Christian Swertz

Customized learning Sequences by Metadata

In response to a long-term research program for a didactical ontology, this report intends to present the results and methods for representing didactical models from the ontology we developed. The question is: How can computer technology be used to support the communication of knowledge in an educational context? This question cannot be answered by psychological experiments that ignore the core of educational behaviour: the transmission of meaning (Hönigswald 1927). Therefore this article focuses on the didactical tradition.

One of the aims of didactical knowledge organization is adapting content to the different media. Adapting content to media has been a challenge for didactical theory ever since Gutenberg invented printing. Comenius, one of the founders of didactical theory, reflected on Gutenberg's invention in 1657: He described books as an innovative technology and an important medium for teaching that allows us to improve tuition, offers new forms of learning and helps the lower classes – arguments that have not changed. Today's task was posed by Heimann in 1976, when he questioned how aims, content, media, and didactical models could be combined and incorporated. Whilst Heimann focused on the content, our focus is on the medium computer technology. If computer technology is here to stay, we must query now how knowledge can be organized and communicated through this medium. How do we consolidate knowledge and apply it to education with the help of computer technology?

As Meder (1998) and Swertz (2000) demonstrated in a theoretical analysis of the media structure of computer technology, this medium requires a special form of knowledge organisation, which allows learners to examine the content individually and in a reflective way, thus requiring teachers to produce individually navigable hypertexts. Individualization does not mean offering "pure" self-directed learning, as learning presupposes instruction by others. We have to aid teachers in reorganizing knowledge into hypertexts that allow for a reflective individual navigation. Supporting learners in finding their individual path is also a crucial factor.

1 Theoretical Considerations

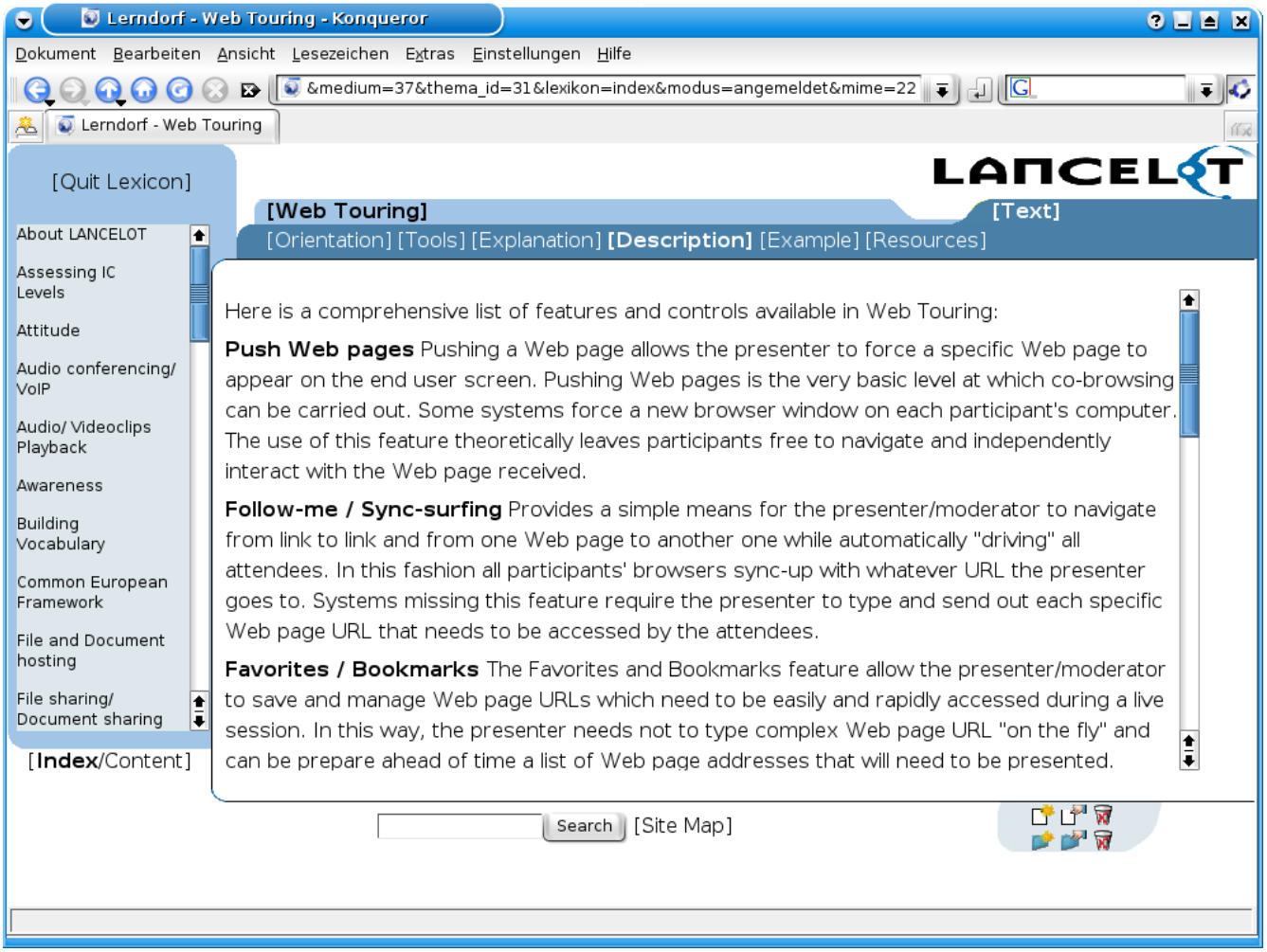
It is difficult to write a theory about media since writing a theory of media presupposes the use of media. Therefore a medium can only be reflected in the relation to media (on pluralism see Fromme 1997). When comparing computer technology to books, there are certain differences in the physical dimension of the medium: Books consist of colour on paper. The paper is tied in numbered sequences. The colour is most often used to form letters. Letters are dominantly used in books, matching the arrangement of the tied paper (McLuhan 1992). This arrangement is characteristic for the production of equal copies: Books require for the knowledge to be arranged in linear sequences that are reproduced in equal copies. This well known structure of books requires for a certain style of instruction: The idea of „everybody learns the same thing equally" (Comenius) and the idea of a single perfect learning sequence are a reflection of the equal copies of books.

These ideas change when another medium becomes culturally predominant. How can computer technology be understood from this perspective? Today computers are built as digital all-purpose Turing machines. Usually keyboards and mice are used as input devices and screens as output devices. Key attributes of this medium are the limited space on the screen and the possibility to use algorithms during the presentation of knowledge to alter the presentation of the knowledge. The application of algorithms during presentation replaces the equal copies; an individual presentation becomes possible. From this point of view, individual learning has to reflect the physical structure of computer technology. This individualization is connected to another granularity: Screens only show a small part of computer memory – everything not shown is detracted from sensual reception.

As we know Hypertexts (Iske 2001) are a suite of this structure of computer technology – but in practice we often find continuous texts in online learning environments (as on this CD). How can the question of individualized Hypertexts be answered by didactics? The key problem is the navigation aid: How does a learner find the next step? How can the available knowledge be made accessible? How does a hypertext have to be arranged in order to support individual navigation, self dependent learning and an individually chosen didactical model? In order to solve these problems we have to offer both

navigational aids allowing the learner to move around and a variety of didactical models.

Web-Didactics does not offer a single instructional design model (e.g. Problem Based Learning, Task Oriented Learning) but a choice of didactical models that were approved in the educational tradition. These models were adapted according to the granularity of the computer screen. The aim of Web-Didactics is a systematically and therefore clearly structured knowledge base that considers different didactical models, therefore allowing for individual learning. Self-directed learning and dependent learning are combined. How can learning material be prepared to allow for individual navigation?



Preparing content for learning requires two steps:

1. The content has to be *decontextualized*. It has to be taken from existing sources and transformed according to the required granularity. This process leads to a knowledge base that is organized according to didactical principles.

2. The produced elements must be *recontextualized* to map them into learning time. (for de- and recontextualisation see Flechsig 1991).

Decontextualisation means building up a didactically structured knowledge base. Knowledge is derived from existing contexts and is prepared for the learning process. Web-Didactics distinguishes between four levels. The lowest level is the screen page.

2 Decontextualisation

2.1 Media Types

The key attribute of the screen page is the media type (**first level**). The media type of the page shown in Figure 1 (taken from the EU-funded project LACNELOT) is „Text“. Using different media is an old didactical principle, which should be applied to hypertexts accordingly. Computer technology offers various forms of presentation: Pictures, graphics, videos, sounds etc., thus giving different didactical options. Which media types have to be considered from a didactical perspective?

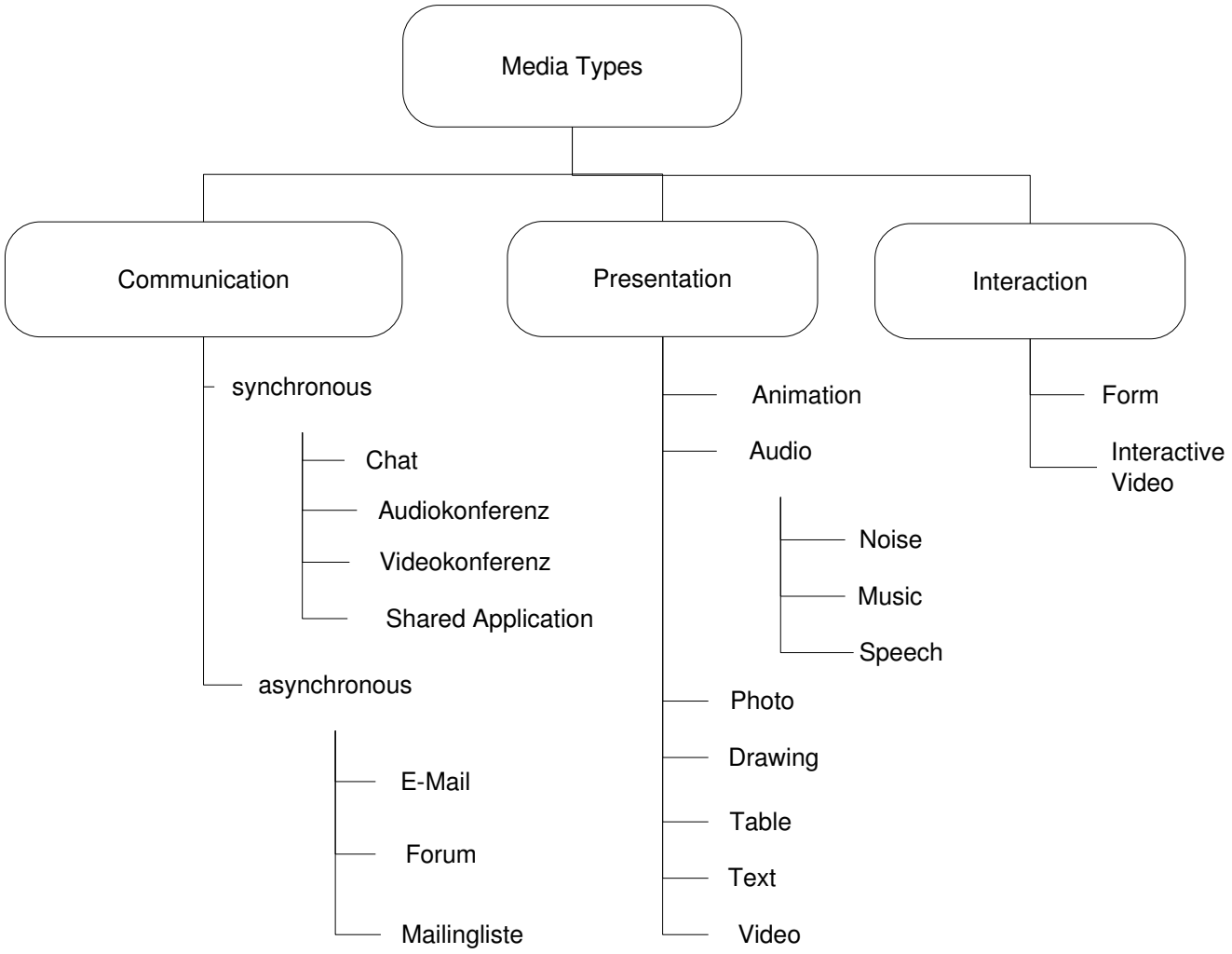


Figure *** shows the Media Types currently specified in Web-Didactics. The idea is not to produce every media type in every learning environment, but to guide authors to a systematic production of different media types. However, the variation of media types is crucial. For navigation, different media types have to be combined to form a knowledge type.

2.2 Knowledge Types

Knowledge Types form the second level in decontextualisation. In Figure ** different knowledge types like Orientation, Explanation and Description are shown. The knowledge types are metadata which are used as a navigational aid for self-directed learning. Web-Didactics draws a distinction between receptive, interactive and cooperative knowledge types. Receptive Knowledge is passively perceived. Interactive knowledge offers interaction with the computer and cooperative knowledge involves communication with other people.

2.2.1 Receptive Knowledge Types

While using receptive knowledge, learners stay passive. Figure *** shows the receptive knowledge types. The distinction of orientation, explanation, action, and sources is derived from a concept suggested by Flechsig (1990).

- In *Orientational Knowledge* a subject is mentioned and placed in context without detailed explanations or instructions on how to use it. One possible construction of a learning unit would be to start by accessing previous knowledge („As you may know...“), placing it in context („... belongs to ...“) and mentioning relevant concepts („Important concepts are ...“).

- *Explanational knowledge* offers reasons why something is the way it is or why something is seen in a certain way.

- *Instructional Knowledge* tells you what to do and how to do it.

- *Source knowledge* indicates where you can find more information on this particular subject.

The distinction was made as to fit the didactical models to be realised. We chose knowledge types that occur in learning models mentioned in literature. The compilation is therefore derived through a heuristic approach and has to be proven by empirical studies. If necessary, the compilation can be modified. Figure *** shows the receptive knowledge types currently specified in Web-Didactics. Using computer technology receptive knowledge types can be accompanied with interactive knowledge types.

2.2.2 Interactive Knowledge Types

Interactive knowledge is where learners interact with the computer. Interaction with the computer takes place in simulations and in assignments where the answers can be evaluated automatically.

Assignments that require cooperation with a teacher or other learners belong to the cooperative knowledge types. Simulation is a versatile genre that can be used from social behaviour to technical controls. Most often the association of interactive knowledge with cooperative knowledge is sensible

2.2.3 Cooperative Knowledge Types

Within cooperative knowledge, learners communicate with other learners or teachers. This can happen at certain points in the learning process where group work, discussion or a talk is planned. But sometimes learners do have unplanned communication needs. In case they do not understand something or they are loosing control of the learning process they do need immediate communication like placing a question to the teacher. Therefore spontaneous cooperations that could happen at any time are distincted from from planned co-operations that are planned at certain point in the learning process. The planned cooperation types are classified by group size: Consultations take place between two people, learning conferences are planned for several hundred participants.

Learning Unit:

5-10 receptive, interactive or cooperative knowledge units are combined in one learning unit. What characterizes a learning unit? Learning units are the **third level** of decontextualisation. Learning units are defined by concepts. The navigation within concepts is highlighted in the drawing. The distinction of media types, knowledge types and learning units makes up a hierarchical structure: Learning units consist of knowledge units. Knowledge units consist of media units. The network

structure that is typical for hypertext seems to be missing.

The network emerges from the following structure: The concepts of the learning unit are understood as thesaurus terms. Thesaurus terms have to be unique. They occur only once in a knowledge base. The terms are not linked by a hierarchy but by typed relations. Terms linked by typed relations make up a knowledge network that consists of local hierarchies of knowledge types and media types. How can typed relations be used as navigational aids? Relations make relevant concepts accessible within a media unit. That is reasonable if a concept is mentioned but not explained within a media unit. In this case, the concept has to be made accessible through a relation in order to keep the coherence of the hypertext.

Relation types

Which relation types have to be considered? Relation types are taken from thesaurus standards. Within thesauri, hierarchical and associative relations are distinguished. Hierarchical relations reproduce concepts that are subordinated. Associative relations reproduce concepts that are co-subordinated. Relations are used to map the logical structure of concepts. As the logical structure is often followed by didactical models, logical structures can be used for didactical design. Only in rare cases didactical steps are made contrary to logical structure. In these cases didactical relations are used.

Relations make up the **fourth level** of Web-Didactics and they are the last element of decontextualisation.

We can summarize: Web-Didactics as an ontology to prepare knowledge for learning by decontextualisation differentiates media types, knowledge types, index terms and relations. These types could be used as a vocabulary for meta data systems (e.g. IMS-LD). The graduation is orientated at the granularity of the screen. A knowledge base that allows for varied individual navigation paths is set up by a systematic variation of media types, knowledge types and relations. How can didactical models be applied to such a knowledge base?

Recontextualisation

Didactical models are used for recontextualisation, that is, the arrangement of screen pages within a didactical hypertext. As self-directed learning and dependent learning are necessarily aligned (Litt 1964), we have to cover of both ideas. Web-Didactics integrate self-directed and dependent learning by offering media types, knowledge types and index terms as navigation aids. These navigation aids avoid cognitive overload and lost-in-hyperspace problems through their systematic structure. Thus learners are offered the possibility for self-directed learning. For dependent learning, the screen pages are arranged by applying didactical models to the meta data. How can this sequence be presented to learners?

Recontextualising screen pages by didactical models means to fix a certain sequence. This sequence can be offered to learners complementing the individual navigation, thus integrating self-directed and dependent learning. The sequence leads through the media types, knowledge types and learning units with the help of simple forward and backward buttons. The screen shot above shows that the backward button leads to the screen page containing an animation. Didactical models are specified for every level of decontextualisation in Web-Didactics. Which didactical models have to be taken into account?

Media types are ordered according to media models. There are two media models: one leads from concrete to abstract and from abstract to concrete. The first model goes from concrete to abstract since fewer and fewer qualities of the object are represented: The word „tree“ does not show elements of a real tree, while a picture of a tree shows more qualities of a real tree. In practice, hardly ever all possible media types are produced. In most cases only one or two media types are presented for every knowledge type. How are the knowledge types sequenced?

Knowledge types are sequenced by **micro models**. The next knowledge type is called if every media type within the knowledge type has been presented to the learner. Micro models are:

- example oriented model
- model according to Herbart

•learning by discovery

•task oriented model

•role based learning

•theory driven

•action oriented

•problem based learning

I will show the last three exemplary models:

The drawing (***) shows the **theory driven** micro model. The core is the explanatory knowledge that contains the theory that is seen as justification for knowledge. This model does not contain cooperative knowledge. It thus matches the requirements of the lonely learner.

The core of the **action orientated** micro model is action knowledge, which is placed at the beginning of a sequence . This model shows some advantages of decontextualisation: By organising knowledge into media types, knowledge types and learning units it is possible to offer different didactical models without rearranging all of the knowledge for every model. As explanatory knowledge is used in the theory driven model and in the action oriented model the same knowledge unit will be presented to the learner. This allows for an effective reuse of knowledge units. This can also be seen in the micro model on problem based learning:

The core of **problem based learning** is the task to be solved. Hence the task is presented at an early stage within the learning unit. Problem based learning shows another thing to consider while using Web-Didactics: Learners do not need to complete the learning sequence: If learners are able to solve the tasks without further knowledge, they can answer the question and skip to the next learning unit.

The presented micro models gave evidence that a great variety of didactical models can be realised by different sequences of media types, knowledge types and learning units. If the possibility of altering the media types, knowledge types and relations is also considered, the complexity of didactics shows. To develop varieties matching the requirements of different cultures is an interesting task that requires empirical research.

How can learning units be sequenced?

The third level of decontextualisation covers the sequencing of learning units. The next learning unit is called if all media units and knowledge units within the learning units have been passed through before. Which didactical models can be differentiated on the third level?

Didactical models on the third level are referred to as macro models. As micro models use one knowledge type as a key type, macro models use a relation type as a key type. Macro models that have been specified so far are (key relations in brackets):

•deductive model (hierarchical relations) with the varieties depth first and width first

•inductive model (hierarchical relations) with the varieties depth first and width first

•goal based bottom up (hierarchical relations),

•spiral model (context-of)

•constructive model (used-for)

•network model (all types)

•guide tours (didactical before).

For instance, figure ... (***) shows a simple hierarchy of learning units. The inductive model with width first sequences the learning unit as 4-5-2-6-7-3-1??, the deductive model with depth first sequences the learning units as 1-2-4-5-3-6-7.?? In bigger learning environments the learning units can be combined to courses. Between courses only the relations „generalize“ and „beside“ are used, accordingly, only inductive and deductive strategies are used.

Recontextualisation is implemented by

•media models,

•micro models,

•macro models and

•course models.

By decontextualising knowledge to a knowledge base considering different didactical models, it is made sure that different paths for individual navigation are available. At the same time the recontextualisation enables the single learner to choose his or her own didactical model, as the application of the models to the meta data can be done by algorithms.

The mentioned models are all well established and we already specified software requirements. However, implementation has so far only taken place rudimentarily. Empirical proof for the mentioned cooperation is therefore still a desideratum.

Research

What do empirical studies show about Web-Didactics? In order to test Web-Didactics, we have been developing and using the learning management system „InLearn“ since 1998. The first focus was to develop methods for content production. After producing content for some years we were able to start testing the content with learners. In studies we have been using qualitative and quantitative research methods. Here I will show you only two examples:

One of the points we have been using quantitative studies for, was to test the satisfaction of learners with knowledge types and navigation aids. The diagrams show results from a small seminar at a University (n=21). We asked learners if they felt that the knowledge types are helpful („Knowledge Types helpful“) and that they understood the navigation aids („Navigation comprehensible“). Results show that the knowledge types are accepted and the navigation aids where judged as helpful (Ja = Yes). Critical points were that we do not offer off line versions and that the content cannot be downloaded as a whole. For qualitative research we asked the learners to use the platform while thinking aloud. We used a screen cam to record the visible screen and the verbal expressions. We analyzed the recordings taking into account usability, navigational behaviour and knowledge reception. Our analyses shows that learners understand the navigational aids very quickly – even without any introduction (we gave learners just the task to learn something about a certain concept and the URL) the navigational aids are used intuitively. While learning, learners used very different strategies for navigation. This shows that the aim of Web-Didactics, to support an individual navigation, has been reached.

Literature

Comenius, Johann Amos (1964): Orbis sensualium pictus. Osnabrück : Zeller.

Flechsig, Karl-Heinz (1991): Wissenssynthesen (Verfahren). Studienbrief im Weiterbildungsprogramm Wissensorganisator. GQWO: Göttingen.

Fromme, Johannes (1997): Pädagogik als Sprachspiel. Leske+Budrich: Opladen.

Herbart, Johann Friedrich (1979): Zwei Vorlesungen über Pädagogik. In: Adl-Amini, Bijan: Pädagogische Theorie und Erzieherische Praxis. Stuttgart, S. 106-111.

Heimann, Paul (1976): Didaktik als Theorie und Lehre. In: ders.: Didaktik als Unterrichtswissenschaft. Klett: Stuttgart, S. 142-167.

Hönigswald, Richard (1927): Über die Grundlagen der Pädagogik. Ein Beitrag zur Frage des pädagogischen Universitäts-Unterrichts. Ernst Reinhardt: München.

Iske, Stefan(2001): Hypertext als Technologie des Umgang mit Informationen. Bertelsmann: Bielefeld..

Litt, Theodor (1964): Führen oder Wachsenlassen. Klett: Stuttgart.

Meder, Norbert (1998): Neue Technologien und Erziehung/Bildung. In: Borrelli, M.; Ruhloff, J.: Deutsche Gegenwartspädagogik Bd.III, Hohengehren 1998, S. 26-40.

Meder, Norbert (2001): Didaktische Ontologien. http://www.l-3.de/de/literatur/download/did.pdf (25.2.2002).

Rousseau, Jean Jaques (1981): Emile oder über die Erziehung. 5. Aufl. Schöningh: Paderborn.

Swertz, Christian (2002): Konzepte und Methoden zur Qualitätssicherung bei der Produktion von hypertextuellen Online-Lernumgebungen. In: MedienPädagogik (1) (http://www.medienpaed.com/02-1/swertz1.pdf [15.4.2002]).

Swertz, Christian (2004): Didaktisches Design. Ein Leitfaden für den Aufbau hypermedialer Lernsysteme mit der Web-Didaktik. Wilhelm Bertelsmann Verlag: Bielefeld 2004.