IMPULS EC

Interdisziplinäres multimediales Programm für universitäre Lehre und selbstorganisiertes Lernen Electronic Commerce

Research Report 11

Didactic Functions and Their Implementation in DTDs – An Interdisciplinary Model for the Structuring of Internet-Based Learning Solutions

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1 Introduction

How can pedagogical approaches be implemented in an information-technical way with document mark-up languages? How can structured environments for computer- and network-based learning and teaching be constructed with document describing languages? How can the high pedagogical quality of learning content and consistent action within the construction process be universally ensured alongside the simultaneous guaranteeing of standard computer-based editing, especially when many different specialist authors are creating content?

The following Research Report is intended to answer these questions.[1] The interdisciplinarily-developed and didactically-accented structure of XML-based learning contents – as developed within the IMPULS^{EC}[2] Project – is the theme of this Report. The structure of the course of study and its development within the PBL-DTD (a XML structure based upon Problem-Based Learning (PBL), which is described in a Document Type Definition (DTD)) are the results of an interdisciplinary construction process involving both information managers and business educators. The respective area-specific approaches and working methods serve as a base for the overall plan during the formulation of multimedia learning solutions.

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[1] Dissertation projects by Wirth (Lehrstuhl Prof. Dr. Fritz Klauser, Title: Situating and Structuring. Construction of Problem-Based) Learning Environments in the Field of Tension between Pedagogy and Technology.) and Jungmann (Lehrstuhl Prof. Dr. Eric Schoop, Title: Development of a Plan for the Creation of XML-Based, Re-usable Learning Content in the Context of Constructivist-Influenced Learning-Teaching Prozesses.) form the basis of this work. Besides these authors, the following colleagues worked on DTDs within the IMPULS^{EC} Project (in alphabetical order): Ildikó Balázs, Michael Berthold, Lars Geldner, Ruben Gersdorf, Lars Hetmank. This Research Report was translated by Robert D. Stewart assisted by Karin Wirth.

[2] The Project IMPULS^{EC} (Interdisziplinäres multimediales Programm für universitäre Lehre und selbstorganisiertes Lernen: Electronic Commerce – Interdisciplinary Multimedia Program for University Lessons and Self-organized learning: Electronic Commerce) is supported by BMBF as part of the program „New Media in Education“.

The publication is divided as follows: XML is introduced in Chapter Two as the information-technical basis for the conceptions and development work mentioned in the paper. The third chapter described the action taken during the development of the structural models. The didactic bases will be described in Chapter Four. Chapter Five briefly describes the results of this project's work in the form of structural components of problem-oriented learning solutions, and Chapter Six introduces the developed PBL-DTD. Finally, the results will be summarized and the need for further research made clear.

2 XML: Base for Information Technology

2.1 Goals

The data exchange standard eXtensible Markup Language (XML) is a flexible Meta markup language that allows a free semantic marking up of data. Opposed to XML is HTML, an application based upon a defined amount of predefined elements which control the presenting of information and currently the most-popular markup language of the World Wide Web. XML is most importantly supposed to guarantee a better exchange of information within the Internet, however, during the development of the specification it was also accepted that XML can be used by a broad spectrum of applications.

The World Wide Web Consortium (W3C) characterizes the XML specification as follows:

> ”The eXtensible Markup Language (XML) is a subset of SGML (…). Its goal is to enable generic SGML to be served, received, and processed on the Web in the way that is now possible with HTML. XML has been designed for ease of implementation and for interoperability with both SGML and HTML” (W3C, 2000).

Since the information contained within XML documents is effectively structured and marked through the use of metadata, it is guaranteed that applications can search, sort, filter, order to process this information in a variety of ways.

Due to this potential, there are a plethora of applications on the market that allow the editing of XML documents. The application possibilities of XML range from document management to the efficient creation of Internet applications and to the support of data exchange within the scope of the Enterprise Application Integration (cp. Turowski & Fellner, 2001).

Within the context of E-Learning, XML is most often used in the following application areas (Jungmann, 2003; Lucke, Wiesner & Schmeck, 2002):

- Depicting of Metadaten,
- Interoperability of Learning Systems (e.g. Learning Management Systeme (LMS), Authoring Systems),

- Exchange of User Data and
- Structuring of Learning Content.

According to the pedagogical perspective, there are two decisive reasons for the use of a custom application using XML for the construction of network-based learning solutions (cp. Gersdorf, Jungmann, Schoop, Wirth & Klauser, 2002):

- The specialist authors would develop the learning content according to a curricularly- and didactically-validated structure described within a DTD and
- The learning content would be user-friendly and presented in a standardized way due to the automatic allocation of the layout, even if several specialist authors were involved in its construction.

The use of XML is supported by the technical perspective for the following reasons:

- Structurally-conform content can be created,
- There is the possibility of reusing individual structural components,
- The platform independence concerning data storage is given,
- A separation between content and structure from the layout becomes possible and
- The contents can be presented uniformly when using formatting languages.

The concept of the metalanguage XML will be introduced in the next chapter.

2.2 Concept

XML is based upon the concept of separating structure, content and layout (cp. Diagram 1) and has become widely-used over the last few years as a flexible mark-up language.

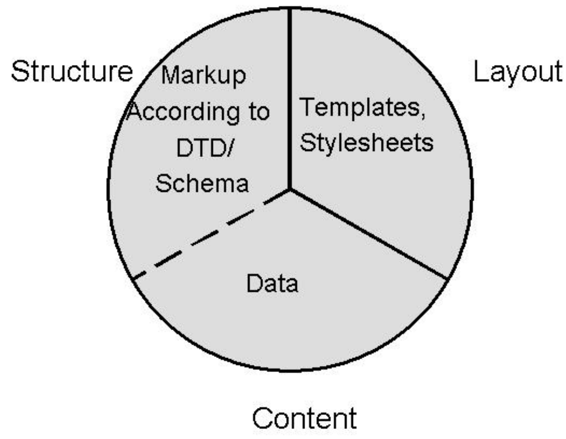

Diagram 1: Components of Documents (cp. Gersdorf, 2002; Schuster & Wilhelm, 2000, p. 374)

More exactly, XML has to be understood as a meta mark-up language that offers the possibility of defining other languages based upon it. Such languages, for example SVG (Scalable Vector Graphics) for the depiction of vector graphics within the Internet or SCORM (Sharable Content Object Reference Model) for the platform-independent creation of learning content (see ADL, 2003) for Internet-based learning solutions are often termed applications (see Diagram 2).

Beside the concept of the metalanguage (see Diagram 2, inner circle) exist the so-called Co-Standards, which are based upon the XML concept but cover specific tasking fields (e.g. the formatting with XSL[3] or the linking with XPointer[4]).

The PBL-DTD introduced in this article is to be placed with the applications (see Diagram 2, outer circle).

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3 XSL (eXtensible Stylesheet Language) is used in order to automatically format XML documents.

4 XPointers deals with application-independent definitions of cross references in and between XML documents.

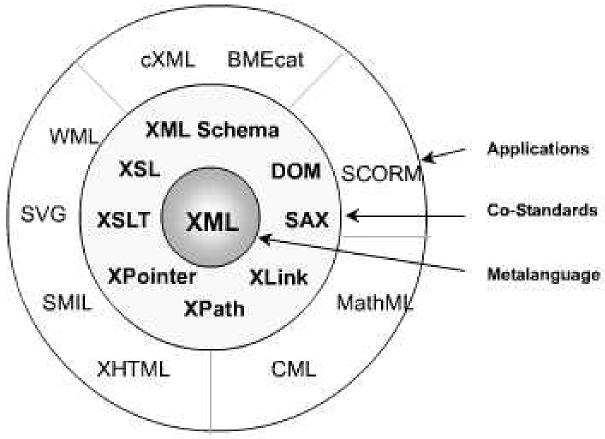

Diagram 2: The Metalanguage XML, its Co-Standards and Applications (Anders, Jungmann & Schramm, 2002; Michel, 1999)

2.3 Structuring of Documents

2.3.1 Structure Definition

XML structures are to be characterized as follows (Lobin, 2000, p. 4):

- A XML application decides which information is there, names this information and specifies its descriptive characteristics.
- The information units are set in relation to each other through certain rules.
- These rules are summarized as a grammar.
- Real information is set in relation to the information units and aligned in a structured manner.

Lobin points out that structured information is nothing more than the „aligning of information units through rules“[5] and compares it with correctly-

[5] Translated by the authors.

structured sentences, which can be understood as the „aligning of words through rules“[6] (Lobin, 2000, p. 4).

The structure of XML documents can be decided by using Document Type Definitions (DTD), which function as a kind of template for the creation of new documents (cp. Goldfarb & Prescod, 2000). In order to do this, it can be decided with the help of markups which tags may exist within the document and how these are to be nested. The most-important advantage of marking up documents conforming to the DTD is (next to the "template-oriented" content structuring) that the marked-up content can be automatically identified and further edited within the scope of a machine interpretative process (detailed classification, searching, combination). The XML concept differentiates in general between well-formed documents corresponding to the XML syntax rules but do not have access to a so-called DTD, and valid documents (those corresponding to a specific DTD and its validity). If an automatable processing is striven for by documents, valid documents must be produced.

XML schema is termed „the next generation of structure-defining languages“ (Phillips, 2002, p. 207). The XML schema definition was approved in May 2001 by the W3C. This concept has in comparison to the DTD the following three advantages (cp. Michel, 1999):

- The application of the same syntax for the creation of both documents and structures,
- Functional surplus value through the additional description of given data structures and
- The simplified descent of the characteristics of declared objects.

Due to the unified usage of the XML syntax in both the schema description as well as in the document, the Parser algorithm is simplified. This happens by the reduction of the set of processable syntactic rules. As a result of this, the performance of the processing is increased. Since no special DTD syntax is need, the language can be easily learned by the programmer. A further important value is the possibility of describing any given data structures.

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[6] Translated by the authors.

Should other advantages of the XML schema than those specifically named be pursued, the XML applications based upon XML DTD and XML schema act identically.

2.3.2 Structure Components

XML documents consist of various information units. These can be divided into two groups. The first group is made up of concrete data, the second of metadata. Metadata can both take on the form of abstract, attributable units as well as contain cross references to external, specific data, which then allocate functions to the concrete data (Lobin, 2000, p. 9).

It can be differentiated between various forms of metadata:

- DTD attributes,
- Standardized metadata (e.g. SCORM),
- Metadata of the Content Management Systems and
- Didactic Metadata.

The abstract units are termed elements and differentiated as follows:

- Data Elements,
- Container Elements and
- Empty Elements.

Data Elements contain concrete data and describe their function. Container Elements consist merely of other elements. Empty Elements show the presence of information units, however they consist of neither data nor elements.

The contexts of the information units are depicted within a tree structure. Through connectors, the occurrence of elements (necessary/optional), the frequency, the order and the alternative occurrences of multiple elements can be shown (Lobin, 2000, p. 10f.).

Altogether, the elements can consist in four different states:

a	→	a must appear at least once
a?	→	a can appear at least once but can also be left out
a+	→	a must appear at least once, and can appear as often as necessary
a*	→	a can appear at least once, or as often as necessary, but can also be left out

To decide the relationship of the elements towards each other, the following connectors are used:

a, b	→	b follows a
a | b	→	either a or b

Additional information can be defined by attributes for the description of the elements' characteristics. For example, an element can be more closely specified through the giving of an attribute *key word*. However, there are often difficulties during the concrete implementation. The decision whether or not to use elements or attributes has to be made within the context of the specific application instance. There is no basic rule of thumb for this (Lobin, 2000). Nevertheless, the following tips have been formulated thanks to experience.

A definition as element is most appropriate if the information will be used through various mediums (e.g. paper or Internet). If attention is to be paid to ordinal relationships and occurrence frequency, information is to be depicted as element content (Lobin, 2000). Furthermore, elements can contain other elements. If information units consist of other information, however, these are to be depicted as elements.

The information that rarely or never is seen is useful as „background or navigational information“[7] and therefore for representation within an attribute (Lobin, 2000, p. 32). A limiting of the content (e.g. the giving of the value *Impuls_Schuh_AG* for the attribute *model company*) is possible at the

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[7] Translated by the authors.

declaration of the attribute but not at the declaration of an element. Elements should always contain a part of the document's content, whereby attributes should show information about these elements.

In addition to elements and attributes, DTDs can contain entities. Entities allow the non-linear organization of document components. In order to use entities, one includes an entity reference in the document. An XML-Processor replaces the Entity reference with the Entity itself, and reorganizes the document into a linear structure. Entities allow, among other possibilities, a division of a whole DTD into multiple, smaller DTDs. The result of this modularization is a clear arrangement and better maintainability.

Besides the three forms of structure components already mentioned, further specifications exist such as the Notation that are not discussed here due to limits on space.

The introduced structure components can be summarized and defined as follows:

- **Element**: a Markup Tag defined within a DTD. The content of the element (e.g. further elements or text) is placed between the Start markup and the End markup,
- **Attribute**: a description of the characteristics of elements,
- **Entity**: an amount of characters that are put together as a unit and are used within the DTD or XML document under a specific name as a text replacement.

The document's structure is decided through XML schema or DTDs[8] (cp. Goldfarb & Prescod, 2000).

2.4 Differentiation from HTML

HTML has been used for simply structured web-based training courses since quite some time, but is inappropriate for larger E-Learning solutions.

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8 In the further course of this article, the original DTD concept, which is sufficient for our application needs, will be introduced.

HTML leads to problems

- during the exchange and reuse of components,
- during the automated processing and
- during the automated evaluation of the document's content.

In addition, there is no attention paid to structural or semantic aspects within the concept of the mark-up language, therefore a specification of the structure happens solely thanks to the layout.

The following restrictions are characteristic for HTML:

- **Limited Structure**: Only format information – not the actual document structures – is described.
- **Missing Validation**: A testing of the structural validity is not possible.
- **A Lack of Expansion Possibilities**: Definite layout-oriented elements are usable, but custom definitions are not possible. Semantic information is not depictable.

By comparing HTML and XML it becomes clear that XML is combined with a higher investment but is, however, better suited for the creation of complex content for network-based teaching-learning processes.

3 Procedure within the IMPULS ^{EC} Project

Within the IMPULS^{EC} Project, document structures for the creation of learning contents were created by interdisciplinary collaboration on the basis of document engineering. The method of document engineering was based on the assumption that – similar to the situation for data engineering – methods were necessary for the application-oriented development of a meta-model over document-internal contentual and structural elements and relationships (Schoop, 1997). The procedure used during the development of a DTD or XML schema has until now barely been documented within the literature. The guidelines of the XML syntax were used during the modeling. The goal is the depiction of the "real world" within a corresponding model system (within the IMPULS^{EC} Project in structure models for didactically prepared learning content).

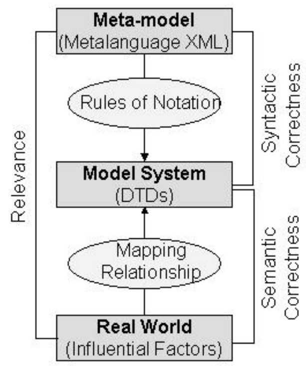

Diagram 3: Model System (based upon Schraml, 1997)

If the development of structure models is to be attempted, the next step is to implement a structuring at the macrolevel.

From the technical point of view, the following aspects are especially important during the creation of the structure model (cp. Jungmann, Wirth, Klauser & Schoop, 2003):

- Reusing of documents,
- Usability during their creation,
- Manageability,
- Access and
- Interoperability.

In the first step, curricular and didactic-methodical structure components are created using the pedagogical overall plan and with attention paid to the application context (here, learning content for the topic Electronic Commerce). As a result of this step, technically formulated, potential semantic components are available that could be used in the document model that will be developed.

The relationships of these semantic components towards each other as well as towards the overall plan, their relevance as well as their implementability are specified in a second step. In this step, the curricular and didactic-methodical structure components are implemented into elements of a DTD. The selection process during the setting of the elements is attempted in an iterativ process with the following phases (cp. Schraml, 1997):

- Basic selection: The amount of the alternatives is reduced and visualized with the fitting instruments. It is thereby decided most importantly which of the curricular and didactic-methodical structure components can be implemented with the help of XML.
- Specific selection: An evaluation of the singular components is attempted. The structure components are formulated in this step. At the naming of the elements, it must be decided how that concrete element can be called (e.g. Question, Assignment, Test) and which attributes as well as entities can be utilized.

Technically seen, a structuring of documents only makes sense at the depth in which the structure information is also being further processed.

Information that can not be further structured (e.g. audio files) is attributed with metadata in order to guarantee fast and precise access to their content.

The following actions are possible during the modeling of DTDs:

- top-down: starting from the root element and continuing to the data-carrying elements, or
- bottom-up: from the concrete content continuing to the highest level of abstraction.

Various “graphical, semi-formal, formal and textual technologies” (Schraml, 1997) exist for the representation of hierarchical document type models. In the IMPULS^{EC} Project, inverted construction diagrams are used whereby a root element in multiple hierarchical levels continuing to the lowest level (the „leaves of the tree“) is refined within its information content (Schraml, 1997).

The development and documentation of the document type model is followed by the implementation.[9] The didactically accented structure will be introduced in the following chapters.

[9] A further research report will discuss the implementation.

4 Didactic Base: Problem-Based Approaches

Within the IMPULS^{EC} Project, situated approaches have been selected for the curricular and didactic-methodical formulation of the course of study "Electronic Commerce". According to the literature, situated approaches are a compilation of concepts assuming that learning takes place within a context whose social, material, motivational and emotional factors decisively influence the way of learning as well as the applicability of the knowledge (Klauser, 1998a, p. 4). Situated approaches are intended to take into account and to consciously create the context relationship of the learning process during the formulation of learning situations (Mandl, Gruber & Renkl, 2002, p. 141).

One elaborate and empirically-tested situated approach for the structuring of learning environments and sequences is Problem-Based Learning. The bases of Problem-Based Learning were developed in the 1960s and since that time received worldwide, both used and further developed for the pedagogically-based dealing with modern information- and communication-mediums (cp. Boud & Felleti, 1994; Klauser 1998b; for E-Learning especially Klauser, 2002). In addition to Problem-Based Learning, other approaches for the situated formulation of learning environments include Cognitive Apprenticeship[10], Anchored Instruction[11] und Cognitive-Flexibility Theory[12]. The following four commonalities characterize situated approaches:

The forming of learning environments is oriented towards the learner and his knowledge, abilities, and skills as well as towards the intended learning process. Specific assumptions form the base of the way of acting (cp. Klauser, 1998b, p. 333). Learning is considered to be the active and constructive relationship between the student and the learning environment. Learners construct their knowledge by interpreting perceptually-conditioned

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10 The Cognitive Apprenticeship approach (Collins, Brown & Newman, 1989) uses the traditional institution of apprenticeship in the area of crafts and its exchange of experience between experts and novices as its example (cp. Mandl, Gruber, Renkl, 2002, p. 145).

11 Anchored Instruction (Cognition and Technology Group at Vanderbilt, 1990) offers the learners complex problem situations in the form of narrative stories, which serve the learners as a cognitive, motivational and emotional anchor (cp. Klauser, 2002, p. 7).

12 Within the Cognitive Flexibility Theory, the focus is on the offering of complex problems from multiple perspectives and in various contexts (cp. Mandl, Gruber & Renkl, 2002, p. 144; Klauser, 2002, p. 7).

experiences and by dealing critically with the offered information, problems and situations in a goal-oriented manner. To do this, it is necessary to offer an independent directing of the learning activities, as well as reflexive and metacognitive learning phases. In addition, effective teaching-learning processes complete themselves within social interaction and communication as well as during the critical handling of the historical and cultural background of the basic information, problems and situations (Mandl, Gruber & Renkl, 2002, p. 140).

The orientation toward the intended learning process is also valid, with changed demands, for the learning environment. Learning environments are to be constructed according to these demands, so that they:

- Offer challenges and can intrinsically motivate,
- Support the identification with the situation in which the knowledge will be applied,
- Allow possibilities to make mistakes and to offer the chance to correct them as well as
- Guarantee a degree of freedom during the processing of assignments.

Situated approaches emphasize the importance of problem-solving processes for learning (Mandl, Gruber & Renkl, 2002, p. 143). According to Problem-Based Learning, learning is planned and initiated as generative problem solving. The student is confronted at the beginning of the learning sequence with a complex problem and consequently generates his knowledge during the process of working on the problem. By working on the problem, the student identifies and localizes the necessary information, makes it usable, adds it to his mental model and evaluates it within the context of solving the problem. Complex problems thus serve as a curricular and didactic-methodical starting point and point of reference. Studies have shown that complex problems are especially effective when they depict situations that are authentic and close to reality, and for the learners subjectively meaningful.

Situated approaches connect criteria for the formulation of curricula to criteria of teaching-learning formulation (connection of macro and micro sequencing). Macro sequencing contains, according to Achtenhagen, Tramm, Preiß, Seemann-Weymar John and Schunck (1992) the temporal arranging of single curricular elements into courses while micro sequencing is understood to be the didactic creation of these curricular elements (cp. Achtenhagen, Tramm, Preiß, Seemann-Weymar & John, 1992, p. 106). This connection relates not only to the area-specific, in other words the goal- and content-related, dimension. The connection of micro and macro sequencing goes beyond this according to institutional situations (cp. Klauser, 1998b, p. 334).

Situated approaches emphasize the importance of the new media for the learning process (cp. for Problem-Based Learning Klauser, 2002, p. 4; and for situated approaches in general Mandl, Gruber & Renkl, 2002, p. 143). The following five advantages characteristic for the new media are the most important (cp. among others Issing & Klimsa, 2002, pp. 1-2; Mandl, Gruber & Renkl, 2002, pp. 146-148; Klimsa, 2002, pp. 15-18):

- The new media, and especially computers and the Internet, support new kinds of interaction and communication.
- They are especially useful for the visualizing of complex processes, of algorithms and working activity as well as for the presentation of complex contexts/relationships.
- New media make easier the creation of complex learning environments and make available through networking and interconnection nonlinear learning paths.
- As a cognitive tool, new media can effectively support the building of mental models.

The contextualizing and structuring of the learning environment occurs within the IMPULS^{EC} Project using situated approaches as the fundament. The technical prerequisite for this is the application of XML. It will be described in the following how network-based learning environments can be formulated using XML as a basis according to pedagogical criteria.

5 Structuring of Multimedia Learning Environments

5.1 Pedagogical Focus of the Construction Processes

The structuring of multimedia, network-based learning environments takes place, according to pedagogical understanding, during the didactic transformation of the specialist material into learning content. Within this transformation process, not only thematic components but also intentional, learning-psychological, methodical and medial aspects must be paid proper attention. The transformation- as well as modelling-processes are oriented towards the anticipated learning goal and the learning process. This process sets both the didactic-methodical structure of a learning environment and its medial preparation as well as the curricular granularity (cp. Gersdorf, Jungmann, Schoop, Wirth & Klauser, 2002). The result of the process is the didactically prepared learning content (cp. Diagram 4).

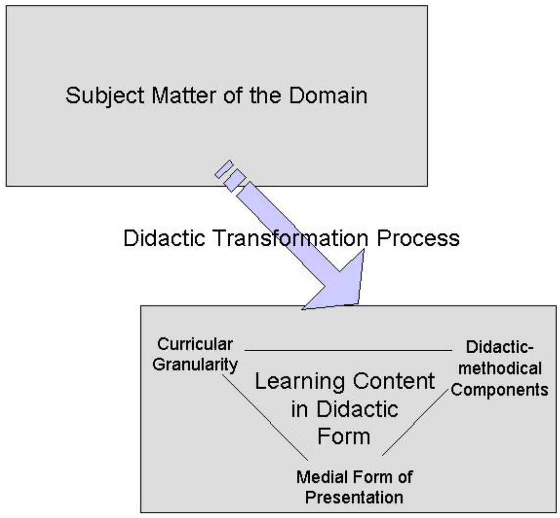

Diagram 4: Didactic Transformation Process

The following questions (among others) must be answered before attempting a didactically-accented development of learning environments based upon XML:

- Which size resp. granularity of the curriculum- and learning units is didactically reasonable for learning environments? More exactly in relation to intended learning activities or expected student achievements as well as in relation to possibilities for qualification and certification?
- Which structure forms the base of the learning environment? Which didactic-methodical components are necessary within this structure for the realization of a student-appropriate learning environment?
- Which medial presentation possibilities are available? Which presentation possibilities should the authors use?

These questions will be answered in the following.

5.2 Curricular Granularity

The search for the optimal size (granularity) for learning units during the development of computer- and network-based learning environments is closely tied to the question of modularity. Modules are defined as a part of a whole (cp. Sloane, 1997; Eckelmans, Haas, Hoppe & Packmohr, 2002). Statements within the technical and pedagogical literature about the criteria that set the granularity of learning environments differ widely, however.

In the technical sense, a module consists of various contentual-related multimedia objects that together fill one or more screen pages. The size resp. the granularity of modules is set by the fundamental specialist material as well as its structure and extent (cp. for example Finsterle & Rotard, 2002, p. 118). The modules – according to this idea – can be developed by various authors, have internal access within each other and as a whole form one learning unit (cp. Eckelmans, Haas, Hoppe & Packmohr, 2002). This assumption can, however, lead to the affect that at the same level modules may result that have very differing sizes.

The size as well as granularity is, according to the pedagogical conception, never only to be determined by the specialist material at its base. From the pedagogical perspective, the next step is to take into account learning-psychological criteria. This includes, for example, the directing of attention as well as the cognitive processing possibilities of learners. In addition, curricular and didactic criteria play a central role.

Within the information-technical discussion about computer-supported courses of study, it is often assumed that contentual units can be put together as desired into modules. The idea that the quality of the (combined) learning units is set merely by the area specific quality of the single modules is the reason for this conception. It is ignored, however, that learning content is area-specific content that must first be didactically prepared for a pedagogical situation and then modeled.

The didactic preparation contains questions like:

- for whom (intended group),
- with which goal (intention),
- in which context (methodical preparation),
- in which order (sequencing),
- with which instruments (media) and
- with which content (selection)

should modules be constructed. These questions are very important for both the creation of modules as well as during the renewed combination of modules into learning sequences.

5.3 Didactic Function

To ensure didactic coherence, learning sequences must be constructed so that the anticipated learning goals and processes are initiated and supported. The learning sequences must fulfil specific didactic functions that are directed towards the phases of the learning process. The didactic functions can be differentiated as follows.

1) **Initiation of the learning process**. The learners receive in this phase a complex problem that is coupled with a task. Complex problems have the function of initiating the anticipated learning process as well as of challenging and motivating the learners. Tasks are supposed to supply the learners with a goal for orientation during problem processing.

   The didactic function of the complex problem corresponds with that phase of the learning process in which the learners orient themselves, take on a situational setting, formulate individual goals corresponding to their interests and execute an initial planning of their learning activities. Complex problems support the learners in this phase: They serve as a point of departure and relation in order to actively integrate the information into the cognitive structure (cp. Klauser 1998b.).

Complex problems should be created to be challenging with the subject of study as well as intrinsically motivating. Therefore, they must be designed to include for the learners the possibility of identification. For the solving of the complex problems, the learners are given all necessary information. The complex problem contains as well information that is only partially or not at all necessary for the solution. The learners are challenged to evaluate all information as it relates to the possibility of that information being useful for solving the problem.

2) **Accompanying of the learning process**. The didactic function of the learning content consists of (in addition to other factors) making available the necessary information, offering help and support as well as giving suggestions as to how the learning content can be processed in relation to differing perspectives and contexts.

The content is to be created so that it contains systematic preparation and structuring. It is to complemented through requests and orders aimed at the goal-directed processing. In addition, the learners are supported in an area specific and non-area specific way as well as by technical or organizational direction and help. During the making ready of learning content, it must be taken into account that the learners must be given the possibility of making decisions during the taking on of supported activities. The didactically prepared content should assist the learners in constructing their knowledge actively by using the problem. Communication and cooperation during the learning process between learners and their Teletutor using synchronous and asynchronous components of the Learning Management System must be guaranteed.

Within this phase of the learning process, learners identify and evaluate the available information as it relates to their goals, use and divide the available resources, organize and classify the learned information, realize their strategies for the processing of the problem and test as well as correct them accordingly (cp. Tergan, 2001; Reinmann-Rothmeier, 2002).

3) **Testing of the learning success**. The testing of learning success takes place through assignments made available within the learning environment. These assignments have a dual function.

   Firstly, testing of the learning success serves to record and evaluate the student's performance and therefore serves the selection as well as qualification process. Assignments of this nature must correspond in an area-specific way to a representative excerpt of the basic learning content and must also be manageable in a technical, organizational way. Next to the correct solution, the relative weighting of the single assignments within the test as a whole must (can) be given.

   Secondly, assignments for the testing of learning success must (may) enable the learners to compare their individual solutions with a sample solution or various alternative results. Using the assignments, learners can attempt a test and evaluation of their own learning activities, their deficits and weaknesses, but also of their progress.

5.4 Medial Forms of Presentation

The introduced didactic functions can be medially presented in a variety of ways. The term "medium" is understood in a mostly technically-oriented definition as follows: "Objects, technical appliances or configurations with which messages can be saved and communicated" (Weidenmann, 2002, p. 46).

Weidenmann (2002) asserts that a multimedia learning environment can be characterized according to three dimensions:

- „Learning environments that are divided between various storage and presentation technologies" are considered to be **multimedial** (p. 47).
- „Learning environments that show differing symbol systems and encoding" (p. 47) are termed **multicodal**.
- In comparison, **multimodal** learning environments are "learning environments that appeal to different sense modalities of the users (p. 47).

A contentual context can, for example, be implemented using written and spoken text as multimodal. Another possibility is to visually implement a contentual context (monomodal) with text and pictures (multicodal).

According to the learning-psychological perspective, when it comes to the question of how learning content can be medially implemented, it by no means is (only) referring to the data format (for example gif, jpg or avi) of the respective documents.

5.5 Different Types of Didactic Elements

If the structuring and sequencing of a learning environment should take place according to a Document Type Definition, then the didactic-methodical components as well as curricular units and medial presentation forms as elements of the DTD must also be decided upon.

According to the question introduced in chapter 5.1, three kinds of DTD element types are necessary for a didactically meaningful preparation of the document structure (cp. Diagram 5):

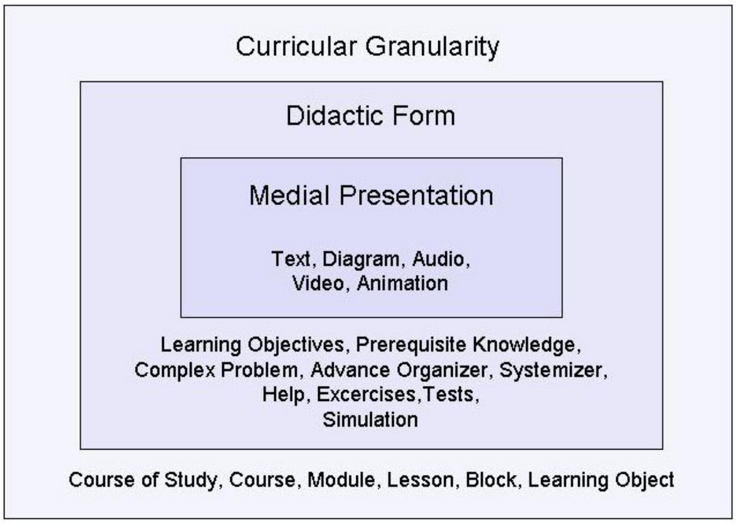

Diagram 5: Kinds of didactic element types

1) **Element types with macro-sequential function**. They answer the question of curricular granularity and modularity. Examples of these elements are lessons, modules or courses.

2) **Element types with micro-sequential function.** They depict the didactic-methodical components within the DTD. Complex problems, learning goal formulations or organizational actions are possibilities.
3) **Element types with presentational function.** They control the medial form of preparation for the learning content. As elements, texts, depictions, videos or animations can be differentiated.

Starting with the didactically-accented element types, the single elements of one DTD structure formulated according to the Problem-Based Learning approach are described in the following. The IMPULS^{EC} Project serves thereby as the main point of reference.

6 The Problem-Based Learning-DTD (PBL-DTD)

6.1 Structural Components with Curricular Granularity

6.1.1 Modularity of the PBL-DTD

The PBL-DTD consists of various partial DTDs that are mostly independent of one another and are only connected to each other through Entity references. These include the following:

- Course of study,
- Learning object,
- Media objects (text, graphics, animation, audio, video),
- Literature and
- Glossary.

The DTD glossary assumes a special role that constitutes an independent application and is not integrated into the PBL-DTD.

6.1.2 Course of Study

Within the PBL-DTD, a *course of study*[13] consists of various *courses*, which are then subdivided into *modules*. *Modules* are made up of *lessons* whose learning content has been transformed into *learning objects*. *Learning objects* are thematic and summarized for the further information-technical processing into *blocks*.

A course of study, as the largest unit for qualification, is made up of various courses. It is the "container" for the single courses. Accordingly, learning goals for the entire course of study are formulated and controlled by testing. Other didactic elements do not exist at the level of the course of study.

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[13] In the following, DTD-elements will be written in cursive.

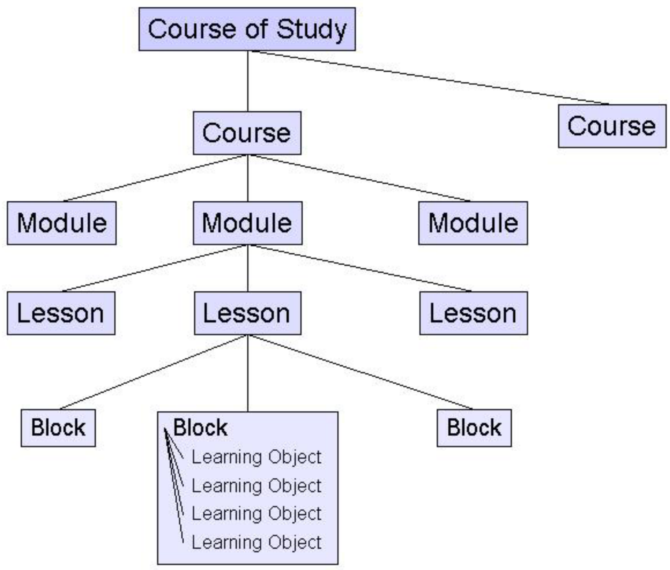

Diagram 6: Curricular Granularity of a Course of Study

6.1.3 Lesson

The lesson is the smallest didactic unit. According to learning psychology, a lesson contains with its 20-30 minutes of presentation time the amount of time calling for a learning break afterwards.

The lesson contains, in addition to the didactic elements depicted in the following diagram 7, the element m*etadata* (for the further processing at the information-technical level) as well as the element *help* and the learning objects that have been summarized into *learning objects*.

The *block* consists of a thematic unit of related learning content that should not be separated. Within one block it is possible to create linguistic relationships between learning objects (e.g. “firstly”, “secondly…”, or “accordingly…”). The student calls on the first *learning object* of a *block* using the *Advance Organizer* of the corresponding lesson.

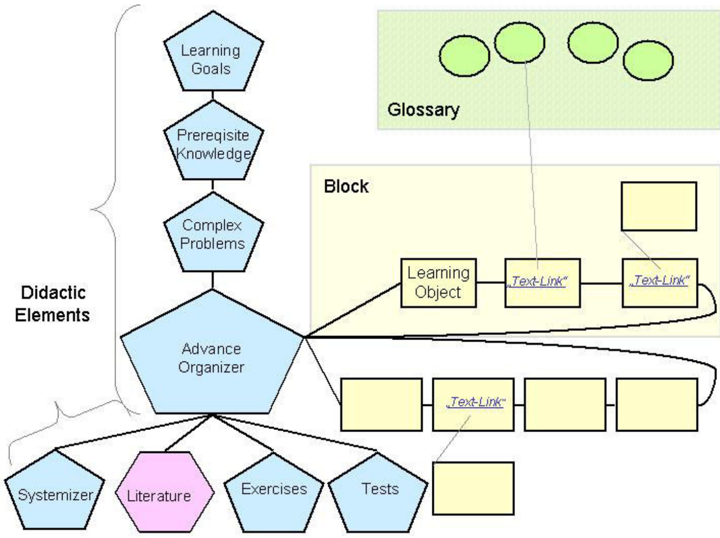

Diagram 7: Construction of a Lesson

6.1.4 Learning Object

The *learning object* is the smallest content-related screen unit. The author should design the *learning object* in such a way that scrolling within the screen is avoided if possible.

In terms of content, the single elements of the *learning object* should relate to each other so that they build one thematic element.

Within a learning object, one can differentiate between the following elements:

- *Example,*
- *Mnemonic phrase*
- *Definition*

as well as

- *Media object* and
- *Free Text*.

The element *example* creates a reference to a model company, for example the IMPULS-Schuh AG. Other references to model companies make sense in the element *complex problem(s)*.

The element *mnemonic phrase* makes available introductory rules for dealing with the information offered.

Within the element *definition*, established terms of a topic are described in their expert area content context.

The elements *free text* and *media object* are described in chapter 6.3.

6.2 Structural Components with Didactic Functionality

6.2.1 Complex Problems and Work Assignments

The central didactic structural component of a learning environment is the complex problem. It has the function of initiating the learning process for the student in a challenging, motivating way (cp. chapter 5.3). With the complex problem, the learners receive a problem that is meaningful for their future career working area. Problems can be differentiated from assignments in that the solving algorithm is still unknown to the learners (cp. Klauser, Schoop, Gersdorf, Jungmann & Wirth, 2002). At the lesson level, problems for single learners with the corresponding prior knowledge could represent assignments as well.

The complex problem is implemented through a DTD element with the same name. A *complex problem* is made up of the *introduction* to the problem, the *task* and the *tips and hints.* Additionally, the complex problem contains a *sample solution*[14], with which the learners can compare their own solutions (cp. Diagram 8).

[14] Multiple solutions are possible when solving complex problems. One of these solutions is depicted in the sample solution.

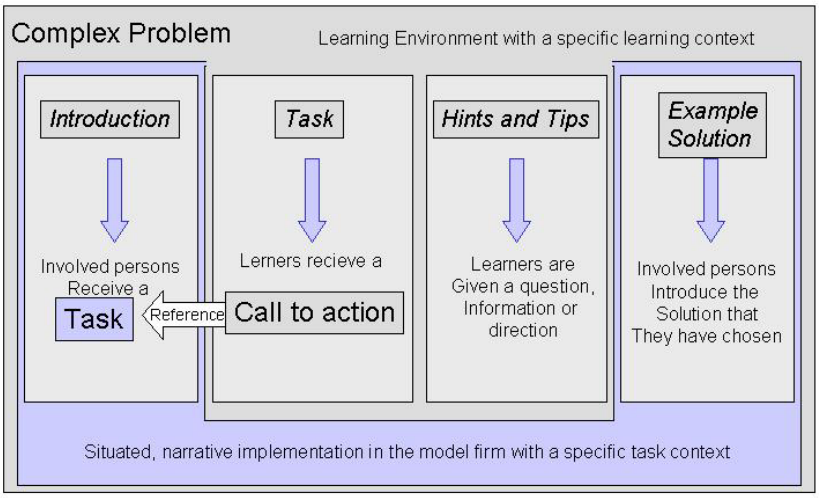

Diagram 8: Components of a Complex Problem

The *introduction* to a problem contains the description of the situation, the definition of the goal, information (both relevant and irrelevant for the solving of the problem) as well as authentic documents with reference to a model company. The problem depicts a situation in the model company. Employees of the model company are confronted by a problem that they must solve. One team member is assigned the task of coming up with suggestions for solving the problem.

The *task* is then passed on to the learners. They are requested to support their team member during the processing of the assignment (e.g. “Work on this for Herr Meyer…”). Simultaneously, the steps are described that are necessary for working on the learning content (cp. Diagram 9).

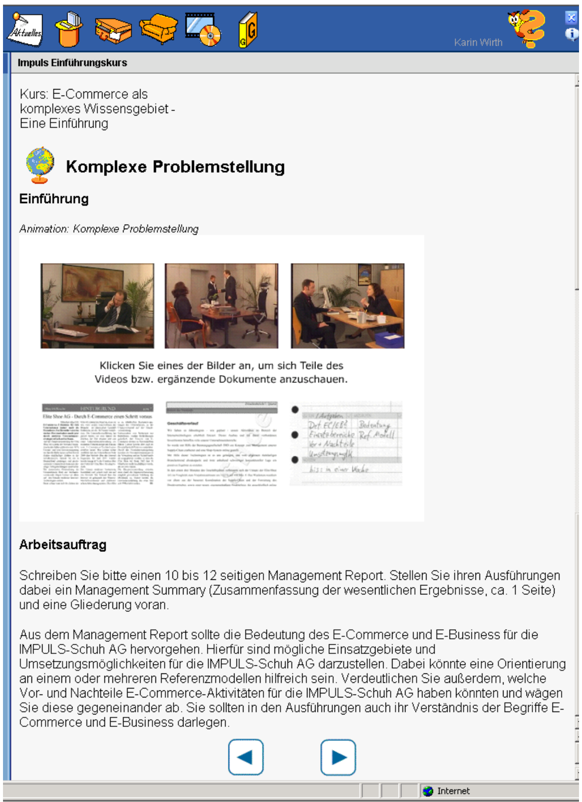

Diagram 9: Example for a Complex Problem and a Task

Work hints and tips serve, according to the prerequisites of each student, to support the student during the processing of complex problem.

The *sample solution* depicts the way that an expert works during the solving of the problem. Complex problems have different possible solutions and various paths to the solutions. The element *sample solution* contains one possible solution of the problem as well as the depiction of one possible method for solving the problem. The *sample solution* is, according to the didactic point of view, a necessary component for both an assignment as well as for a problem. It creates additional potential for independent work, raises the level of transparency and promotes higher motivation.

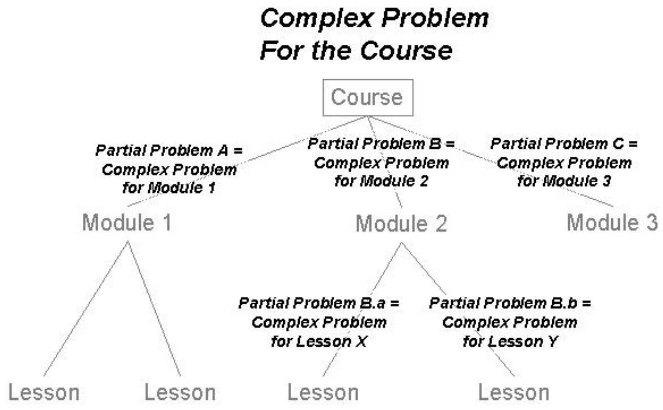

Diagram 10: Division of the Complex Problem into Partial Problems

The complex problem of one course can be divided in terms of content into various partial problems (cp. Diagram 10). These partial problems build the framework for the modules' problems. Similarly, a module with its partial problems makes available the framework for the lessons' problems. Through this content-based "nesting", it should be made possible for the learners to integrate the learning content into a subject-based and situationally-ordered context (cp. Diagram 11).

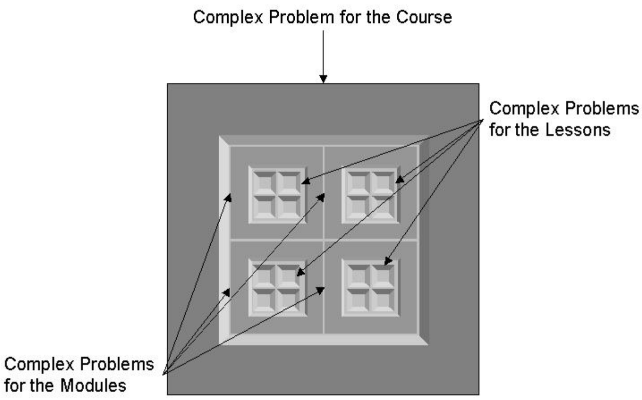

Diagram 11: Nesting of the Complex Problem

6.2.2 Advance Organizer und Systematizer

An Advance Organizer creates an overview of the complex goal- and content-structure of the offered learning content. An Advance Organizer contains the relevant technical terms for the learners at an appropriate level of abstraction (Ausubel, 1978, p. 65). The function of the Advance Organizer consists, according to Ausubel, in the connecting of respective prior knowledge and the construction of a systematic structure of the contents using the terminology.

Within the IMPULS[EC] Project, the element *Advance Organizer* contains a further function. Combined with the learning environment's navigational plan, the *Advance Organizer* ensures content-based orientation. Using the *Advance Organizer*, the student can navigate between various learning sequences and within the levels (course/module/lesson) (cp. Diagram 12).

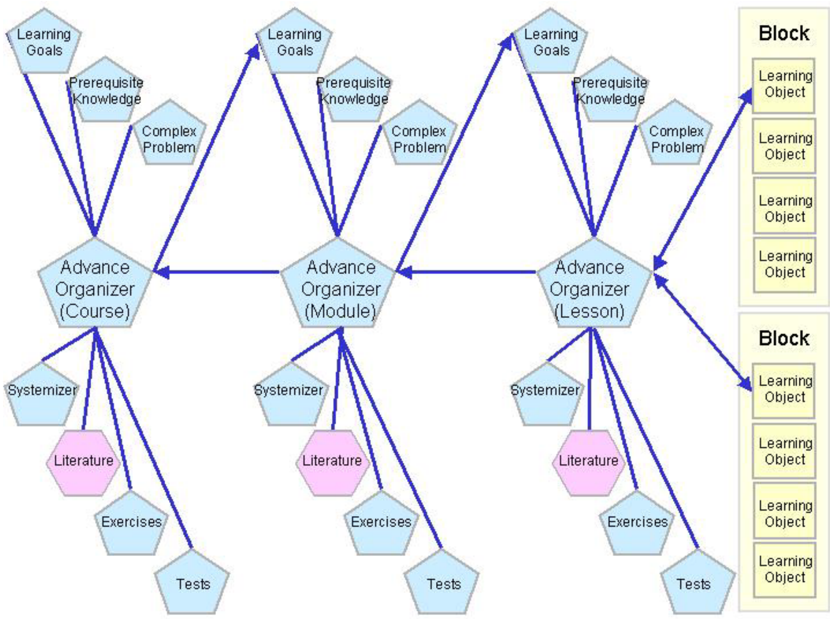

Diagram 12: Navigational Plan within the Course of Study "Electronic Commerce"

In order for an *Advance Organizer* to be able to fulfil the functions of ensuring orientation, the learners must be able to call upon it from any given place within the learning environment. To this end, the button for the *Advance Organizer* (a map) was included in the navigation list of the *learning objects*. (In addition to this, other buttons intended for navigation were included, such as "forward" and "backward".)

The didactic structural component S*ystematizer* is closely related, both in terms of content and function, to the formulation of the learning goal and the advance organizer. Through S*ystematizer*, the learners receive an overview of the processed content and the knowledge learned as well as a look ahead at the more in-depth or complementary content and literature.

6.2.3 Exercises and Testing

Corresponding to the dual function of testing (cp. chapter 5.3), the elements *LEK (*testing of learning success) and *SUE* (exercises) can be differentiated from each other. During *self-testing*, the learners have the possibility to compare their respective level of learned knowledge, skills and abilities using assignments as well as sample solutions using experts' solution methods as examples. The *testing of learning success* makes it possible to execute a certification.

The assignments for *self-testing* and the *testing of learning success* are made up of closed and open types of assignments. The learners can practice or apply their newly-learned knowledge with a new assignment, as well as apply their knowledge within other contexts. For practice, application and transferral, the learners have available on the one hand open types of assignments. Open types of assignments consist of an *introduction*, a *task* with *working tips and hints* as well as of a *sample solution*, comparable to *complex problems*. On the other hand, closed types of work assignments are offered. These types of assignments are developed with external tools[15] and imbedded into the structure using a corresponding reference.

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[15] The authoring tool Macromedia Authorware is used for the IMPULS^{EC} Project.

The following multi-media based forms of assignments are available:

- Single Choice,
- Multiple Choice,
- True-False Question,
- Short Answer,
- Drag-Drop-Question,
- Hot-Objects-Question and
- Hot-Spot-Question.

The goal of the future broadening of the PBL-DTD is to make these types of assignments independent of authoring systems and based upon XML (e.g. using the IMS Question & Test Interoperability Specification (QTI)).

6.3 Structural Components with Medial Presentation Form

The text to be recorded is intended within the PBL-DTD as the element *Free Text*. It is possible (among other possibilities) to correspondingly show enumerations and numberings as well as textual citations about elements. This is also true for tables.

References to other learning content of the course of study, in the Internet, to the glossary or to the literature are shown using the element *reference*. The type of reference is defined using attributes.

Diagrams, videos, animations and audio data are combined in the PBL-DTD into the container element *Media Object*. It must be noted that the author of these media objects has to intend a printable version as well. Therefore, the author records the relevant texts or diagrams in order to make them available for a print version. In addition to the named multimedia objects, the possibility exists of including further documents (e.g. ppt or pdf). All media objects must be provided with metadata using attributes of the specific M*edia Object* DTD, so that a later search is made possible and that the objects are correspondingly referenced. During the formulation of the *Media Objects*, special attention must be paid to learning-psychological and (media-) aesthetic criteria (cp. Jungmann, Wirth, Klauser & Schoop, 2002).

7 Summary

A main advantage of the XML approach in comparison to using HTML is the possibility of using XML to develop a separate semantic on the basis of a simple, machine-legible and efficiently interpretable grammar. In addition to logical structural directions and content descriptions, more complex characteristics, conditions and rules can be depicted using Document Engineering methods. This contributes to an active support of the authors within the creation- and editing process. These potentials are used within the IMPULS^{EC} Project for the depicting of problem-based structure models. In the forefront of the XML implementation is always the ease of use for the author within his subject-specific application context and the goal of developing student-appropriate content.

Within the IMPULS^{EC} Project, a new path is being struck with the developed DTDs: It concerns the integration of technical and didactic concepts. In a first step, a didactically-ensured structure for the entire learning environment, as well as for its parts and components, was developed. To achieve this it was necessary to determine as detailed as possible the form- and quality characteristics of the learning environment. The created structure was formalized in a second step and depicted in DTDs. At this point, the advantages of working interdisciplinarily came to the fore: the didactic principles, rules and methods were formulated by the business educators and innovatively, understandably explained to the partners from information management while working together. Afterwards, the information managers implemented the didactic guidelines into standardized DTDs using the introduced instruments of application-related Document Engineering. The implementation's results are then tested by the pedagogical partners to ensure that the formulated requests were met. Through these interactive, iterative processes, the DTD modelling reaches a high scientific quality, which comes through in quality of the product, the teaching-learning processes and the learners' results (Kim & Klauser, 2004).

8 Need for Further Research

The development work in the area of XML-based E-Learning solutions is by no means finished. A need for further research exists, especially in the following areas:

- The interdisciplinary action during the creation of XML structural modelling is to be further systematically and methodologically encouraged and documented (Technical Document Engineering).
- The technical structuring possibilities must be broadened to include documents that remain unstructured, especially videos and animations. To achieve this, the necessary instruments must be developed.
- Connected to this, the multi-media based components of the learning environment must be interdisciplinarily structured and synchronized.
- Existing standard metadata sentences are to be researched explicitly using concrete acting requirements for the implementation of problem-oriented approaches (metadata).
- The sets of metadata for the attribution of learning content are to be increased.
- Self-testing exercises and the testing of learning success are to be implemented using a platform independent XML format while doing justice to demands.

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