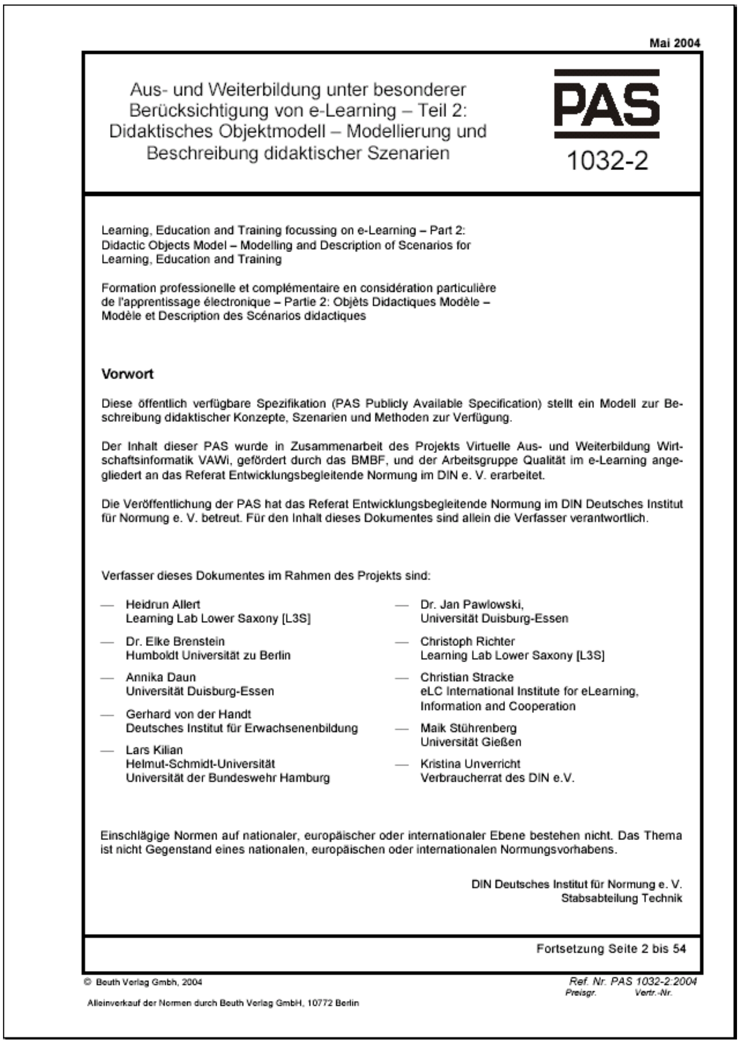
This chapter describes implementations of the modeling approach of Learning Roles. Learning Roles are integrated in the specification PAS 1032-2 *(DIN Didaktisches Objektmodell*, chapter 6.1) and in the concept of *Second-Order Learning Objects* (chapter 6.2). The DIN Didaktisches Objektmodell (DIN DOM) allows to describe learning designs and learning models, making explicit the pedagogical approach and method it is based on. Second-Order Learning Objects (SOLOs) are shared schemes, which foster generative learning.

6.1 Learning Roles in a Specification

The publicly available specification PAS 1032-2 (DIN DOM, Deutsches Institut für Normung e.V., 2004) aims at exchanging, reusing, and comparing instructional concepts, scenarios and methods. It systematically supports the user in:

- Planning, designing, and evaluating learning scenarios;
- selecting and evaluating suitable instructional models and pedagogical approaches;
- exchanging learning designs and course concepts;
- searching and selecting suitable courses, modules and units-of-learning by learners and coaches;
- systematically exchanging experience made with a learning design.

Intended user groups are: Trainers, tutors, instructional designers, authors, who aim to describe, analyze, plan, design, implement, evaluate, identify, and exchange instructional models, scenarios, units-of-learning, methods, courses, and course concepts. Learners, teachers, and deciders, who aim to select and evaluate suitable learning designs based on their preferences and requirements.



Mai 2004

Aus- und Weiterbildung unter besonderer
Berücksichtigung von e-Learning – Teil 2:
Didaktisches Objektmodell – Modellierung und
Beschreibung didaktischer Szenarien

PAS
1032-2

Learning, Education and Training focussing on e-Learning – Part 2:
Didactic Objects Model – Modelling and Description of Scenarios for
Learning, Education and Training

Formation professionelle et complémentaire en considération particulière
de l'apprentissage électronique – Partie 2: Objèts Didactiques Modèle –
Modèle et Description des Scénarios didactiques

Vorwort

Diese öffentlich verfügbare Spezifikation (PAS Publicly Available Specification) stellt ein Modell zur Beschreibung didaktischer Konzepte, Szenarien und Methoden zur Verfügung.

Der Inhalt dieser PAS wurde in Zusammenarbeit des Projekts Virtuelle Aus- und Weiterbildung Wirtschaftsinformatik VAWi, gefördert durch das BMBF, und der Arbeitsgruppe Qualität im e-Learning angegliedert an das Referat Entwicklungsbegleitende Normung im DIN e. V. erarbeitet.

Die Veröffentlichung der PAS hat das Referat Entwicklungsbegleitende Normung im DIN Deutsches Institut für Normung e. V. betreut. Für den Inhalt dieses Dokumentes sind allein die Verfasser verantwortlich.

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Figure 6.1: Publicly Available Specification 1032-2 (Deutsches Institut für Normung e.V., 2004).

The DIN DOM working group started in 2002, focusing on two major objectives:

1. Harmonizing and enhancing existing modeling languages and specifications for learning technologies such as IEEE LOM (2002), Didaktische Ontologien (Meder, 2000), EML (Koper, 2001), ELM (Pawlowski, 2001), and Learning Roles (Allert, Richter, & Nejdl, 2003);
2. developing a specification which allows to reference, describe, and compare instructional models, learning scenarios, and methods.

Both aspects were seen as crucial. Harmonizing existing specifications and modeling languages was evaluated as important, as different frameworks exist in parallel and users are often lost in deciding which one to choose. Even more, each specification focuses on different aspects and does not provide a comprehensive approach. The second objective was evaluated as important, as existing specifications aim at neutrality regarding learning models and pedagogical approaches. But, being expressive regarding the learning model which guides the design of a learning scenario allows to compare learning designs. It allows users to decide not only what but also how they are going to learn. The category *method* in DIN DOM comprises learning models and pedagogical approaches. The authors of DIN DOM agreed on defining a model which explicitly describes instructional models and methods. DIN DOM does not re-invent IMS LD. During the work of defining the conceptual model of DIN DOM, IMS LD was published. The working group decided to build upon IMS LD. Some basic categories of DIN DOM are equivalent to those of IMS LD. Beyond these, DIN DOM strengthens concepts which do not exist in IMS LD, namely: the (intended) *context*, and the (actual) *experience* made with the scenario. Focusing on these aspects does not only allow to exchange a learning design itself, but also the experience made during use. Furthermore, DIN DOM elaborates the concept *method* (figure 6.2).

Within this work it is relevant to answer the question of how the meta-level category *role type* and the approach of Learning Roles are integrated into the conceptual model of DIN DOM. This will be answered after explaining the specification and its core concepts. DIN DOM is a Publicly Available Specification (PAS 1032-2, figure 6.1). The specification contains a conceptual model specifying the structural elements and their relations, an information model, and an XML and XSD binding for implementation.

The PAS 1032-2, *Aus- und Weiterbildung unter besonderer Berücksichtigung von e-Learning, Teil 2, Didaktisches Objektmodell - Modellierung und Beschreibung didaktischer Szenarien* (Deutsches Institut für Normung e.V., 2004) has been worked out by the project *Virtuelle Aus- und Weiterbildung Wirtschaftsinformatik VAWI* founded by the Federal Ministry of Education and Research, Germany and the working group *Qualität im eLearning - AG Didaktik*, at the *Referat Entwicklungsbegleitende Normung*, German Institute for Standardization (DIN e.V.). The Referat Entwicklungsbegleitende Normung, DIN e.v. (represented by Siglinde Kaiser) also coordinated the publication. Authors are: Heidrun Allert (Research Center L3S), Dr. Elke Brenstein, (Humboldt Universität zu Berlin), Annika Daun (Universität Duisburg-Essen), Gerhard von der Handt (Deutsches Institut für Erwachsenenbildung), Lars Kilian (Helmut-Schmidt-Universität, Universität der Bundeswehr Hamburg), Dr. Jan Pawlowski (Uni-

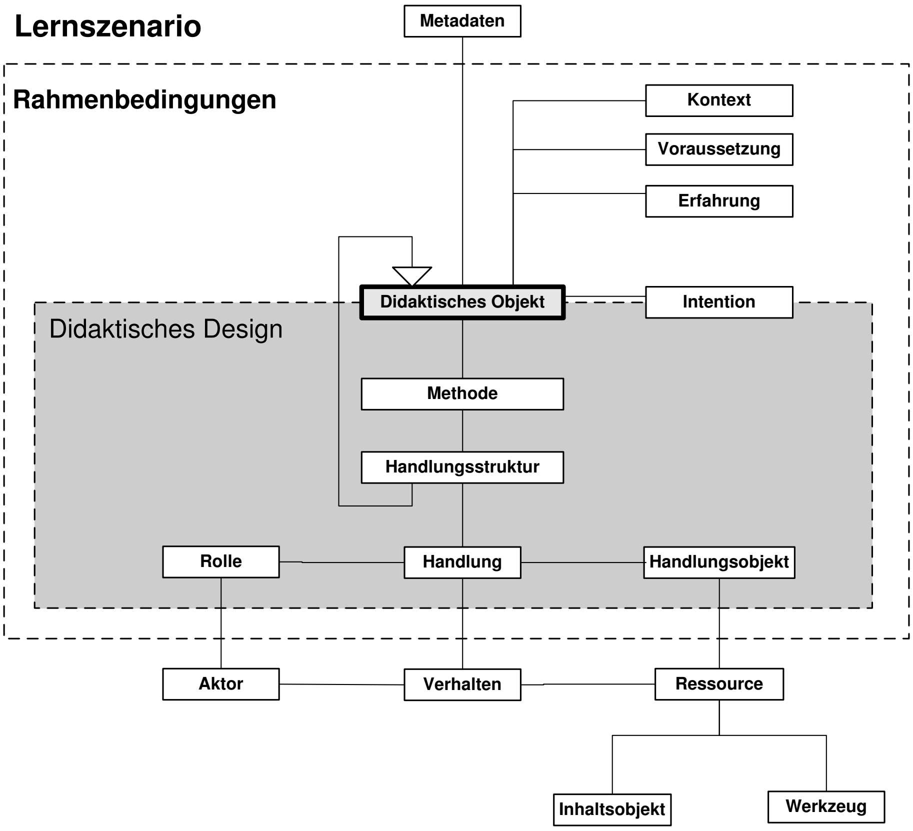


Figure 6.2: The conceptual model of the DIN Didaktisches Objektmodell.

versität Duisburg-Essen), Christoph Richter (Research Center L3S), Christian Stracke (eLC International Institute for eLearning, Information and Cooperation), Maik Stührenberg (Universität Gießen), Kristina Unverricht (Verbraucherrat des DIN e.V.).

6.1.1 Central Concept: Instructional Object (DO)

First, the specification PAS 1032-2 (DIN DOM) and its core concepts are explained. As the conceptual model is published in German a translation of all categories and concepts is given:

- Lernszenario - scenario of learning, unit-of-learning;
- Rahmenbedingungen - contextual conditions;
- Didaktisches Design - Instructional Design;
- Metadaten - metadata:
- Kontext - context;
- Voraussetzung - requirement;

Objective	**Description**	**Example**
Selection	Catalogs listing available learning resources; support for selecting; sampling consistent sequences of learning objects (LO).	Metadata (e.g. IEEE-LOM). Portals for learning objects (e.g. EducaNext, Ariadne)
Arrangement	Sampling and arranging learning resources in a package (container).	Export and import of content, content packaging (e.g. SCORM^{TM}).
Describing Processes	Defining structural elements in order to prescribe a process of learning and instruction.	IMS Learning Design, Educational Modelling Language (EML), DIN DOM.

Table 6.1: Objectives of specifications and standards for learning technologies (cp. Klebl, 2004, enhanced).

- Erfahrung - experience;
- Didaktisches Objekt (DO) - Instructional Object (DO);
- Intention - intention;
- Methode - method (instructional model, learning model, pedagogical approach);
- Handlungsstruktur - structure of activities;
- Rolle - actor role;
- Handlung - activity;
- Handlungsobjekt - object of activity;
- Aktor - actor;
- Verhalten - behavior;
- Ressource - resource;
- Inhaltsobjekt - information asset;
- Werkzeug - tool.

The categories *intention*, *method*, *actor role*, *activity*, and *object of activity* describe the structural elements of a learning scenario itself. The categories *context*, *requirement*, and *experience* describe the situational context and contextual conditions. Central category is the *Instructional Object* (Didaktisches Objekt,

Figure 6.3: In DIN DOM the *Instructional Design* and its contextual conditions form the *Instructional Object*.

DO). The DO, which is a unit-of-learning at any level of aggregation and granularity (course, module, learning activity), is related to its situational context, contextual conditions, and resources used. The *Instructional Design* along with its *contextual conditions* form the Instructional Object (figure 6.3).

6.1.2 Central Category: Method

DIN DOM focuses on explicitly describing learning models, teaching strategies, and pedagogical approaches. The category *method* comprises learning models, teaching strategies, and pedagogical approaches. Ir reflects the underlying rationale of a learning scenario and determines the structure of activity. (figure 6.4).

The *Instructional Design* describes the structural elements of a learning scenario. Any element relevant to plan, initiate, structure, and evaluate learning processes is described and related within the *Instructional Design.* Central category within the Instructional Design is the category *method* as any learning design is based on a specific learning model and pedagogical approach. The *method* explicitly refers to an epistemological foundation and reflects an underlying rationale which guides the design of the learning scenario. The theoretical foundation goes beyond purely sequencing activities.

Method is a central category in DIN DOM, as the specification focuses on making explicit the method a unit-of-learning is based on. DIN DOM allows to describe a *method* and to refer to further external resources (e.g. literature which explains the method. The scope of the element method in DIN DOM differs from that in IMS LD. IMS LD describes a method by the sequence of activities specified in the unit-of-study itself (bottom up, step-by-step): *"The method contains two*

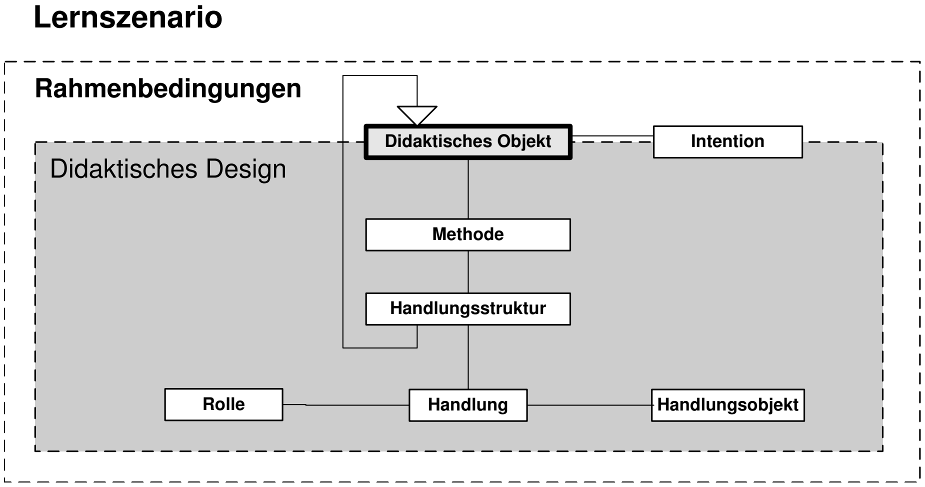


Figure 6.4: The central category *method* in DIN DOM.

core parts of the Learning Design Specification: the play and conditions, along with some completion and on-completion statements" (IMS Global Learning Consortium, 2003b). In IMS LD deciding which method a unit-of-study is based on, means to decipher any activity specified by the unit-of-study step by step. In contrast, DIN DOM allows to explicitly refer to a specific method, its theoretical foundation, and underlying rationale.

6.1.3 Focusing on Contextual Conditions

The category *Instructional Object (DO)* relates the Instructional Design to its contextual conditions (Rahmenbedingungen).

The contextual conditions describe situational aspects which are relevant with regard to the DO (figure 6.5). DIN DOM distinguishes between the context as intended (*context*) and the actual context of use (*experience*). The experience refers to the experience made during the course of a unit-of-learning. The DO is not modeled as isolated, but as embedded in a context. Contextual conditions play a major role when planning and selecting a suitable learning design. This conceptualization, which takes into account contextual conditions, is based on the Hamburger Modell (Schulz, 1980). Focusing on the categories method *and* contextual conditions in DIN DOM allows to systematically collect and systematize experiences made with a specific pedagogical approach.

In contrast to other specifications DIN DOM strengthens the description of the context of an unit-of-learning. This comprises the *context as intended* as well the actual *context of use.* The category *context* refers to the context the DO is intended for. The category *experience* refers to the actual context during use: Which experiences have been made during runtime? How has the DO been used? Is it a best-practice example? A bad-practice example? Sorts of context are: Organizational conditions as well as personal, institutional, and economic resources.

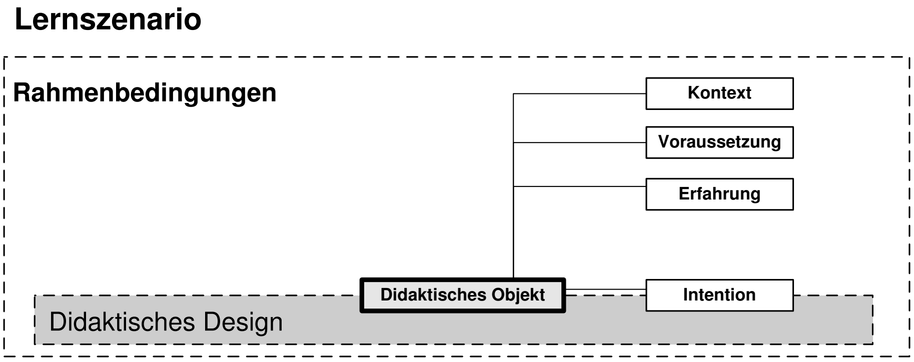


Figure 6.5: Focusing on contextual conditions.

The category *requirement* refers to any requirement relevant regarding the unit-of-learning. Requirements comprise tools, resources, skills, etc.. For example, (missing) skills of learners and teachers can co-determine the selection and implementation of a specific method.

6.1.4 Meta-Level Category ***Role Type*** in DIN DOM

Describing learning processes as sequence of planned activities of teaching and learning, is central in DIN DOM as well as in IMS LD. The structural elements in DIN DOM describing a process of learning are: *actor role*, *activity*, and *object of activity*. These categories are comparable with elements in IMS LD, Level A (*role*, *activity*, *environment*), as the DIN DOM working group decided to build upon the work of IMD LD. But, there are two differences in the meta-model, which are crucial:

1. DIN DOM distinguishes the meta-level category 'role type' from 'natural type' (M1);
2. DIN DOM refers to the meta-meta-level category 'meta-type' (M2).

The meta-level category role type allows to model the diversity of pedagogical approaches in DIN DOM (figure 6.6). Even though IMS LD knows the role type actor *role*, which is used intuitively, it does not know the meta-level category role type itself. The structural elements *role*, *activity* and *environment* in the conceptual model of IMS LD are modeled as natural types.

The actor role in IMS LD means that an actor can play several roles, and that one and the same role can be played by several actors: *"when the learning design is instantiated and actual people have been assigned to the various roles"* (IMS Global Learning Consortium, 2003a). In DIN DOM not only the actor role is modeled as role type, but also *activity* and *object of activity* are role types. When instantiated, a *behavior* fills the role *activity* and a *resource* fills the role *object of activity*. The pedagogical approach (*method*) which guides the design of the unit-of-learning defines the set of roles the natural types *actor*, *behavior* and *resource* fill in a learning process. In contrast to the concept *behavior*, the concept *activity* is defined as goal-orientated (Aebli, 1993). Within a learning process a behavior becomes an *activity.* The learning model defines the role, the behavior fills. The behavior now works intentional within the learning process.

One and the same object, e.g. a text, can fill different roles in different units-of-learning. It depends on the pedagogical approach whether a learner (actor) reads (behavior) a text (resource) for *orientation* in an expository scenario or as *problem statement* in a scenario of problem-based learning. A resource fills the role *problem statement* in the one scenario and *outcome of a brainstorming activity* in another scenario. Not only actors, but also resources, and behaviors fill different roles in different scenarios. While an approach of Expository Teaching defines the actor roles *teacher* and *learner*, a Community of Practice approach defines the roles *community coordinator*, *core member*, *active member*, and *peripheral member.* These roles, which are specified according to a specific method (model of learning), can not be matched.

Instruction does not only mean to select and sequence activities and resources, but also to decide for what purposes they are used. This means to decide what roles they fill within a learning process. In a learning process a text is not an information asset per se, but an information asset which fills a specific role. Besides this, the meta-level category role type allows to distinguish between design and runtime. A text is a text and only during runtime it is instantiated to fill the role problem statement.

The meta-level category *meta-type* allows to refer to an external epistemology and to concepts which can not be formalized. From reflecting pedagogical meta-models such as the 'Bildungstheorie' and the 'Hamburger Modell' we know that education is not just about sequencing learning activities and resources and assigning them to roles (even if this seems obvious from a technical point of view), but that there are decisions on higher levels of reflection. Concepts such as Bildung and Engagement but also epistemological foundation and underlying rationale are crucial as they guide any decision within the design of a unit-of-learning. The category *method* in DIN DOM reflects the meta-type (M2) as it refers to concepts, which go beyond what can be described in the conceptual model of DIN DOM.

6.2 Second-Order Learning Objects

Processes of innovative and generative learning as well as processes of knowledge-creation can be fostered, but neither determined nor prescribed and preplanned. The design of learning activities can not determine the learning process and the course of actions itself. Teaching and instruction do not determine learning (cp. Scheunpflug, 2001).

6.2.1 Fostering Generative Processes

IMS Learning Design mentions the relevance of unplanned processes for collaborative learning. Whereas Level A and B do strictly separate design time from runtime (figure 6.7), Level C is designated to events generated in the course of the learning activity (during runtime):

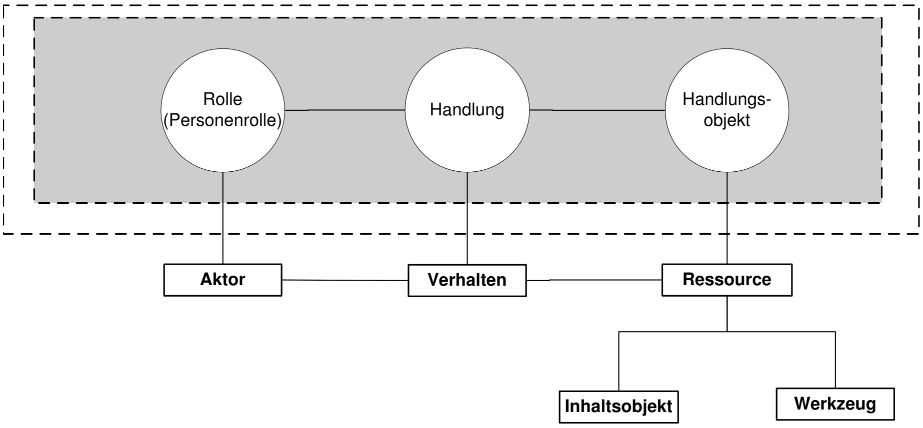


Figure 6.6: The meta-level categories *natural type* and *role type* in DIN DOM. Natural types are indicated with a rectangle, role types are indicated with a cycle.

> "Learning Design Level C introduces notification or "messaging" both between system components and between roles. This adds a new dimension by supporting real-time event-driven work/learning flow. Activities can then be set as a consequence of dynamic changes to the learner's profiles and/or of events generated in the course of the learning activities. (. . .) More generally, it enables the automation of learning flow activities, which are triggered by the completion of tasks, rather than the learning flows being preplanned. Collaborative events can be supported where the activities of roles are dependent on the state of the activities of others. These can therefore be designed as a network of event rules rather than as a preplanned order of events. A consequence of this dependence on runtime events is that the activities set to learners are no longer predictable, whereas in Levels A and B, the ordering of learners' activities is wholly predictable." (IMS Global Learning Consortium, 2003b)

It is not the collaborative character of learning activities which makes them not strictly preplanable and prescribable, but the generative character (as outlined in the chapter on learning concepts). Nevertheless, collaborative learning processes often are generative.

The best practice example *'Problem Based Learning'* taken from the IMS LD Best Practice Guide (IMS Global Learning Consortium, 2003a) demonstrates: Preparation and postprocessing of generative processes are prescribable and well-planned, but the generative activity itself (*carry out research*) remains unstructured. Learners are not supported anyhow (figure 6.8).

To successfully manage, accomplish, and reflect processes of generative learning, learners require competences in several spheres, such as project management, problem solving strategies, team management, strategies of (scientific) inquiry, self organization skills, strategies to learn from faults and imperfections, etc.

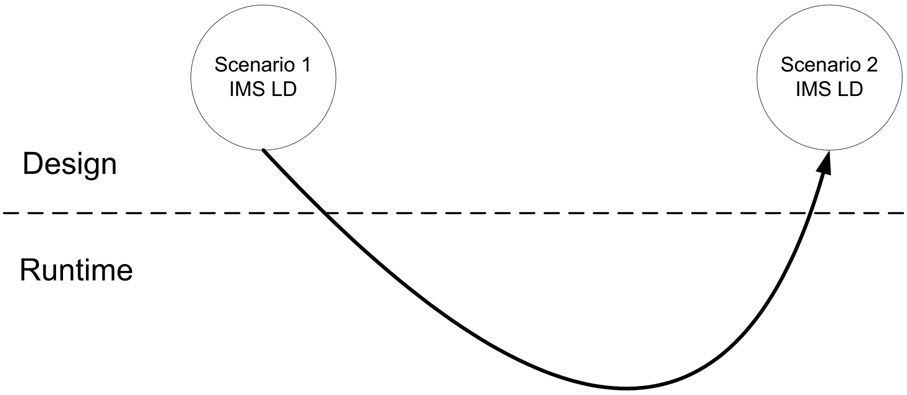


Figure 6.7: Separating design time from runtime in IMS LD. Scenario 1 and scenario 2 are preplanned and prescribed with IMS LD Level A and B. In IMS LD Level C is designated to events generated during runtime.

Some learners have all these skills and competences. But those learners and groups which have not are lost soon as the cognitive load (concentrating on both, the strategy and the contents of the project) is immense. As most learners need support and guidance to manage and structure generative processes, the guiding question beyond Second-Order Learning Objects is: How to supported generative learning processes without determining them[1].

Second-Order Learning Objects are shared schemes. They communicate strategies and foster generative learning. Instances of SOLOs are *shared mediating artifacts*, facilitating the generative process of learning (e.g. within a group) and organizing collaborative work and learning around the *shared knowledge artifact.* Planning, structuring, and reflection are an integral part of the learning activity.

6.2.2 First- and Second-Order Learning Objects

The concept of learning objects has attracted a lot of research and discussion in the field of Educational Technology. Nevertheless, there is no general agreement on a definition of learning objects (cp. Polsani, 2003; Wiley, 2003). While in principle, IEEE-LOM's definition of a learning object as "*any entity, digital or non-digital, which can be used, re-used or referenced during technology supported learning*" (IEEE LOM, 2002) is open to a wide variety of objects and conceptual ideas. Discussions have addressed questions such as:

- Whether the concept of learning objects is restricted to digital resources, or whether it also includes non digital resources;

---

[1] The concept of Second-Order Learning Objects presented in this chapter has been previously described in the British Journal of Educational Technology (Allert et al., 2004). The concept of Second-Order Learning Objects is based on work done by my colleague Christoph Richter, who investigates the use of mediating artifacts as a means for planning and organizing (collaborative) learning activities (Richter et al., 2005).

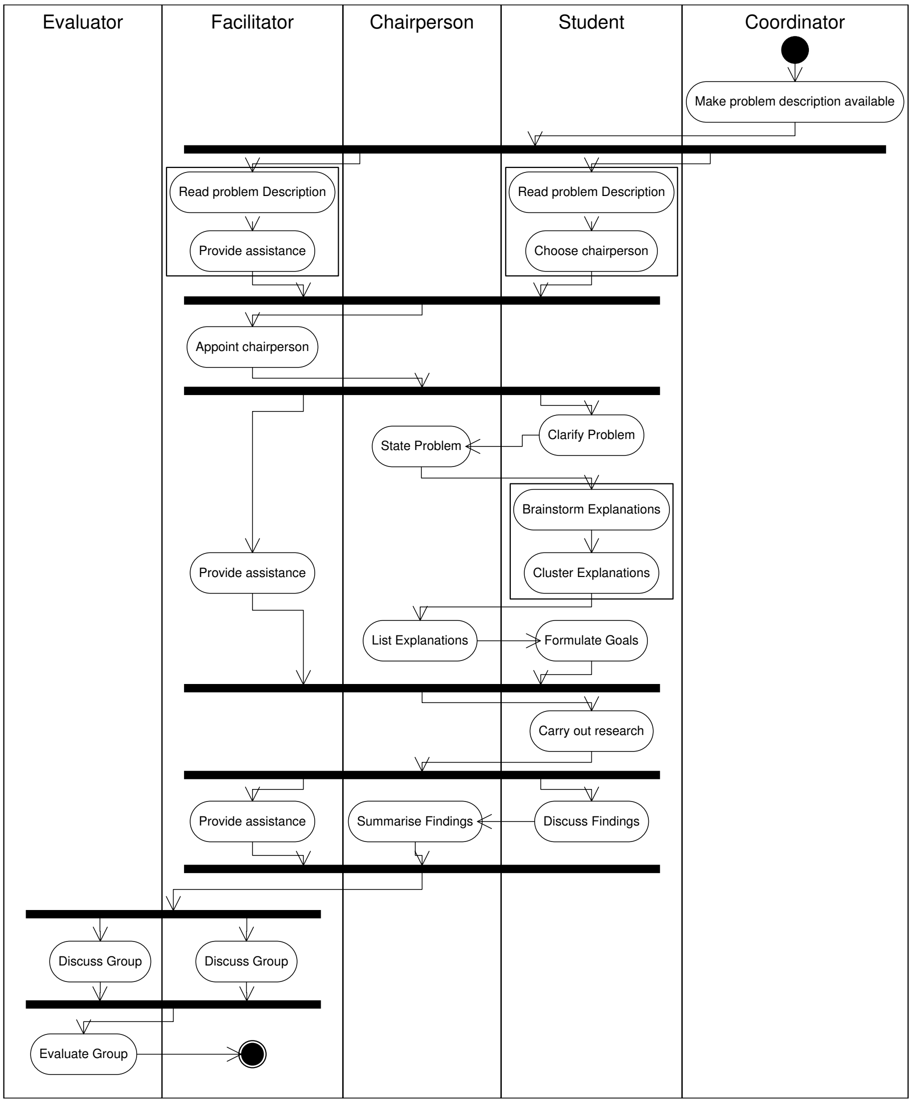


Figure 6.8: UML Activity Diagram for a prototypical unit-of-study *Problem-Based Learning* - taken from IMS LD Best Practice Guide (IMS Global Learning Consortium, 2003b).

- whether a learning object is a resources which is explicitly designed for learning purposes, entailing an inherent learning objective, or whether a learning object is any resource which is used in a process of learning.

With regard to the concept of lifelong learning a crucial question is:

- Whether the concept of learning objects is limited to reproductive aspects of learning, or whether it also addresses productive aspects of learning.

Current standards focus on the reproductive aspect of learning (cp. Allert et al., 2003). In this section the scope is broadened to the use of learning objects in scenarios of generative learning, that is the productive aspect of learning. Two types of learning objects, which are structurally different and complementary, are distinguished: First-Order Learning Objects (FOLO) and Second-Order Learning Objects (SOLO).

First-Order Learning Objects are resources which are created or redesigned towards a specific learning objective. The learning objective is an integral part of the First-Order Learning Object, no matter if it is explicitly stated or not. Usually FOLOs are designed to present information, which has to be acquired and re-constructed by the learner. Textbooks, lectures, educational films, and simulations are examples for First-Order Learning Objects (cp. the category *learning resource type* in IEEE LOM, 2002). FOLOs are content-driven.

Second-Order Learning Objects are resources which provide and reflect a strategy, such as generative strategies, learning strategies, problem solving and decision making strategies. They are a medium for planning, structuring, reflection, and inquiry. SOLOs are a means to foster knowledge creation as they provide scaffolds, schemes, generative scripts, strategies, and conceptual models. They foster generative and reflective activities as part of productive processes on an individual, collaborative, organizational, and societal level.

Defining different types of learning objects is based on current contributions in the field of educational metadata. For example, Wiley (2003) argues for a clear separation of instructional strategies and content: *"(...) learning objects should not contain content at all; rather, they should contain the educational equivalent of algorithms - instructional strategies (teaching techniques) for operating on separately available, structured content"* (p. 6). Also the Educational Modelling Language EML (Koper, 2001) and IMS Learning Design (IMS Global Learning Consortium, 2003b) separate the description of learning processes and activities from the description of learning resources. The concept of Second-Order Learning Objects alters the present notion of learning objects, as the learning strategy itself becomes a learning object.

The notion of First- and Second-Order Learning Objects refers to the notion of first- and second-order learning environments introduced by Scardamalia and Bereiter (1996). While in a first order learning environment learning can be seen as the adaptation to the environment and the predefined learning objective and therefore is reproductive, learning processes facilitated by a second-order learning environment change the environment itself so that an ongoing process of change and re-adaptation evolves. Processes of knowledge-creation, including inquiry, reflection, and innovation, which take place in second-order learning environments are ill-structured generative processes. Processes of inquiry, reflection, and innovation are open with respect to their results. They do not succeed without planning, but are insufficiently described by planning. In contrast to reproductive learning these processes can hardly be predetermined. Accordingly, Second-Order Learning Objects are not formal process models controlling the workflow of learning but collaborative artifacts mediating processes such as planning, structuring, organizing, reflecting, and communicating knowledge generating endeavors.

Here is a list of some classes of generative strategies which constitute Second-Order Learning Objects:

- Meta-cognitive strategies for individuals and groups;
- creativity techniques for individuals and groups;
- methods that foster organizational development, including double-loop-learning;
- evaluation (reflection) on an organizational and societal level;
- learning strategies;
- methods for conducting inquiries (how to make a survey, etc.);
- approaches that help to organize and foster interaction and learning on a community level (Communities of Practice, virtual conferences, open space, etc.);
- methods of scientific inquiry;
- methods for strategic planning;
- problem solving and decision making strategies.

Besides productive learning, SOLOs support self-regulated learning. According to Reiserer and Mandl (2002) lifelong learning is characterized by self-regulated learning. *The notion of lifelong learning implies that learning is largely planned, accomplished, controlled, assessed, and evaluated by the learner himself* (p. 924, translated). The learner decides about the learning objectives and the strategies (cognitive, meta-cognitive, and resource-oriented strategies). Examples of SOLOs supporting self-organized learning are SOLOs such as *Become Acquainted with a New Topic*, *Preparing for a Presentation*, and *Embed Learning into Your Work Flow.*

SOLOs support the development of skills and competencies, such as:

- Managing and structuring information;
- decision making;

- problem solving;
- mediating skills;
- planning skills;
- entrepreneurial skills;
- strategic management;
- organizing team-oriented work;
- planning and coordinating projects;
- self-regulated learning.

Whereas SOLOs provide learning strategies, FOLOs provide learning content. SOLOs support the development of competencies such as meta-cognitive skills. Due to their inherent character, these competencies cannot form learning objectives which can be directly worked towards and reached completely. Learners do not asymptotically approximate these learning objectives. There are no fixed criteria and benchmarks. Achieving these competencies is an ongoing and dynamic process. Just as someone who is competent in strategic management has to adjust his strategic competencies within any unforeseen situation in any new project, learners have to advance these competencies within any new situation and project. These competencies are not gained in isolated and abstract manner. A student of software engineering gains strategic competencies within a project of software engineering. But she or he does not gain it ad hoc and by chance: Developing competencies has to be explicitly supported.

6.2.3 Generative Learning as Situated Action

Generative learning is situated in activities and processes, such as work, innovation, organizational, and societal change. Processes of generative learning are integrated and embedded in their context. They are intertwined with local conditions rather than isolated. Being situated is a basic constituent of generative learning. This section describes the use of SOLOs as mediating artifacts in processes of generative learning and provides an example of use. Then it is shown, that metadata and semantic-based techniques can be used as a means for planning, structuring, reflection, and collaboration in generative learning processes.

Second-Order Learning Objects as a means to plan and organize activities. Plans are artifacts which outline the relation between intentions, activities, resources, and outcomes. As plans and generative scripts play a prominent role in processes of generative learning they are a representative of Second-Order Learning Object. As processes of generative learning are bound to specific situations, the creation and adoption of plans cannot be separated from the context and the learning activity itself, but has to be tied to the concrete situation. Consequently, plans can and usually have to be modified or changed in the course of the activity. Plans support structuring activities and processes. SOLOs support

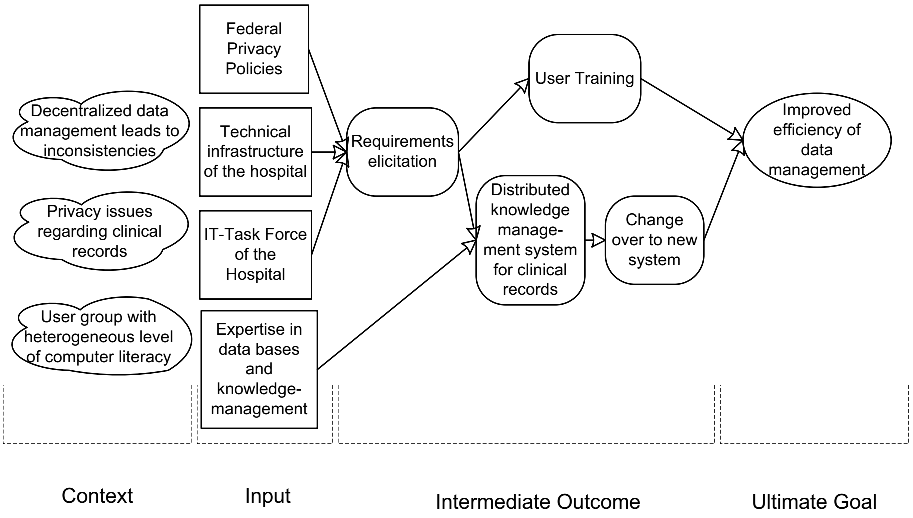


Figure 6.9: Program Logic Map of the project *Computer-Supported Clinical Record Management.*

learners to make plans. Planning, structuring, and reflecting is an explicit and integral part of generative learning. SOLOs are modeled according to various methods. There are many methods which guide the creation of plans.

To explain the concept of SOLOs, an example, which is taken up throughout the following sections, is outlined: The SOLO *Program Logic Mapping* represents a model of a planning method, called Program Logic Map (PLM). This SOLO is used and instantiated by a group of students in the fourth year at a University of Applied Sciences. In the fourth year, students are responsible for a project, such as the project *Computer-Supported Clinical Record Management.* With support of a SOLO, the students plan the program they will implement. Figure 6.9 it is a graphical representation of the Program Logic Map the group draws. It is the shared mediating artifact instantiating the SOLO. According to the notation chosen, clouds represent the context of a project, rectangles the available input and resources, rounded rectangles the intermediate goals, and ellipses the ultimate goal.

Second-Order Learning Objects as a means to structure processes. The use of SOLOs as a representation of planned activities is different from that of formally specified learning designs. In the latter case the description of learning activities is seen as self-contained and represented in a formal process model. In contrast, SOLOs do not automatically control the flow of activities but assign planning to the learning activity. They allow to modify and change plans and schemes during the course of the activity. For example, the creation and modification of a Program Logic Map is crucial throughout the life cycle of a project. Thereby, changes and alterations are of great importance, as Bardram (1997) states: *"Deviating from a plan is a breakdown and therefore a potential learning situation"*. Deviations motivate and require readjustment and modification of plans and the creation of entirely new ones (Volpert, 1999).

Activities are not predetermined but are the product of interacting with an environment. SOLOs are not fixed entities, but are open to change, modification and enhancement.

Second-Order Learning Objects as collaborative artifacts. Within collaborative settings SOLOs facilitate meta-communication to plan, structure and reflect the actual course of activities and the status of a project. Schemes work as knowledge artifacts and mediating artifacts of meta-communication, which are shared and modified within groups. Shared schemes can be used to coordinate activities of different stakeholders and to organize projects and collaborative work. SOLOs integrate individual and organizational learning, as an SOLO inevitable reflects shared meaning making.

SOLOs are shared schemes. SOLOs support the creation of shared mediating artifacts. The Program Logic Map of the project *Computer-Supported Clinical Record Management*, shown in figure 6.9 is a shared mediating artifact, which instantiates the SOLO *Program Logic Mapping (PLM)*. The SOLO provides a scheme, which allows the organize and structure the field of activities. The scheme is specified according to a specific method (the method of Program Logic Mapping). Then, the SOLO is provided and exchanged within a network. A group of learners searches for a suitable SOLO within the network, finds one, and instantiates it. During the course of their learning process they do not only create, modify and change the instance of the SOLO (the shared mediating artifact), but eventually also modify the SOLO (the scheme) itself as they adapt the SOLO to the specific situation they face. Then, they make available the new SOLO again. Schemes reflect certain practices, which are common within a community. Modifying schemes means making explicit (organizational and societal) learning.

Knowing *how* things are usually done is an important prerequisite for being integrated in a community. Improving such practices and extending the set of available strategies means innovation and change. New strategies are created in the course of activities and are reflected in schematic representations in order to establish new routines and to extend the set of available strategies.

6.2.4 Modeling Second-Order Learning Objects

The character of situated activities defines some requirements regarding the modeling approach:

- SOLOs have an intended purpose and a theoretical foundation (e.g. a method, a learning model, etc.);
- SOLOs must be open to change (as a consequence of generative processes being situated);
- SOLOs represent a strategy abstracted from concrete content;
- in order to enable collaboration, SOLOs must encode a shared and explicitly defined meaning.

Intended purpose and functional equivalences. A SOLOs represents the description of a strategy, abstracted from any particular activity. Besides a description of activities, they include the intended purpose of these activities. This is crucial as a learner must be able to change the plan according to the situation he is confronted with. Changing a SOLO is a consequence of situated action. SOLOs must allow reflection and change, as design and execution (plan and performance) of a learning activity cannot be separated from each other. Plans must be adapted to the actual situation. Only if an actor knows the intended purpose (role) of an activity, he is able to reflect whether the activity planned is suitable to the situation he is confronted with. Knowing the intended purpose allows to: Adapt the plan to the actual situation, deviate from the plan, and change the plan. Functional equivalences mean to select and perform an alternative activity which fills the same role and purpose.

A SOLO explains which role an activity fills within the learning process. Some examples illustrate this:

- A test or exam can serve different purposes (fill different roles), such as *selection* or *constructive feedback*. The relevant question is, what role it is meant to fill within the learning process.
- An oral exam at the end of a term might be equivalent to continuous feedback during the entire term (functional equivalence).
- A learning activity (e.g. a discussion) might proceed entirely different and might produce different outcomes depending on the role it fills.

Changing plans. SOLOs must be open to change. SOLOs and tools, which integrate SOLOs, must allow non-linear procedures such as iterations and recursions. Learners must be able to integrate activities, which are not described by the SOLO. Learners must be allowed to combine and mix different SOLOs. According to the concept of exchange and reusability, modified SOLOs are shared again.

Natural types and role types. As SOLOs are sets of roles, the modeling approach of Learning Roles allows to describe SOLOs. SOLOs define sets of role types according to a specific method. The method reflects an underlying rationale. A role type represents the function and intended purpose a resource fills within the learning process. FOLOs as well as further SOLOs can be referred to as instance of a natural type filling a role type.

The use of the SOLO *Program Logic Mapping.* According to figure 6.10, Program Logic Mapping comprises the roles *context*, *input*, *intermediate outcome*, and *ultimate goal.* According to the SOLO *Program Logic Mapping*, these aspects are relevant structural elements of the program-management-strategy Program Logic Mapping and hence, form role types. Information assets, persons, services, technologies, and activities are natural types which can fill these role types. For example, the information asset titled *Federal Privacy Policy* is an instance of the natural type *information asset* which fills the role type *input.* Resources are instances of natural types which can fill roles specified by the

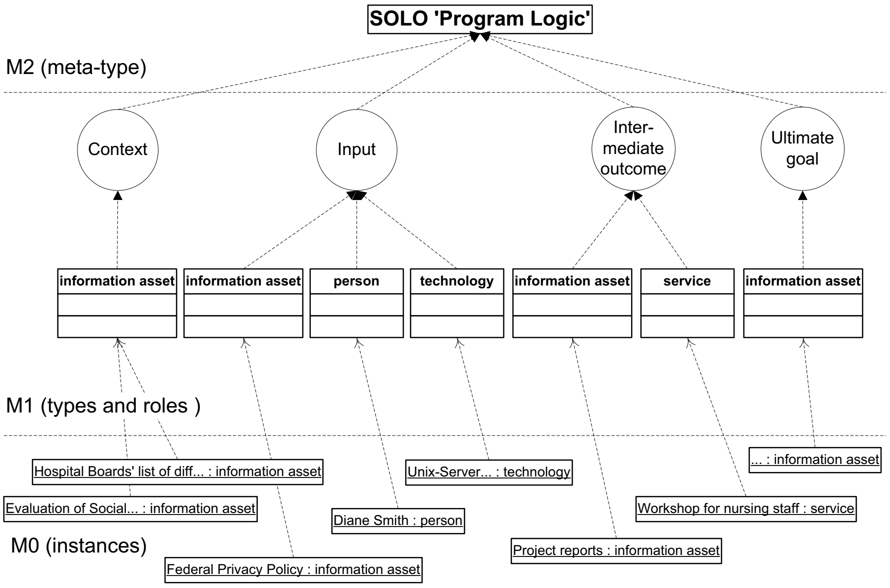


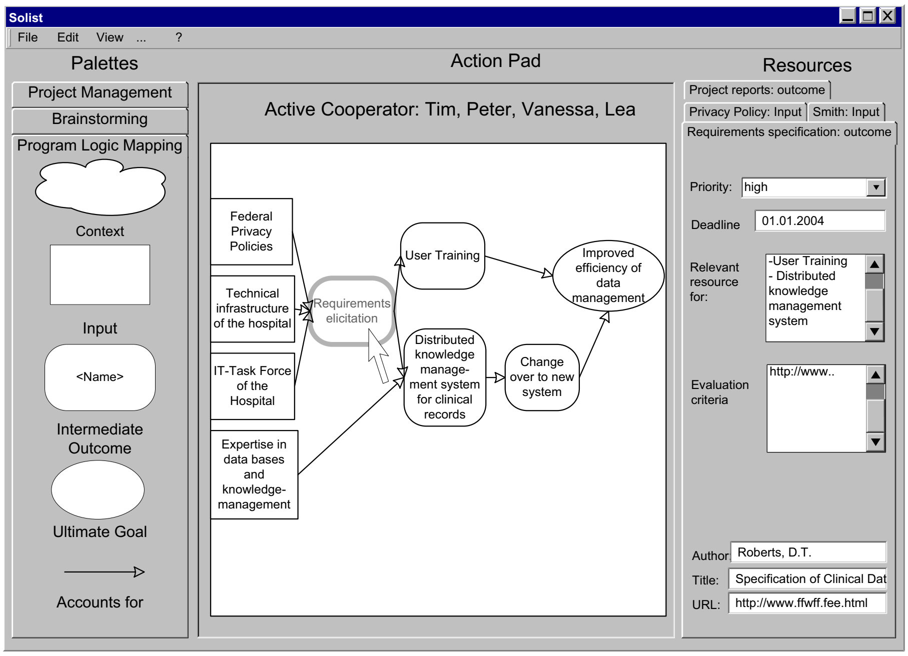
Figure 6.10: Modeling a Program Logic Map scenario.

SOLO. Resources (instances of natural types) can, among other objects, include First-Order Learning Objects (FOLOs) and further SOLOs. According to the modeling approach of Learning Roles, a SOLO is a set of role types, representing a coherent system. A SOLO is a shared scheme. A SOLO which is instantiated by a group of learners is a *shared mediating artifact*, which structures and supports collaborative work and generative learning.

6.2.5 Applications Integrating SOLOs: SOLIST

Comparable with a Learning Management System, which integrates learning objects (FOLOs), there are tools which integrate SOLOs. This chapter gives an example of how such a tool might look like and how it might be used. A group of learners plans to conduct a session of Program Logic Mapping. They search for a suitable SOLO and integrate it into a tool. Within the tool, the SOLO is represented as a palette: Roles are represented as icons in the palette (figure 6.11). A double-click onto an icon shows the description and intended purpose of this role. The group can drag&drop any icon onto the action pad (the shared stage). During runtime they reference resources (which can be uploaded to the library or found on the Internet) they use and produce within the session. These resources are instances of natural types filling the role types the SOLO specifies. Resources are instances such as html-files (presenting a problem statement, etc.), text-files, FOLOs (presenting background knowledge), further SOLOs (e.g. brainstorming) and so on.

At any time the group of learners can integrate a new structural element (role type) into the SOLO not specified in the SOLO before. To do so, they generate a new icon and describe it. The SOLO is now modified and can again be shared. Also the process model of the actual session, as visualized on the action pad, can



Priority: high

Deadline 01.01.2004

Relevant resource for: -User Training - Distributed knowledge management system

Evaluation criteria http://www..

Author Roberts, D.T.

Title: Specification of Clinical Dat

URL: http://www.ffwff.fee.html

Figure 6.11: Screenshot of a user interface prototype of SOLIST.

be saved as a file, containing all references to any of the resources and instances used within the session. It is the mediating artifact, shared by the group.

Palette. The palette visualizes the SOLO and its role types.

Symbols. Symbols visualize role types as icons.

Action Pad. The action pad works a shared stage.

Library. The library provides resources, which are referenced as soon as they fill role types (e.g. FOLOs, information assets, further SOLOs).

The concept of strategy-oriented Second-Order Learning Objects is introduced as a means to foster knowledge creation and generative learning. This concept complements the concept of content-oriented First-Order Learning Objects. Core requirements of Second-Order Learning Objects are derived from the situatedness of generative learning processes. Second-Order Learning Objects provide shared schemes which allow learners to structure collaboration and organize learning activities in a meaningful way. The notion of SOLOs as shared schemes has extensive consequences on the use of metadata for educational purposes. Beyond using metadata to ensure the interoperability and re-usability of learning objects, the use of metadata schemes becomes an important aspect of learning itself. The use of the role-based modeling approach allows the use of multiple schemes and overcomes the need for unifying schemes.

Neither the idea of generative learning nor the development of scrips as a means to foster generative learning and knowledge creation is genuinely new. Accordingly, the design of Second-Order Learning Objects and the development of technical support applications can draw on a lot of prior work and ongoing research. Regarding the design of Second-Order Learning Objects input might stem from research regarding the use of external representations for individual and collaborative learning (e.g. Suthers, 2001), the use of scripts and scaffolds for problem solving, the development of modeling languages for design purposes, as well as techniques for knowledge management. Additionally, semantic web technologies provide important means for the creation of powerful technical applications.

Chapter 7

Conclusion and Further Work

Based on analyzing different concepts of learning and instructional meta-models, this work proposed a modeling approach applicable in the field of technology enhanced learning and described its implementation. The analysis of concepts of learning contrasted reproductive with generative learning and isolated with integrated learning. It has shown that learning takes place on an individual, organizational and societal level. The analysis of instructional meta-models presented activity-centered and system-centered models. It stated that sequencing learning activities and resources does not necessarily result in learning. Reflecting current learning technology specifications revealed that they focus on reproductive and isolated learning and are not pedagogically flexible with regard to situated learning.

The modeling approach of Learning Roles provides a role-based functional-structural view on learning scenarios. Learning scenarios are modeled as coherent social systems. The following sections are structured around the relevant aspects I focused on in this thesis.

7.1 Concluding Statements

In concluding this work, the following six thesis statements are given. These statements provide an overview over insights gained and results achieved in this thesis.

Coherent Social Systems for Learning reduce complexity. Learning scenarios form coherent social systems, as roles are related and expectations are tied to roles. They implicitly or explicitly reflect a concept of learning and are epistemologically founded. The model of learning a scenario is based on forms expectations regarding the setting, the actors, the use of media, the learning culture, the learning processes, responsibilities, activities, the form of assessment, relations, etc. A Learning Role models a coherent social system reflecting a specific model of learning. Modeling systems reduces complexity, as meaning processing systems draw a difference between the system and its environment. They define how to process meaning and environmental complexity. According to the modeling approach of Learning Roles contextualized metadata explicitly reflects a model of learning. Role-based modeling facilitates orientation within a given context and allows comparing contexts instead of generalizing and homogenizing across divers contexts (Allert et al., 2003).

Community-Centered Metadata. Meaning is constructed and re-constructed within a context. A Learning Role specifies a set of role-based metadata reflecting a learning model. Consistent use of metadata is more likely to be ensured within communities. This assumption is based on Wenger's notion of *"meaning within communities"* (Wenger, 1998). A community consisting of practitioners and scientists defines a scheme (a Learning Role) based on a discrete model and concept of learning. With regard to the requirement of *pedagogical flexibility* a specification must not prescribe any specific model of learning. To address this requirement, the approach of Learning Roles is based on explicitly modeling diversity. This means, specifying diverse Learning Roles explicitly reflecting discrete models and concepts of learning. Therefore, a Learning Role (a scheme) is not neutral with regard to pedagogical approaches, but viable and expressive[1]. An entity fills different roles within different systems. For example, a person fills the role *Community Coordinator* within a Community of Practice (CoP) while it fills the role *Participant* in a problem solving team. An information asset fills the role *Best Practice* in a CoP while it is used as *Orientation* in a scenario of Expository Teaching. Semantic interoperability is ensured via the type-based and static metadata[2].

Types and Roles to Model Functional Equivalences. Distinguishing *natural types* from *role types* allows to separate an entity from its instructional role and purpose within a learning process. It demands explicitly specifying the purpose. Knowing the purpose allows to dynamically introduce and integrate an entity which has suitable qualities into the learning scenario at any time. It allows to realize alternatives and equivalences. Specifying instructional roles activities, information assets, and persons are supposed to fill, allows to realize functional equivalences in the course of planning and during run time. Based on the situation the learner is confronted with, the learner himself, a coach, and any agent which regulates the learning process is able to integrate an entity, which is able to fill the role, during the learning process itself. The modeling approach of

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[1] According to the modeling approach of LR, the question is not, whether an specification is *neutral/not-neutral*, but whether it is *viable/non-viable*. A LR has to be viable, adequately describing a specific learning model. The notion of viability is based on von Glasersfeld (1995): *"Handlungen, Begriffe und begriffliche Operationen sind dann viabel, wenn sie zu den Zwecken oder Beschreibungen passen, für die wir sie benutzen"* (von Glasersfeld E. (1997). Radikaler Konstruktivismus. Frankfurt: Suhrkamp, p.43).

[2] Applying this concept to LOM would mean to distinguish and identify types and roles. The category *General* is more likely to define type-based attributes of a learning object. The category *Educational* specifies role-based attributes (as the LOM scheme is not neutral regarding concepts of learning (cp. chapter 3)). According to this work, the category Educational is not neutral and flexible with regard to different concepts of learning. Therefore, according to the modeling approach of Learning Roles, LOM may define several sets of attributes (schemes).

Learning Roles is flexible and takes into account concepts of situated, integrated, and generative learning.

Sharing Pedagogically Enriched Schemes. Schemes and specifications are never neutral with regard to an epistemological foundation and Interest of Knowledge. They are pedagogically enriched, as they inevitably reflect a specific concept and model of learning. Friesen (2005) refers to this as pedagogically engaged. The modeling approach of LRs is based on this finding and recommends to create and exchange pedagogically enriched schemes.

Second-Order Learning Objects. The concept of strategy-driven Second-Order Learning Objects (SOLOs) as a complement to content-driven First-Order Learning Objects (FOLOs) is proposed. In order to specify core requirements for Second-Order Learning Objects this work drew on the characteristics of situated and generative learning processes. It described their use for fostering generative processes and collaboration. Furthermore, it was argued that Second-Order Learning Objects are shared schemes. The notion of SOLOs as shared schemes has extensive consequences on the use of metadata for educational purposes. Until now, metadata has been used to ensure the interoperability and re-usability of content-based learning objects, focusing on reproductive forms of learning; now the use of metadata and metadata schemes becomes an important aspect of generative learning. SOLOs foster planning, reflection and organizing learning processes. Planning is an integral part of learning. The role-based modeling approach of Learning Roles motivates the use of multiple schemes and overcomes the need for a unique and neutral scheme.

Making the Underlying Rationale Explicit. Instructional design goes beyond sequencing learning activities and learning content. Learning designs are based on an underlying rationale, which comprises an assumption of why a program works with regard to an ultimate intention. Butson (2003) argues that specifications focus on the technical description of processes and resources but ignore underlying pedagogical ideas and rationales. Dillenbourg (2002) makes a similar point in the context of CSCL scripts. He stresses the importance of an explicit design rationale that complements the pure sequence of activities described by formal notational systems. Furthermore, Friesen (2005) states, that the approach of object-oriented modeling is of limited value with regard to modeling learning processes. A Learning Role reflects an underlying rationale and underlying foundation (meta-type at M2).

7.2 Further Work

While this work aims to raise an awareness for the significance of generative learning and a provides a flexible modeling approach, there are several directions for future research and development. Further work with regard to the modeling approach of Learning Roles is to implement and empirically test it in different learning contexts. Beyond this, role-based modeling is only a first step towards a system-centered modeling approach providing a functional-structural view on systems. It will be very interesting to investigate further aspects, building on the foundation given in this thesis. Further work has to investigate and prove whether a role type is defined as binary relation (Guarino, 1992) or as n-ary relation (see chapter 5.2). Furthermore, modeling the relation system/context has to be investigated more deeply.

Regarding the notion of community-centered metadata, implementing means to find communities which specify sets of metadata (schemes), based on different concepts and models of learning. For example, the CSCL community might specify sets based on the concept of generative learning and the model of Communities of Practice.

Regarding the concept of Second-Order Learning Objects there are also several directions for future research and development. To date there is no application that allow the use and exchange of arbitrary Second-Order Learning Objects as the learning strategy is often part of the tool and cannot be exchanged and modified by the user (e.g. the knowledge forum CSILE which fosters generative learning). In contrast, the concept of SOLOs aims to exchange those strategies. Semantic web technologies provide important means for the creation of powerful technical applications. A second challenge arises from the fact that generative learning often takes place in informal educational settings and workplace learning. Regarding the design of Second-Order Learning Objects input might stem from research regarding the use of external representations for individual and collaborative learning (e.g. Suthers, 2001), the use of scripts and scaffolds for problem-solving, the development of modeling languages for design purposes, as well as techniques for knowledge management. Finally, we have to learn more about adequate ways to represent SOLOs and mediating artifacts, created and shared by learners. At the Upper Austrian University of Applied Sciences in Hagenberg, this work is started in the context of student's projects. Students instantiate, modify, and create SOLOs, called Minimal Activity Plans (MAPs), reflecting their project-based collaborative learning. These MAPs are constructed in the context of projects, groups of students conduct in cooperation with industrial partners. MAPs reflect the dynamic interaction of individual and organizational learning. They foster self-regulated learning within the groups and are shared within the organization (Richter et al., 2005).

Regarding the specification PAS 1032-2 (Deutsches Institut für Normung e.V., 2004), which integrates the concepts of roles, implementing means to test its validity. Currently a working group of the Forum Distance Learning, an expert forum for distance education, tests its usefulness.

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Appendix A

Curriculum Vitae

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10/1989 - 05/1994. Pädagogische Hochschule, Freiburg i.Br., Baden Württemberg. Erstes Staatsexamen für das Lehramt an Grund- und Hauptschulen, Schwerpunkt Hauptschule. Fächerkombination: Technik, Englisch, Geographie.

10/1994 - 12/1997. Pädagogische Hochschule, Freiburg i.Br., Baden Württemberg. Diplom Erziehungswissenschaften, Fachrichtung Medienpädagogik und Kommunikationswissenschaft.

A.2 Berufliche Tätigkeit

08/1988 - 07/1989. Caritas Verband, Freiburg i.Br., Baden Württemberg. Freiwilliges Soziales Gemeinschaftsjahr.

01/1998 - 12/1999. IQ Consult, Beratungsgesellschaft für Innovation und Qualifikation, Düsseldorf, Nordrhein-Westfalen. Wissenschaftliche Mitarbeit.

01/2000 - 08/2004. Universität Hannover, Hannover, Niedersachsen. Wissenschaftliche Mitarbeit am Institut für Informationssysteme - Fachgebiet Wissensbasierte Systeme und am Forschungszentrum L3S.

Seit 09/2004. Fachhochschule Oberösterreich, Hagenberg, Österreich. Professur Medienpsychologie und Mediendidaktik. Studiengangsleitung, FH-Diplomstudiengang Engineering für Computerbasiertes Lernen.