# Knowledge and Media Engineering for Distance Education

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#### ABSTRACT

Designing media for learning is a difficult process and any deficiencies in the authoring process are likely to be reflected in the student's educational experiences. Course sequencing has became an important research issue for educational hypermedia, which among others resulted in standardization issues of learning metadata. However, the complexity of the design process has often been overlooked. A big problem is the necessity to start from a text-based tradition of teaching and learning, which is used to design knowledge in a fixed way and in a hierarchical and linear structure of knowledge management. Educational media will only efficiently support the learning process, if the conceptual design models of the members of the design team fit together and if these conceptual models take into consideration the tasks and needs of different learners in the information society. Vital aspects of the conceptual models of the design are concerned with user- and task analysis, which in the context of webbased courses is at least to some extent a didactic conception of the media.

## 1. INTRODUCTION

Educational media, for example web-based courses, are used by students with many different goals and levels of knowledge (Kritzenberger and Herczeg, 2000). There is a need for web-based courses that allow to modify and adapt parameters accordingly and to tailor courses flexibly to the needs of different user groups. On the other hand it is obvious that educational media are produced in a text-based tradition of teaching and learning. Starting from this tradition means that content authors produce hierarchical, linear text-structures of courses. However, a linear printed book does not adapt to the needs of different users, e.g. with respect to different levels of difficulty, learning goals, learning strategy, or media preferences. These original "book documents" are in subsequent production stages transferred into hypertext, enriched with hypertext and multimedia functionality, as well as with interactive elements. The later issues are normally not done by the content authors themselves, but by other experts involved in the production process, e.g. concept makers, multimedia producers, pedagogues, software ergonomic experts, etc.. They cooperate as distributed design team, which is separated in time and place.

The text-based tradition of producing courses compels the authors to decide on a structure too early in the authoring process. The result in this kind of text-based production process suffers from severe problems. Among these problems, the hypermedia documents tend to become linear and do not model the (true) semantic structure of the domain itself. This problem is vital in systems which do not provide dynamic links, because the author has to provide the correct links for every possible user of that hypermedia system. Course sequencing became an important research issue in the last years. It is the goal of the sequencing approach to generate a lesson for a target group, e.g. for students, which is capable to be tailored to the needs of that group. One result of the sequencing approach is the work on standardization issues of learning metadata, such as Instructional Management Systems (IMS) or the efforts of IEEE's Learning Technology Standard Committee (LTSC).

Furthermore, not only the semantic structure has to be taken into consideration during the production process but also the different didactic media conceptions, which includes user- and task-analysis (Herczeg, 1994) with respect to learners and the learning process.

# 2. KNOWLEDGE ENGINEERING IN THE DIDACTIC FIELD FOR TASK- AND USER-ADEQUATE EDUCATIONAL MEDIA

It has been noted for the process of authoring hypermedia systems, that it is a complex one, which has often been overlooked by hypermedia designers (cf. Theng and Thimbley, 1998; Conklin, 1987). From the practice of the development of educational courses it is obvious that the authoring process of educational hypermedia can be described in several stages (see following sections), where the development is distributed over different people contributing to the development process with different kinds of expertise and different conceptual models. These

people of the design team are normally distributed over time and over place. Each of theses experts develop his or her own conceptual model and didactic knowledge is represented in different ways and qualities. One of the main problems in the production process of didactic media is the didactic transformation of teaching and learning contents and goals. By many practitioners, this problem is reduced to a question of collecting and structuring of content.

This paper is based on experience in two national projects. The one project is called "Virtual University of Applied Sciences" www.vfh.de (period of duration 1998-2003). It aims at establishing a location independent university with a curriculum for computer science of multimedia systems and for business engineering (Bachelor, Master). The authors of this paper are involved in the production of web-based courses, in the design of user-adequate learning spaces and in the support of the design process. Their focus is on usability recommendations and quality management for the course material during the development process. Other aspects like teaching strategies, learning processes or technical issues concerning the course production are supervised by other dedicated consulting groups within this project. The other project "Distance Education in Medical Computer Science" (started in January 1999) aims at providing a complete course of studies for the specialization of students in medical computer science. The course of studies is offered at a virtual university (Hagen, Germany). Our responsibility is to transfer the linear text documents (mostly MS-Word format) into hypermedia networks and multimedia courses (Kritzenberger and Herczeg, 2001).

# 2.1 Stage 1: Conversion from linear text documents to HTML-documents

Content authors normally start writing the courses as linear text documents. This way of producing course material is a quite normal way of teachers' knowledge organization, as people seem to be not good at writing in a nonhierarchical fashion. Extensive research on that suggests that readers form mental hierarchical representations of texts have been cited (Charney, 1987; van Dijk and Kintsch, 1983). However, this compels users to decide on a structure too early in the authoring process.



Figure 1: Conversion from linear text-documents to HTML-document

Content authors write linear text documents, which are transferred into web-based courses (HTMLdocuments) not by the content authors but for example by media producers. Normally, a conversion tool is used for this task, which reflects directly the document markup in order to preserve the hierarchical structure in the first-order hypertext (Rada, 1992). The most significant first-order links are those connecting outline headings. The linear hypertext is similar to Trigg's (Trigg, 1988) idea of paths authored into hypermedia systems. That is nodes are encountered one after the other, guiding the learners through the hyper-space. However, as the hypertext can be used in different ways from the original text, specific media aspects have to be considered in design, e.g. how to give the learner orientation in the information space.

The conception of the text documents by the content authors implicitly covers a didactic planning, which can partly be deduced by analysis of the sequential structure of the instructional texts and elements. In further stages of course production, these considerations on didactics have to be transformed into a proper media conception.

#### 2.2 Stage 2: Conception of the Hypermedia Document

Although our common way of organizing information in a text is through hierarchies, it is not the proper way of structuring domain knowledge for hyper-spaces. Therefore, in the second stage, the text structure is re-organized the domain knowledge into a hypertext with elementary knowledge units and their relationships, for which a variety of notations exist (Murray, 1998). Among them are ER-Model (Verdejo et al., 2000) and semantic networks (Fischer

and Steinmetz, 2000), that is as a directed graph in which concepts are represented as nodes and relations between concepts are represented as typed links (Conklin, 1987). IEEE Learning Technology Architecture (LTSC) proposes a set of knowledge library (knowledge base) which is responsible for the sequencing of a lesson, while the actual compilation of the lesson is performed in the delivery component. A set of semantic relations (e.g. super concept, part-of, problem-solution, instance, causes etc.) is used, which are stored as metadata to describe how concepts relate to other concepts. A similar approach is used in Multibook (Steinacker et al., 1999; Fischer and Steinmetz, 2000). The sequencing of a lesson is then a filter to select a specific structure to be presented to the learner. In this conception the student's learning process is modeled as navigational alternatives over the structure of semantic relations between the concepts (knowledge base). Conceptual relations may for example be typed as pre-condition, post-condition, invariant, satisfy condition, derive as activities etc.



Figure 2: Hypermedia Course

#### 2.3 Stage 3: Multimedia Course

At this point of modeling of the learning environment an inherent problem comes up. In many cases there are not sufficient kinds of relational types, in order to characterize the relation between two knowledge elements in a proper way. Rich typologies of relations are borrowed from discourse analysis models (e.g. Rhetorical Structure Theory) (Mann and Thompson, 1987) in order to type complex relationships between concepts. Another problem in this stage of the production of web-based courses arises from a didactical point of view for the conception of media. Semantic networks are models for the representation of propositional knowledge. The reduction of didactic modeling on this kind of representation and to reduce analysis on it means to neglects other kinds of knowledge of which didactic analysis should also be aware of (Kerres, 1998).

In the current practice of the design process of web-based courses, the hypertexts are enhanced with time-based multimedia like audio, video or animations etc.. This is regarded as being helpful for a more precise presentation for some kinds of facts and a more concrete way explaining processes, which would otherwise be too complicated to be explained properly and therefore hardly be understood by the learners.

For example can simulations help to demonstrate how time-based actions follow each other in complex processes. However, the question on supporting the learning process with multimedia remains unsolved and the senses are prone to be overloaded. Unfortunately, practice shows that the conception and design of media is often used as secondary question in didactic models for the production stage of multimedia courses. With the growing significance of media in teaching and learning with web-based courses in distance education, a didactic planning model centered around the media aspect is necessary.



Figure 3: Multimedia Course

Propositional knowledge representation in semantic networks is not sufficient for the proper representation of the goals of teaching and learning activities. In didactic thinking there are further goals describing for example what quality of knowledge acquisition in the learning process should be achieved. It is helpful to analyze the kinds of knowledge (Tennyson and Rasch, 1988) on which learning content is based in order to deduce consequences for presentation:

declarative knowledge: abstract concrete
procedural knowledge: meta-cognitive anchored analog (scripts, mental images, cognitive maps...)

Only declarative knowledge is properly structured and represented with propositions and relations between them, whereas procedural knowledge is rule-based knowledge ("if... then..."). Contextual knowledge is bound to experiences of concrete situations, which allow another kind of access to knowledge structures and can hardly be described with propositions of production rules. But here is a chance to analyze the domain and to find content which is of the kind and to model it with digital media.

## 2.4 Stage 4: Interactive computer-based training

Interactivity means a quality of action and reaction of user and system and vice-versa, where the focus is on internal cognitive operations of the learner.



Figure 4: Interactive computer-based training

For the didactic conception of interaction with computer-based training program, the main focus has to be on the learner's cognitive operations. Also information processing procedures of the learners have to be considered. This considerations go beyond the models of knowledge representation and look at the learning procedures itself, that is how knowledge is acquired by the learner. It implies that different stages of acquisition of expertise have to be considered in the design, e.g. the compilation of knowledge. Another aspect is, that the design should inspire the learners to various kinds of alternative learning activities.

# 2.5 Stage 5: Computer-Supported Cooperative Learning (CSCL)

The last stage in the development of web-courses for lifelong learning is the integration into a tele-cooperation and communication environment, for example into a virtual university. A special advantage of this constellation is the combination between information and communication component. The CSCL approach is based on the following premises: that learning and skill acquisition is facilitated by generative problem solving, collaborative work and use of multiple cases.

As collaborative work is central to learning, students are expected to assignment in groups in order to articulate and reflect their thinking and subsequent transfer. Furthermore, the availability and use of multiple cases during problem solving facilitates learning new knowledge and transfer of previous solutions to the current problem (Kolodner, 1993). A shared electronic environment has to seamlessly integrate a full variety of functions and has to tie together tools that students will use while solving problems and collaborating.



Figure 5: CSCL

## **3 CONCLUSIONS**

User- and task adequate learning environments to be used for lifelong learning for all, need didactic media conception with transformation through different stages of production, where different media constellations are in the center of conceptual models of the developers. The problem in development is, that the expert knowledge is distributed over the different members of a design team. The conclusion lies near that the quality of educational media will grow, if this knowledge, that is the conceptual models of the developers, is better managed. A user- and task-based framework for analysis and a proper tool for knowledge management will be helpful to solve this problem (Kritzenberger, Hartwig, and Herczeg, 2001).

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