IMPULS EC

Interdisziplinäres multimediales Programm für universitäre Lehre und selbstorganisiertes Lernen: Electronic Commerce

The Construction of Complex Internet-Based Learning Environments in the field of Tension of Pedagogical and Technical Rationality

Research Report 10

Klauser, F.; Schoop, E.; Wirth, K.; Jungmann, B.; Gersdorf, R.

Herausgeber.:
Bogaschewsky, R.; Hoppe, U.; Klauser, F.; Schoop, E.; Weinhardt, Ch.

Die Herausgeber

Prof. Dr. Ronald Bogaschewsky
Julius-Maximilians-Universität Würzburg
Lehrstuhl für BWL und Industriebetriebslehre
D-97070 Würzburg

Prof. Dr. Uwe Hoppe
Universität Osnabrück
Lehrstuhl für BWL/ Organisation und Wirtschaftsinformatik
D-49069 Osnabrück

Prof. Dr. Fritz Klauser
Universität Leipzig
Lehrstuhl für Berufs- und Wirtschaftspädagogik
D-04229 Leipzig

Prof. Dr. Eric Schoop
Technische Universität Dresden
Lehrstuhl für Wirtschaftsinformatik, insb. Informationsmanagement
D–01062 Dresden

Prof. Dr. Christof Weinhardt
Universität Karlsruhe (TH)
Lehrstuhl für Informationsbetriebswirtschaftslehre
D-76131 Karlsruhe

Osnabrück, April 2004

ISBN 3-936475-15-6

Klauser, F.; Schoop, E.; Wirth, K.; Jungmann, B.; Gersdorf, R.

The Construction of Complex Internet-Based Learning Environments in the Field of Tension of Pedagogical and Technical Rationality

IMPULS^{EC} Research Report 10

Herausgeber: Bogaschewsky, R.; Hoppe, U.; Klauser, F.; Schoop, E.; Weinhardt, Ch.

The Authors' Forward

The following report is the print version of a presentation held in September 2002 by the authors – both business educators and information managers – at two academic events: at the fall meeting of the Section for Vocational- and Business Pedagogy of the German Society for Education Science in Karlsruhe, and at the Leipzig Computer-Science Fair.

What made this presentation exceptional was the attempt to show interdisciplinary work results in an interdisciplinary way at discipline-specific discussion forums. The collaborative presentation was adopted to the participants in the forums, and was given a different emphasis depending upon the disciplinary area.

Not only the results of the collaboration were looked at, but also and most importantly the necessary steps and methods that had been utilized, as well as both the reciprocal points of collaboration and friction occurring between the different disciplines during their collaborative work. In order to retain the character of the presentation, its style was used for the print version of the Research Reports and complemented by a systematic look at the academic literature as well as by thorough explanations, which were considered necessary by the authors for the comprehension of the interested readers from the two disciplines involved.

This Research Report was translated by Robert D. Stewart assisted by Karin Wirth.

Fritz Klauser

Eric Schoop

Ruben Gersdorf

Berit Jungmann

Karin Wirth

Table of Contents

List of Diagrams

1 Starting Point and Prerequisites for Action

Duffy and Jonassen published a text in 1992 titled: “Constructivism and the Technology of Instruction: A Conversation” (Duffy & Jonassen, 1992). The book summarizes the struggle between two camps: between the so-called intructionists, instructional designers, objectivists or technicians on the one hand, and the so-called contructivists, theorists of learning or pedagogues on the other.

The debate was begun primarily because of the conflicting opinions about how the new information and communication technologies could be used for teaching and learning, as well as – and one can see here the differing emphases – how teaching and learning processes could be formulated with the help of technology.

This article is not intended to moderate the debate. Sufficient literature exists for this purpose (compare among others Schulmeister, 2002, p. 166ff.). It simply comes down to one point of this debate that is of importance for the following considerations:

While the so-called intructionists or instructional designers – supported by traditional behavioral and cognitive teaching and learning paradigms – focus on the possibilities and demands of the new mediums as the starting point of their considerations, the constructivists prefer a so-called learning-centered perspective, whereby not only selected domains and learning processes but also the potential for technical and practical teaching itself were barely looked at.

Due to their struggle with each other over their differing positions, both sides reacted to the opposing arguments with misunderstanding and, partially, ignorance:

The instructional designers rejected decisively and without consideration the criticism of their reliance on technology, their picture of the learner, their method of setting learning objectives and presentation of knowledge, as well as of the dominance of expository methods within their arrangements. Likewise, the Constructivists rejected the criticism of the unclarity of their objectives, content, teaching-learning processes and learning results, as well as the reproach that they were naive in terms of the practical implementation of their educational plans.

Although promised by the title of the book by Duffy and Jonasson, neither a conversation, a real exchange nor even a basic understanding of the differing positions came about. It was obvious that the readiness was simply non-existent. The supposed conversation broke off as well. In its place appeared, with a few exceptions, a time of silence between the two camps, which still exists today and has far-reaching consequences for the practice and theory of the construction and the implementation of computer- and Internet-supported multimedia teaching-learning arrangements:

Instructional designers and technicians on the one hand, and constructivists and pedagogues on the other have been extensively developing their arrangements in a disciplinary way. When collaboration between the two camps actually occurs, it is typically dominated by one of the two perspectives. The other side is often then seen as an addition, has some specific service to produce, and sometimes functions merely as an alibi. A myriad of prototypes, demo-versions, executable one-time-solutions or proprietary systems have thus been produced,

- which in extreme cases are technically state-of-the-art but pedagogically limited, or the other way around,
- which are platform- or operating-system-dependant, and which do not or hardly offer content- or functionality-usage outside of the particular system,
- which are relatively limited as to domains and target groups and
- which are relatively locked-down, meaning that only the creators themselves can program and modify the content.

In short, solutions are produced that can mostly only be used for their intended context of development.

In addition, a specific development methodology and instruments are created and used for each individual arrangement, which often can not be used for other projects.

We can paint a similar picture with regards to the theoretical bases for the construction, implementation and evaluation of multimedia learning possibilities:

- There are no plans for the integration and combination of innovative, pedagogical approaches on the one hand and the technical possibilities and demands on the other, which could help lead to non-specific usage possibilities.
- Likewise, there are hardly any approaches and criteria for the development of content, problems, exercises, feedback, transfer assignments, assistance, achievement testing and the possibilities for interaction, or for the design of visual interfaces and Tele-tutoring, which are shared and equally accepted by both the pedagogical and the technical side.

To sum up: There is a deficit in regards to the available, theory-grounded plans and instruments that could function as a sort of standard or criterium for quality for either disciplinary or inter-disciplinary action.

A quality control in regards to the process of construction, to the product or to its implementation and evaluation is hardly possible under these circumstances.

This situation is the deciding factor as to why computer- and Internet-supported learning has not yet achieved the expected and hoped-for dissemination, and why the new mediums have only marginally been used on a larger scale for the effective shaping of teaching and learning processes.

In view of the situation just described, what can we hope for from our contribution?

Of primary importance is to try and correct the described deficit and to accentuate the discussion in an interdisciplinary way. For this reason, both business educators and information managers have their say within our contribution. This is supported by our belief that a real and wide-ranging progression in the area of E-Learning can only be successful if the involved disciplines enter into a discussion about their respective paradigmatic assumptions and area-specific approaches, build up real understanding for each other, and thereby create a shared position which could function as a basis for cooperation.

The occasion and basis for this interdisciplinary discourse is the research and development project IMPULS^{EC}. The project will be broadly introduced in point two, whereby the main point will remain the pedagogical plan. In point three, we will emphasize the information-technical side of the project, discuss problem areas in the collaborative effort, and formulate demands upon the pedagogical design of complex, Internet-based learning environments from the technical perspective. The business-educator response and the solutions found together will be presented in part four. The report will then end with a few summarizing remarks.

2 The IMPULS^{EC} Research and Development Project

2.1 Project Partners and Goal-Setting

IMPULS^{EC} stands for Interdisciplinary Multimedia Program for University Teaching and Self-Organized Learning of the Topic Electronic Commerce (in German, the words form the acronym IMPULS). The whole project deals with an intention shared by five universities, which is being financed by the federal ministry for education and research from April 2001 until March 31, 2004[1] as part of the initiative known as “New Media in Education”. Cooperative partners include IBM and ECCO-Schuh AG. The project itself is being led by business managers, information managers and business educators working together. The groups working on the project include

- the Institute for Business Management/Organization and Business Informatics at the University of Osnabrück under the leadership of Prof. Dr. Uwe Hoppe,
- the Institute for Business Informatics, in particular Information Management, at the Technical University in Dresden under the leadership of Prof. Dr. Eric Schoop,
- the Institute for Business Management and Industrial Business Management at the University of Würzburg, led by Prof. Dr. Ronald Bogaschewsky,
- the Institute for Information Business Management at the University of Karlsruhe under the leadership of Prof. Dr. Christof Weinhardt, and
- the Institute for Economics and Business Education at the University of Leipzig with Prof. Dr. Fritz Klauser as director.

The goal of the project is to develop a modular, multimedia-based course of study for the area of Electronic Commerce, to make it available on the Internet, to integrate it into the teachings of the involved universities as well as to evaluate the teaching-learning process. The plan calls for the combination of phases of self-organized, computer-supported learning and face-to-face meetings.

[1] The project has been extended until September 2004

Students of academic business subjects are the target group. The learning material will be formulated in an interdisciplinary way. The modular set-up should ensure that both those learning and teaching should be able to choose and combine content in a manner corresponding to their learning needs and goals as well as requirements.

11 courses are planned with the following titles:

1) E-Commerce as a complex area of knowledge – an introduction
2) Network Economics – new rules for the networked economy
3) Organization within E-Commerce – electronic markets and networks of businesses
4) Logistics within E-Commerce – how do the goods reach the customers?
5) Business-to-Machine Communication – If machines could talk
6) Information- and Communication-Technology – the heart and basis for E-Commerce
7) E-Finance – electronic intermediation for public finance
8) E-Procurement – catalog-based procurement, market areas, B2B networks
9) Information Management within E-Commerce – people, machines, methods
10) The Learning EC-Organization – flexible, open and communicative
11) E-Learning – the essential process of personnel development

The courses consist of modules and these in turn of various lessons. The construction of the course of study, the courses and the modules follow the principle of the curriculum spiral (compare Bruner, 1974). The learning material will cover 200 hours of university lesson time.

The course offers clearly show the breadth of the content within which the area of the topic is covered, and in which the business management, business informatics as well as the business educational aspects are connected to each other.

The course of study will be supported by a guided tour, which will familiarize the students with the structure and functionalities of the learning material and the learning platform itself. The technical name of the learning platform is “Lotus Learning Space 5.0”, which was put at our disposal for testing-purposes by IBM.

The first course was already run successfully in the summer semester during the training of business informatics. Initial evaluation results were published in a Research Report as well as the *Zeitschrift für Berufs- and Wirtschaftspädagogik.*

2.2 Theoretical Bases

The pedagogical conceptions of the learning material are based upon the following approaches:

I Approaches from Psychology

Above all, discoveries, models and plans have to be named here

- for *learning according to the Constructivist perspective* (cp. Gerstenmaier & Mandl, 1994; Klauser, 2002) and
- for *the situated formulation of learning environments* (cp. Klauser 1998b; Mandl, Gruber & Renkl, 2002) and
- from *research about expertise and expert opinions* (among others Glaser & Chi, 1988; Reimann, 1998), and those which are especially connected to the questions about the sequencing of goals and contents (cp. Klauser, 2000).

Learning is seen from the *Constructivist perspective* as an active, socially transmitted and situated process of the individual construction of knowledge and ability, desire and feeling, interpreted and characterized in the following way (cp. Diagram 6):

- The students construct their own knowledge, in that they interpret their experiences according to their own perceptions. This occurs within and depends upon the context of their own prior knowledge, the respective situation and their current emotional state and willingness to learn. Knowledge and ability are thus generated internally by the respective individual cognitive performance of each person, are dynamic and superceded by a continual process of change.

- This individual construction of knowledge and ability does not happen passively and autonomously. It is rather only possible through the students’ dealing with the learning material and takes place within social integration. Of central importance for the acquisition of knowledge and abilities is the negotiation of meanings within social communities. Effective teaching-learning processes have to be formulated in such a way that they offer the subject’s activities as well as the process of social interaction – the so-called co-operative or collaborative learning – a wide scope.

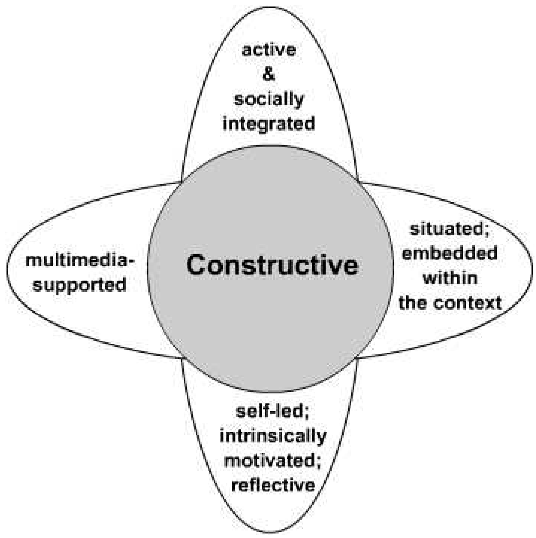

Diagram 1: Characteristics of the Learning Processes according to the Constructivist Perspective

- Learning is also situated. The social, motivational and emotional contextual factors of the learning situation decisively control the ways and means of the learning- and retention-process as well as the use of the knowledge and abilities. If the students in a concrete educational or continuing-educational instance do not have the reference to a relevant context or the subject matter, then the information is of little meaning and there will be no, or at least no lasting or useful connection made with the prior knowledge of the student. This results most importantly in the demand for "authenticity" and "situatedness" from learning situations and learning processes, as well as from the formulation of problems and assignments.

- Active construction demands a high level of independence and self-organization. These requirements decisively base themselves in turn upon the intrinsic motivation of the students, upon their ability and will-power to reflect upon their own learning process, to notice and correct mistakes, and to anticipate and master new challenges. General as well as context- and subject-specific, and metacognitive learning skills are of the utmost importance for the reflection about and control of one's own learning process. Effective teaching-learning processes must support the growth of such skills and allow room to train them through the process of solving problems.
- The modern information and communication technologies have made it possible to support a whole range of activities, situatedness, social interactions, self-control and intrinsic motivation. Contributing to this are, among others, the technical possibilities of the synchronous and asynchronous communication as well as network-based co-operation, various presentation- and work-mediums as well as various presentation- and work methods, tutorial components, feedback-systems and help, and finally the connection to intranets and the Internet. A reasonable and goal-orientated multimedia embedding and support using these components is therefore, according to the Constructivist perspective, an important catalyst for effective learning processes.

The positions regarding the *situated design of learning environments* base themselves upon the described understanding of learning processes and can be summarized as follows (cp. among others Klauser, 1998b; Mandl, Gruber & Renkl, 2002):

Complex learning environments should be formulated so

- that the students are confronted with objectively and subjectively meaningful problems from their career- and daily-life, which makes an independent learning process possible, and both challenges and motivates towards that end;

- that the students can integrate their own prior knowledge, experience, interests and abilities into the process of problem solving, and that new and authentic experiences come about as a result of the learning process;
- that the formulation of tasks can be introduced in a situated, embedded way, and that the changing of contexts and perspective during the tasks is both possible and supported;
- that social co-operation, individualization, and differentiation are promoted through the combination of individual-, partner- and group-work;
- that specific assistance and possibilities for the correction of errors are offered;
- that metacognitive processes, reflection about the learning process, the ways of learning and the results are promoted, and
- that the working out of general rules and conclusions is to be strived for to achieve a necessary connection between casuistic and systematic.

Regarding research about expertise, or one becomes an expert,[2] we mean the realizations involving

- how the knowledge and ability of experts differs from those of novices (beginners or students)[3],

---

[2] Expertise in the sense of the named research results classifies the "area- and assignment-specific problem-solving ability of a person within an area, which puts this person in the situation to consistently do great things " (Frieling & Sonntag, 1999, p. 149). Trans. For this document by R.S.

[3] This research resulted in the following results (among others) (cp. among others Glaser & Chi, 1988; Chi, Feltovic P.J. & Glaser, 1981; Glaser 1991, p. 132 ff.; Reimann, 1998; Gruber & Mandl, 1998):

- Experts have at their disposal a good base of specialist knowledge structured in regards to the acting relevance, and have connected the heuristics of their expert area to general problem-solving techniques.
- The knowledge of the layman or novice is generally related to situation. The knowledge of experts is in addition related to problems and can be generated within various contexts.

- which prerequisites have to be fulfilled in order for the students to develop expertise and
- how teaching-learning processes can be adjusted with regard to expert action within academic-, career- and daily-situations using new media systematically.

Specialists have at their disposal that level of competency enabling the making of connections between their specialist body of knowledge and acting systematics, for which this program is also striving. It is therefore the obvious thing as well as necessary to relate the process of acquisition from experts on the one side, and the construction and implementation of the learning material on the other hand, to each other. It is basically about connecting the goals and contents of the learning material as well as the learning process in a specific way. The sequencing principles "concrete-abstract-reconcrete" (Klauser, 2000), "increasing complexity", "increasing diversity" and "global before local skills" (Collins, Brown & Newman, 1989, pp. 483ff), as well as the sequencing strategy of integration and elaboration (Preiß, 1999) serve quite well as a frame of reference. Modern instructional approaches (compare II) have shown themselves through research to be especially apt for the implementation of such sequencing methods.

II Modern Instructional Approaches

The most important concepts are *Problem-Based Learning*, *Anchored Instruction* and *Cognitive Apprenticeship*, which were developed in the USA in the 1980's and 1990's. Since then they have been received world-wide and used within various educational areas, as well as further developed into empirically and widely-tested curriculum and teaching-learning programs.

The instructional approaches take their theoretical base primarily from the acceptance to learn according to the constructivist perspective, as well as from the research about expertise. They are explicitly conceived with the

---

- In comparison to the knowledge of laymen or novices, expert knowledge is less related to superficial characteristics of the situation, and rather more structured using the founding concepts of their area, given them a strong structure. With this, experts show their "nearness" to their domain of knowledge, which does not mean, however, that this structure is the systematic within the domain.

goal-perspective, that one should connect the development of an elaborate base of knowledge on the side of the students with the educational developing of general and subject-specific problem-solving strategies and learning techniques.

"*Problem-Based Learning*" is designed to integrate the isolated, discipline-based areas of knowledge into a curriculum, and to bring the students starting from day one of their education into an active and co-operative form of learning – that of independent problem solving. Authentic and complex cases are at the core of this method and should be independently worked on, reflected upon and presented by the students themselves (cp. among others Barrows & Myers, 1993; Boud & Feletti, 1994; Klauser, 1998c; 2002).

The "A*nchored Instruction*" approach is about acquiring and applying a connected body of knowledge and ability with the assistance of narrative, video-based case presentations. The narrative format serves the situated embedding of complex problems, and is also the cognitive, motivational and emotional anchor of the problem-solving itself (compare among others Cognition and Technology Group at Vanderbilt, 1990; 1991; 1997; Klauser, 1998a).

The "*Cognitive Apprenticeship*" approach attempts to graft characteristic elements of the traditional craft apprenticeship onto the method of dealing with cognitive problems. "Modelling" is the focus of interest here. An expert shows how he goes about solving a problem and verbalizes simultaneously the cognitive processes hidden from view. The students reflect the expert's body of knowledge and methodology and apply it to the solving of new problems, whereby they are assisted by the experts. (cp. among others Brown, Collins & Duguid, 1989; Dörig, 1994, p. 264ff.; as well as in regards to the teachers' action Dubs, 1998).

III Design of Learning Environments

Primarily related to the design of learning environments are the "findings, conclusions and research agenda" put together by the "Committee on Developments in the Science of Learning" and the "Committee on Learning Research and Educational Practice". These were published in the two volumes title "How People Learn", with the subtitles "Bridging Research and

Practice" (Donovan, Bransford & Pellegrino, 2000) and "Brain, Mind, Experience, and School" (Bransford, Brown & Cocking, 2000).

The focus of interest here is the demand for the creation of the complex teaching-learning arrangements known as "student-, knowledge-, assessment- and community-centered". The above-named, modern instructional approaches and, even more importantly, Constructivist-influenced learning-processes would be aimed for.

2.3 Principles for the Shaping of the Teaching-Learning Process

Proceeding from these theoretical foundations, the activities within the project were logically at first **not** concentrated upon the design of the learning environment and learning material – in other words not primarily upon the material and technological shell for teaching and learning. Rather, a process of discussion about and between all the disciplines and positions happened. Through these discussions, the following principles for the creation of the teaching- and learning-process were agreed to as a basis upon which the different disciplines could begin their construction:

1. Individualization of Learning through the Simultaneous Emphasizing of Social Forms of Learning

Individualization is generally seen as the great value of E-Learning. In this sense, it is about

- the time- and place-independent processing by learners of contents and assignments or
- the technologically-based individualization of the level of difficulty, selection of material, assistance, tests, feedback and learning accompaniment.

The project team assumes that E-Learning is not only to be implemented in a one-sided way focusing upon individualization, but rather must always be discussed and formulated within the context of the social dimension of learning. The social dimension is a basic determining point of every learning process. From this point of view, individualization can only base itself upon sozializing. If individualization is emphasized within this program, it is also at the same time required to formulate the social dimension of learning. There are many widely varied possibilities for this:

- on the one hand, technology-supported through the use of synchronous and asynchronous communication and co-operation using a teamroom, chats, e-mail, online-tutoring, a hotline, video-conferencing or the open-source method, and
- on the other hand, very traditional through the use of face-to-face meetings, which would be implemented complementary to the phases of the self-organized learning.

2. Self-Organized Learning—assisted didactically for greater success

One of the most important values of E-Learning is the possibility to fashion one's own learning in a self-organized way. We know from research that self-organized learning by no means leads automatically to great advances in learning for every student. Such forms of learning are often combined with too-high expectations and demotivation (Friedrich & Mandl, 1997). For this reason, IMPULS^{EC} is built upon making available self-organized learning-processes that are didactically accompanied and actively supported.

3. Acquirement of Knowledge, Development of Abilities and the Influence of Values

The analysis of the market and of current developments shows clearly the inordinate dominance of knowledge components within many E-Learning possibilities. Like in traditional education and continuing education, cognition and facts are emphasized. The ability, attitude and values remain mainly ignored within the goal canon as well as during the shaping of the teaching- and learning-processes. The construction- and implementation-activities within the IMPULS^{EC} project exist in direct contradiction to these views, and focus upon emphasizing and connecting knowledge acquisition, ability development and the influence of values.

4. Discipline-Based Knowledge and Ability – presented, processed and tested in an interdisciplinary way

According to the opinion of the project team, electronic commerce is a complex working- and learning-area, which must be presented, processed and tested in an interdisciplinary way if it is to be disseminated and adopted successfully, expertly and pedagogically effectively. The teaching- and learning-processes are thus formulated in such a way as to lead to the integration and combining of the various points of view from business management and economics, business informatics and business education into modular learning material. The widespread problem of “pigeon-holing thought” and the trend towards the compartmentalizing of knowledge can thus be combated. The ability to conceptualize and work within a set of complex contexts should be promoted. The interdisciplinary nature of the learning material expresses itself in that the course of study is set within the various, academic business disciplines.

5. Complementary Nature of Learning, Practical Action and Systematic Reflection

The current developments within the area of E-Learning show that in general, great value is laid upon (whichever form) of learning, but that practical action and, most importantly, the reflection of contents, ways to learning and learning results are often neglected. – The learned content is often practically applied without the necessary breadth or volume of application. The students must thus mostly create themselves the contexts between topics, elements of knowledge and the execution of action, just like in the traditional forms of education and continuing education. In addition, there is hardly any systematic reflection about computer- and Internet-supported learning with regards to metacognition. In order to fix these deficits, the construction- and implementation-activities within the IMPULS^{EC} project are based upon the complementary nature of learning, practical action and the systematic reflection about contents, learning processes and learning results.

6. Balance of the Relation of Knowledge and Praxis Orientation

The learning material within the presentation is intended for university-level coursework and is to be implemented within the various academic business disciplines. However, this does not intend a one-sided alignment of the contents and learning-processes with academic knowledge and ability. Rather, it is about achieving a balance within the university studies between the orientations of science and practice, as well as to constructively remove the supposed contrast between science and practice through learning materials formed according to the introduced recognitions and methods. The demand for a balance between science and practice orientation is a large part of IMPULS^{EC}'s reason for being, because electronic commerce is a dynamic practice area with extremely advanced applications in businesses and public offices.

How were these principles for the construction of learning environments and learning material actually implemented materially and technically? To answer this question, a few components and functionalities of the Internet-based solution will now be outlined.

2.4 Components and Functionalities for Effective Learning and Teaching

Complex problems, the model company IMPULS-Schuh AG" and video-based episodes

Complex problems taken from the future career area of the students are the curricular and didactic-methodological starting point and point of reference of the courses, modules and lessons. These problems are intended to have not only *one correct answer* but rather *several possible answers and different ways to find a solution*. The posing of problems is wrapped in narration and shown on video in the form of episodes taking place in the model company "IMPULS-Schuh AG" (IMPULS-Shoes corp.). The model company has been modelled after an actual existing company – the ECCO Schuh AG – with a comparable product line, structure of organization and processes as well as with comparable practical tasks. The development of the model company is dependant upon the quality of the business process being formed by the students. The front page of the Internet presence for IMPULS-Schuh AG is to be found at: http://www.IMPULS-schuh.de.

Just like at a "real" company, people with names, faces, characters and ideas will influence and change the business events occuring at IMPULS-Schuh AG. These people work as a team and solve problems together. To this end, they work according to the principles of the division of labor, and each person has respective to their function a totally different competency- and assignment-area that has to be mastered alone. The acting individuals are managers and employees in the model company, or external experts who are helping to solve the problems.

The complex problem in the beginners' course (E-Commerce as a complex area of knowledge – an introduction) is for example constructed in the following manner:

Frightened by reports in the industry press about rising volume and profits at a competing company, the business executive Dr. Schuhmacher calls the company's managers together and invites a business consultant to analyse the reasons for this development. After extensive consultation, the committee comes to the conclusion that the growth in volume and profits at the competing company are due primarily to activities involving electronic business practices. It is decided to first analyze the chances and risks involved in electronic business processes, and then to use this analysis as a basis for the formulation and implementation of a strategy aimed at introducing an E-Commerce solution for IMPULS-Schuh AG. A project team is put together and set to work towards this end.

Figures of Identification and Tasks for the Students

Two recognizable figures, a trainee and the project leader, speak specifically to the students and invite them to integrate themselves into this team and to collaborate on dealing with the problems posed.

Problems posed in the following learning units build upon the complex problem formulated in Course One. A continual relationship to the model company and the acting persons will in this way be ensured throughout the entire course of study.

Each problem portrayal finishes with a task for the students, which focuses on either a "product", a central idea, a technical- or software-solution, a curriculum for an employee training course, etc. It is not only about acquiring knowledge, but rather also about applying it in a "near-real" context.

Generative Problem-Solving and Components for Effecting Learning and Teaching

Within the traditional educational and continuing-educational forms, problems have often served primarily for the application of previously transmitted knowledge. Students must already have the necessary knowledge and abilities at their disposal before working on the problem or its solution. The learning-process within the IMPULS^{EC} project is shaped based on *generative problem-solving* (Klauser, 1998c; 2002). The students acquire and master their knowledge and abilities during the process of problem-solving. To this end, many different components and functionalities are at their disposal, for instance:

- formulation of learning objectives aimed at the knowledge and abilities to be acquired as well as at skills, attitudes and values,
- descriptions of the necessary prior knowledge and abilities for the processing of individual learning units,
- Advance Organizer, which ensures orientation and transparency,
- a media library with collections of material using different media,
- an office for student concerns,
- a cafeteria with synchronous and asynchronous communication,
- a coach who functions as a learning companion,
- technical and expert assistance,
- an interdisciplinary-formulated glossary,
- literature for further reading,
- practice-, application- and transfer-exercises,
- systemizer and
- tests to check the students' learning success.

These are a few of the components and functionalities to be seen on the interface of the learning platform, and which can be used by teachers and students alike. However, nothing has been said about the processes that were necessary to bring all of these things into the interface, and to make them usable and capable of fulfilling their pedagogical purpose. The main area of tension between pedagogy and technology, which will now be carefully observed, was built up within these processes as well as within the steps taken and instruments used in their construction. This is not only about producing harmonized results. Rather, we would like to look at the areas of friction between the disciplines involved and, more exactly, at the following points:

- the fixing and application of terminology,
- the question, how can pedagogically-prepared content be developed in a platform-independent and medium-flexible manner,

- the problem of consistent, and to a certain extent standardized development-methodology and –tools,
- the necessity of efficient implementation with careful attention paid to aspects of the multiple-use and re-use of content components, as well as the necessity of efficient support of the various editing processes, and
- the paramount question of quality assurance for the construction process, the product and the implementation.

3 Technical Potentials—A Challenge to Education

3.1 Business Informatics and Business Education—Different Perspectives and Ways of Proceeding

The early, indeed, immediate agreement on specialist language and ways of proceeding is an important basis for successful interdisciplinary collaboration. Differing paradigmatic assumptions and perspectives, the differing use of terminology, or the often very different academic methodology employed by the different disciplines ensures a high potential of conflict. This must be understood from the very beginning in order to ensure any success for the collaboration, to recognize potential problems in the collaboration and to find corresponding solutions.

Even if this truism seems to be a given, it is continually surprising how few IT-Solutions for E-Learning environments actually base themselves upon serious interdisciplinary collaboration. Rather, one often sees the acquiring of a smattering of pedagogical knowledge occuring parallel to the development. To be truly interdisciplinary means and requires the coming together of specialists from different areas of expertise, not the broadening of isolated expert perspectives into areas of foreign and misunderstood concepts. The teams must be truly convinced, and lots of time, energy and tolerance will be spent during the beginning phases to deal with misunderstandings and the acceptance of compromise solutions. Due to collaborative findings, these solutions will sometimes not be at the absolute pinnacle of information-technology.[4]

The use of terminology such as implementation, learning environment or content proved in the case of IMPULS^{EC} to be problematic. From the pedagogical point-of-view, the use of "content" is especially associated with learning content. In contrast, a specialist author with an important role in the construction of E-Learning environments automatically associates this term with the learning matter within his domain. However, this learning matter is

---

[4] Compare to earlier attempts for the interdisciplinary coming together for work on multimedia learning the activities of the working group „Hypermedia in Education and Continuing-Education" of the GI-Fachgruppe 4.9.1 Hypertext systems from 1992-1995 under co-leadership of Ulrich Glowalla (Psychology) and Eric Schoop (Business Informatics) (Glowalla & Schoop, 1992; Schoop, Glowalla & Witt, 1995).

not at all learning content in the actual sense, which would require a transformation through didactic means. Finally, from the point of view of information technology, this term is used synonomously with its english translation “content” and understood as weakly-structured data that are to be understood, managed and presented (see Diagram Two).

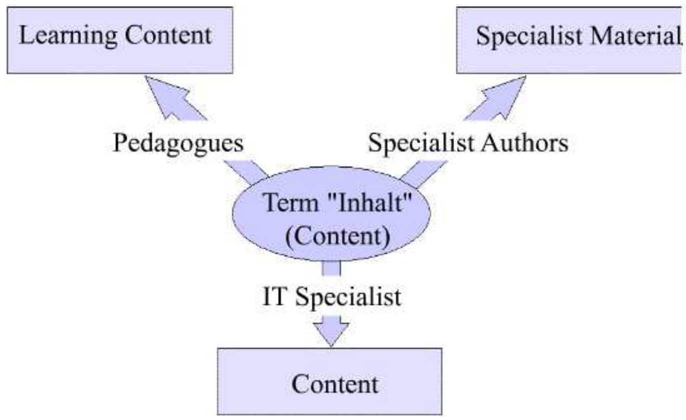

Diagram 2: Different Understandings of Terminology using „Content“ as an Example Case[5]

Interdisciplinary collaboration only really offers the chance to be able to develop and test new and innovative methods if misunderstandings and the sources of problems are recognized and neutralized in the beginning; for example, by finding neutral terms for the respectively different meanings of terminology.

3.2 Current Level of Technology

Currently, a change is occurring within the area of system-technical support for the management of semi-structured data. While the management of structured data experienced support very early on in the form of data base systems with the assistance of special techniques from Data Engineering

[5] This confusion is specifically related to the various meanings of the word “Inhalt” (content) in the German language. There are similar problems with terminology in English.

(ER-Modelling, Normalizing), semi-structured data was treated as a unit with its medium of delivery, the *document*, and for years never more closely analyzed in terms of content or structure. The early Document Management Systems offered no support for access to the various data within the documents themselves. Admittedly, there have been attempts – including Generic Markup Language (GML) at the end of the 1960's and the ISO document-standard SGML (Standard Generic Markup Language) since 1986 – to characterize the data within electronic documents and thereby to make data machine-analysable and -processable[6]. However, a significant broadening of these beginnings did not occur until XML (eXtensible Markup Language) was agreed upon by the World Wide Web Consortium (W3C) in 1997. XML is a simplified successor of SGML specialized for the use of the delivery medium Internet. Through XML it became possible to transfer principles of the organization of structured data to that of semistructured data, and to automate its management through the use of Content Management Systems (CMS) (Gersdorf & Schoop, 2001).

The fundamentals of XML, the management of such documents through CMS, and the resulting potentials for the technical depiction of learning content will be introduced successively.

3.2.1 Separation of the Document's Parts into Structure, Content and Layout

From the technical point of view, all documents consist of their component parts content, structure and layout. *Contents*, which actually represent the information that is to be transmitted or transported, are seen as either static or dynamic data. Static data, for example pictures and text, are time-independent and in the rule capable of being represented on paper; dynamic, or time-dependent data, like animations, video or audio, are in contrast more suitable for presentations using electronic mediums (for example CD-ROM or the Internet). The individual contents are inserted according to the author's plans into documents and have a relationship to one another, through which the document receives its *structure*. More complex texts are in this way generally divided into chapters, parts and paragraphs. Through this structuring, the

[6] comparative book discussion SGML (Schoop & Schraml, 1996)

documents' content can be better received by the human recipient and more conveniently conceived and revised by the authors. Normally, these structures are characterized implicitly by the various representations of the content. For example, headings at the first level are often in boldface, those at the second level in italics, or that headwords and glossary terms are often separate from the text. This formatting, or *layout*, makes it possible for the recipients to recognize the logical structure and thereby to understand the meaning of the actual content. Diagram Three makes clear the connection between structure, content and layout within a document.

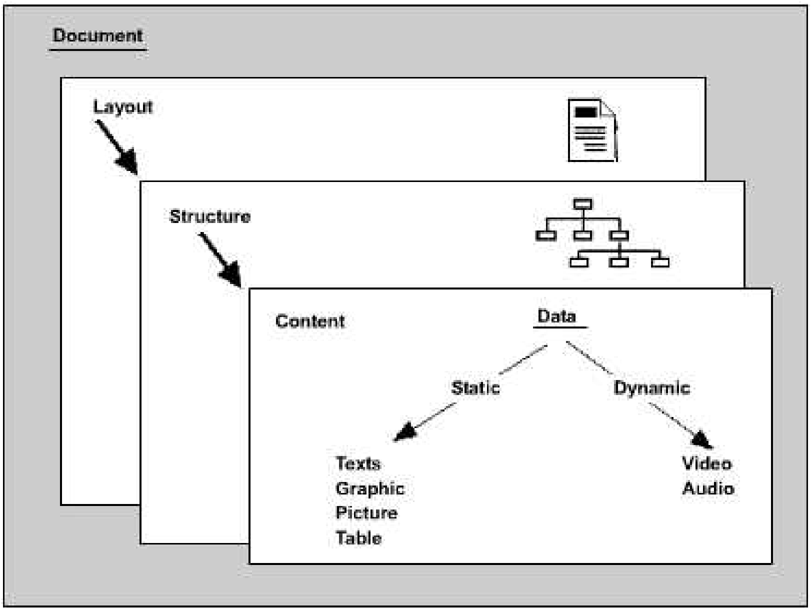

Diagram 3: Connection of the Document Parts Content, Structure and Layout (Schraml, 1997)

The described implicit and often subconscious creation of a document structure through formatting holds, in particular for larger and more complex documents, the danger that the formatting is either inconsistent or that an inconsistant structure has been selected. A decisive disadvantage of the "classic" document processing is that the layout has already allocated the semantic. Due to this, an automatization of the document exchange the further processing processes is nearly impossible. In order to do this, machine-processable metadata are necessary. Here begins the explicit division between the named document parts content, structure and layout. The structures will for this reason be allocated to the unformatted contents. The first-level heading will no longer be printed simply larger and bold, but rather tagged unambiguously. The authors can also be given instructions for their use to help them avoid erroneous structures, for example, third-level headings following first-level headings. The formatting wishes can then be elegantly and document-consistently solved by a secondary layout allocation using explicitly recognizable structural- or content-describing elements (Metadata). For example, while all glossary terms would be shown in italics, the literature references would be automatically underlined.

3.2.2 XML – Basis for a Platform-Independent Development of Learning Content

The basic principle shown above can be implemented with the assistance of a document description language. XML has been adopted by the IMPULS^{EC} project. It is based upon the described concept of the separation of structure, content and layout, and has become ever-more known in the last few years as a flexible mark-up language. More exactly, XML is actually a meta-mark-up language offering the possibility to define other languages based upon XML. Such languages – for instance SVG (Scalable Vector Graphic) for the XML-based figure of vector graphics on the Internet, or SCORM (Sharable Content Object Reference Model) for the platform-independent creation of learning material for Internet-based E-Learning – are often described as applications (see Diagram Four, outside circle). Next to the concept of the meta-language (inner circle) exist the so-called co-standards based upon the concept of XML, but which cover very specific assignment (work) areas (for example, formatting with XSL[7], connection with Xpointer[8]).

---

[7] XSL is a XML Stylesheet language used for the automatic formatting of XML documents.
[8] Xpointer serves the application-independent definition of cross-referencing within and between XML documents.

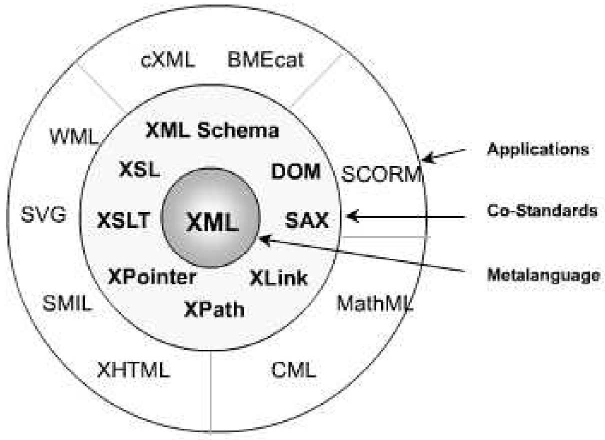

Diagram 4: The Meta-language XML, Co-Standard, and Applications (Anders, Jungmann & Schramm, 2002; Michel, 1999)

The possibility of using XML to create a separate semantic based upon a simple, machine-efficient interpretable grammar shows the actual advantage of the XML approach. In addition to logical structural indicators and content description, one could use document engineering methods[9] to depict complex characteristics, requirements and rules. These would then contribute to the active support of the authors during the creation and editing process. We have used this potential at IMPULS^{EC} to our advantage.

There are two decisive pedagogical reasons for using a separate language or application based upon XML for the construction of network-based E-Learning environments:

1) this language makes possible the development of learning content according to a curricular- and didactically-validated structure described within a Document Type Definition (DTD) and
2) the automatic allocation of the layout ensures a learner-appropriate and consistent presentation of the learning content.

---

[9] For more description see (Schoop & Strobel, 1998).

From the technical point of view, the following possibilities also exist for a comprehensive Content Management using a Content Management System (CMS):

1) XML makes possible to re-use content that has been created once,
2) the allocation of stylesheets enables the (partially-)automated preparation of the content for different mediums and target groups,
3) using transformation, the content can be used on various learning platforms,
4) the content is easy to update and
5) due to standardization, XML offers long-term protection for the effected investments.

The conception and implementation of the necessary prerequisites for working with XML is arduous. First of all, one has to develop a didactically-validated structure for the whole learning system as well as for its parts and components. To accomplish this, it is necessary to ascertain as detailed as possible the design- and quality-features for the creation of the learning system. This structure will then be formally depicted in so-called DTDs (Document Type Definitions). DTDs are the rulebook in which it is decided, how classes of the same kind of documents are to be technically depicted (Goldfarb & Prescod, 2000). They affect the construction and order – in other words, the structure – of the whole learning system and each of its individual parts.

The strength of our demanded and existing interdisciplinary nature begins precisely here: the didactic principles, rules and methods are formulated from the pedagogic partners and not only communicated to the IT partners, but grounded understandably und logically through collaborative work. The IT partners can then implement this didactic standardization in XML-syntax using the introduced instruments for document engineering. The result of this implementation will then be checked by the pedagogical partners to ensure that it fulfills their expectations. Through these interactive processes, which took much time and effort, the DTD-modelling within the IMPULS^{EC} project achieved a never-before seen level of quality.

The content is then created afterwards by the authors according to this structure. Since the authoring tool can check the structural but not the semantic quality of the content, pedagogical advising and quality control of the possible formalized standards is absolutely necessary during the construction phase.

In a further step, all content will be allocated a consistent layout with the help of this structure.

3.3 Architecture — The System-Technical Foundation for the Proposed Plan

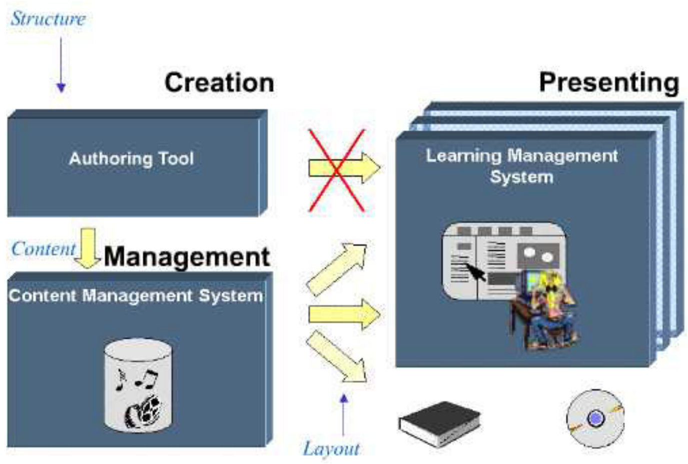

Diagram 5: Architecture

Various systems will be used for the implementation of the developed technical plans (see Diagram Five). With them we shall see the division of the development of learning content and its management on the one hand and the presentation of the content and the realization of the interaction on the other hand in the sense of a two-level architecture. We are intentionally avoiding the immediate availability of the didactically-prepared expert content for one particular Learning Management System.

3.3.1 Creation of Learning Content

The XML-editor XMetaL from SoftQuad is our authoring tool for the creation of text-based learning content, the integration of multimedia components as well as for the registration and management of metadata. Through an additional, user-friendly adaptation to the developed structural specifications, the authors have a comfortable foundation for creating the learning content. The editor XMetaL guarantees already during the creation process that the documents are developed according to the planned structure, in that:

- the necessary elements or part structures are automatically inserted and called upon for the input of the corresponding content,
- only those optional elements and part structures that are allowed at each respective prompt are offered for insertion, and
- the validity of the entire structure will be checked before saving.

Thanks to these advantages, the authors are saved the considerable trouble of constantly ensuring the upholding of the correct structures (for example, the concrete sequence of didactic steps and functions corresponding to the agreed-upon pedagogical concepts), and they can concentrate on the creation of the actual content and its sequencing. During the technical registration of data, the structures are automatically visualized through various formats. The document structure can be shown or not shown as desired. There is also a preview-mode whereby the HTML-output resulting later for the Learning Management System can be looked at in advance.

Non-text-based learning content (audio, video, animation) is created using special programs and then integrated using the data choice dialogue box. Suitable referencing "place-holders" were modeled into the DTD-structure for such content.

3.3.2 Management

The developed learning content is imported using an interface directly from the editor into a data base-based Content Management System (CMS), eidonXportal. At the same time, the learning content is modularized on pre-defined levels, in order to make possible the re-use of content. As the central authority, the CMS also supports the distributed editing processes required for the creation of learning content by several authors working at different locations. The following functionalities (among others) are offered for this:

- the allocation and upholding of access privileges,
- the regulating of access for various users using Check Out/Check In,
- the management of versions and variants, as well as
- support of the work-flow.

3.3.3 *Presentation*

While authors, teachers and tutors – in other words all those involved in the construction of learning content – are working with the CMS, the Learning Management System (LMS) will be used by students, teachers and tutors for the following pedagogical process of the moderated, self-organized acquisition of knowledge. The following functionalities are offered:

- the presentation of learning content,
- course administration,
- the collection and management of data, as well as
- tools for synchronous and asynchronous communication.

The IMPULS^{EC} project has adopted the product Lotus LearningSpace 5.0 for these needs. In order to present the XML-based content in the Internet using LearningSpace, the content will be transfered out of the CMS using a self-designed converter into a data format usable by LMS (most-often, HTML). Further, the needed information is added according to the AICC standard. If a LMS is later introduced that does not support the AICC standard, it will merely be necessary to implement a further converter. This approach ensures that content created one time can be transferred into and used by all of the various LMS systems.

3.4 Demands on Business Educators and Information Technicians

The chosen approach has resulted in the following demands on **business educators** for the collaborative work on the IMPULS^{EC} project:

- ➢ It is necessary to develop and deepen an understanding for the architecture, the basic XML concept and the related instruments (DTDs, editor), as well as to integrate the resulting technical requirements and possibilities into the business educational way of thinking and working.

- It is necessary to secure a lasting didactic consultation, accompaniment and training of the technicians, specialist authors and tutors.
- A system for pedagogical- and mediadidactic-quality control related to the construction process, the products and the implementation must be established and maintained.
- In addition, decisions must be made and numerous guidelines developed with regards to:
  - the structuring and linking of learning content,
  - the presentation of learning content,
  - the formulation of the teaching-learning processes, and
  - the support of students and authors through assistance.

The quality control represents the central factor for success for the construction and use of E-Learning environments. Even more so since in the current discussion this predominant problematic receives inadequate attention. There is potential for research in the area of interlinking of learning content as well as the development, modelling and consistent application of a unified specialist language in the area of informatics and business informatics.

For the information technicians the following areas of work have resulted from the introduced concepts:

1) The technical concept is to be formulated according to pedagogical guidelines.
2) To do this, suitable hardware and software systems must be chosen, obtained, installed and adjusted as well as developed. This means first and foremost the
   - choice, implementation and adjustment of suitable **editors** for the registration of content,
   - choice, implementation and adjustment of the **Content Management System** for the management of content

- choice, implementation and adjustment of a **Learning Management System** for the presentation of content,
- choice, installation and maintaining of a suitable **server**, as well as
- the development of the necessary **converters and interfaces** between the editor and CMS as well as between the CMS and LMS.

3) The users are to be educated in the efficient use of the system.
4) The system is to be constantly administered and maintained.

4 Pedagogically-Emphasized Technical Solutions – A Synthesis

In Chapter Three, a few questions were posed from the technical side that have to be answered from the pedagogical. Discussed in the following section will be, at which work steps and in which way will the questions become active within the construction process, as well as how they shall be answered. For this, the individual steps of the content development – as well as the creation of pedagogically prepared content – will first be shown, after which the pedagogic assignment areas related to each step will be summarized.

4.1 Steps for the Development of Multimedia Content

The approach within the IMPULS[EC] project foresees the following process for the development of multimedia-prepared learning content (see Diagram Six).

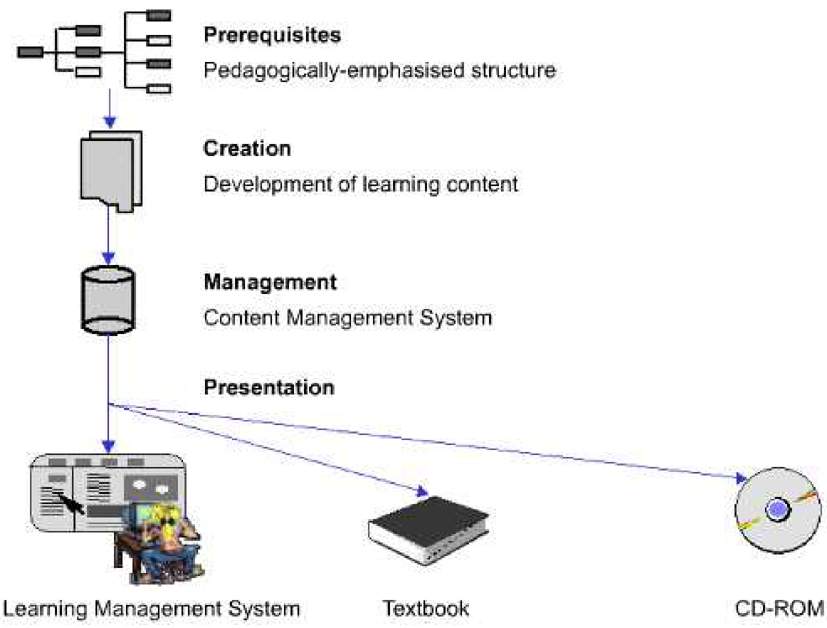

Diagram 6: Steps for Content Development

A valid structure for the entire course of study is to be developed in the first step. This structure is to be both based upon the curricular, didactic and methodological criteria corresponding to the preferred pedagogical approach (cp. Chapters One and Two) as well as technologically realizable; in other words, it must be processable with machine-readable algorithms and data structures (cp. Bogaschewsky, Hoppe, Klauser, Schoop & Weinhardt, 2002; Klauser, 1998d).

This structure is codified using so-called structural guidelines, according to which the authors afterwards create the content for their respective domains (see Diagram Six): The authors develop pedagogically-structured and technically-logical and –representable texts, pictures, animations, audio-sequences or videos, and combine these with one another.

The production of multimedia content requiring lots of processing power, such as video sequences, is transfered to external producers (designers, graphic artists or film studios). They will then be supported and led pedagogically during the creation process. The co-ordination of these assignments takes place through the use of instruments specifically prepared for these needs, such as screenplays, storyboards and flowcharts (cp. Jungmann, Wirth, Klauser & Schoop, 2002).

The multimedia-prepared learning content is imported during step three into the Content Management System (see Diagram Six). This technical system manages the content in the form of identifiable, individually-processable structural objects (courses, modules, lessons, media objects).

The presentation of learning content takes place within a Learning Management System. The learning content can, however, also be printed or saved on CD-ROM from the Content Management System. The content is usable for the teaching-learning processes while remaining platform- and operating system-independent. Therefore, the whole learning system is not only "virtually" but also "actually" available for students and teachers. Because of this, a broad, didactic-methodological area is open for use. In addition, the potentials of computer- and Internet-supported learning can be effectively connected with the benefits of traditional teaching-learning forms.

What are the concrete demands on business educators within these individual steps?

4.2 Assignments for Business Educators

4.2.1 Development of the Structure

The structure of the course of study that is to be worked out has a pedagogically-emphasized orientation. While book texts do perfectly well with title, introduction, main section and conclusion, Internet-based learning environments satisfying the quality levels formulated in Chapters One and Two have to orientate themselves according to a variety of media pedagogic functionalities, and in particular to didactic functions.

Firstly, a general structure for the course of study was developed out of the overall pedagogical concept (cp. Klauser, 1998d; 2002; Bogaschewsky, Hoppe, Klauser, Schoop & Weinhardt, 2002). The key is to choose a basic superstructure that should serve as a unifying foundation for the course of study, and with it all courses, modules and lessons (cp. Jungmann, Wirth, Klauser & Schoop, 2002). Concurrently, the navigation and interaction plan is set in stone and the fundamental units will be prepared for modular storage and the later multiple-use by teachers and tutors

For the pedagogical structuring, all components of the future learning environment will be classified in an intitial step. The most important aspects for the classification are their structure, typical characteristics, position within the whole environment, connection to one another and didactic function.

In a second step, we will examine and consider how many of the creative requirements upon the established parts can actually be technically implemented.

Guidelines mirroring the relationship of the individual parts among each other and their position within the whole learning environment are implemented technically as Document Type Definitions – abbreviated as DTDs (cp. Chapter 3.2). The optical appearance of the whole learning environment is from a technical perspective fixed within so-called stylesheets. A stylesheet decides the layout of the basic documents: typeface, font size and color are just as pre-determined as pagination or the placing of elements.

Guidelines that from the technical perspective cannot be implemented using DTDs or stylesheets but that from the didactic perspective represent important action instructions for the authors will be implemented as formalized guidelines. They contain, for example, media didactic assistance for the combination of pictures and text, or give stylistic recommendations for formulating texts.

For the IMPULS^{EC} project, such a structure was worked out and technically implemented for the various levels of the course of study such as lessons, modules and courses, but also for various didactic components like complex problems, Advance Organizer, other systematizations or the glossary (Gersdorf, Jungmann, Schoop, Wirth & Klauser, 2002). Diagram Seven shows an excerpt from the structure of the course of study with the outline for the course, module and lesson levels as well as the didactic components for the lesson level.

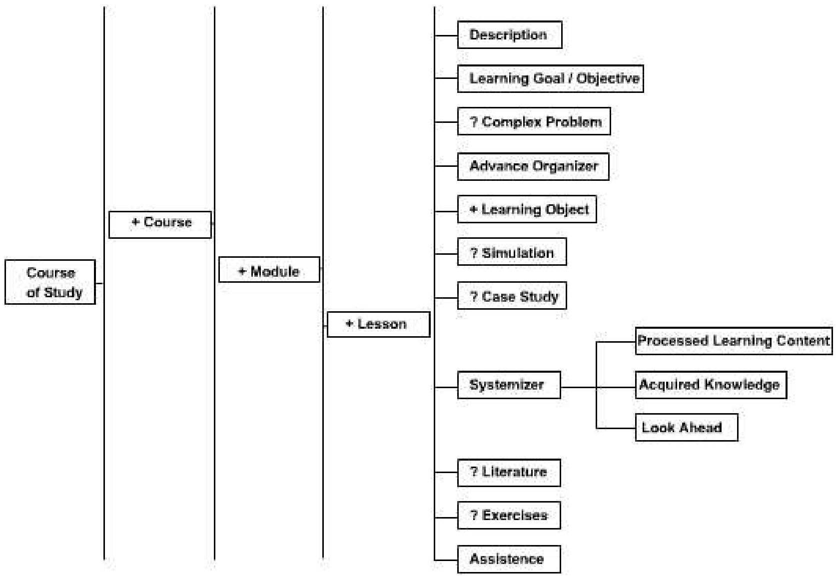

Diagram 7: Structure for the Course of Study

During this process, every ordered step, every component and every didactically-necessary criterium was inspected on its way for how it could be technically realized and which didactic possibilities for action and restrictions would result in the dependence upon the respective technical realization possibilities.

The goal of this action was to fix and shape a unified and technically-processable structure for the individual learning units in a way corresponding to the pedagogical concepts, and simultaneously to create and maintain latitude for action for the specialist authors. This is also especially valid for authors who at the moment are not involved in the project, but who would like to contribute their domain-specific content to the learning environment.

In the IMPULS^{EC} project, Document Type Definitions were developed through intensive, interdisciplinary collaboration as a basic tool for the creation of content. These DTDs form a basis allowing authors from various subject areas to uniformly and effectively construct multimedia learning environments at a high technological and pedagogical level.

In the following section, a visual excerpt of the DTD structure for lessons, the smallest learning environment unit within the course of study, will be introduced. It will be shown precisely which pedagogical questions are connected to such structures, and which solutions in the project were worked out.

As necessary parts for each lesson, an Advance Organizer, a complex problem and one or more content-related learning objects were defined (cp. Diagram Eight).

The questions posed to the pedagogues were related to, for example,

- whether it dealt with a necessary or an optional structural component,
- whether or how often a component could optionally be inserted,
- with which information the components could be later called on and used by the teachers and tutors,
- what sort of relationship exists amongst them, and how they can be technically implemented, or
- which dependencies exist between the individual components that can or must be technically expressed.

Complex problems are the curricular- and didactic-methodological starting-point and point of reference for Internet-based learning and teaching (cp. Klauser, 2002).

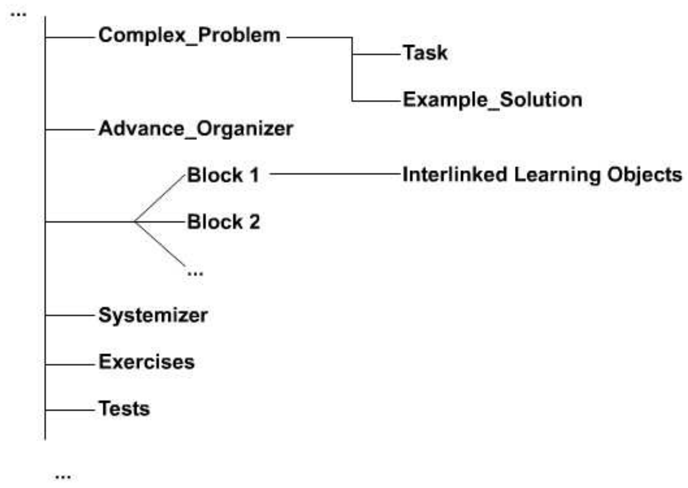

Diagram 8: Excerpt from the DTD structure for one lesson

Problems differentiate themselves from exercises, for example, in that the students do not know the algorithms for the problem solution. Rather, they must first work them out. According to Dörner (1989), problems can be defined as complex when they have the following characteristics:

- Complexity: A large number of components exist independent of each other, and their sum constitutes the problem. The components can accept a large number of conditions.
- Level of Linkage: The influencing of components does not remain isolated, but rather has various primary-, secondary- and remote-effects upon other components and the whole problem.
- Lack of Transparency: Many components are not available at once but rather must be worked towards.
- Dynamic: The components and above all the problem develop their own dynamic. The analysis of momentary conditions does not suffice

for the planning and control of action in many cases. Instead of this, the developmental tendencies of the components and of the whole system must be anticipated and taken into account.

- Polytelie: There are differing ideas of the goal among the actors whose individual acting goals are also interlinked with each other like the components of the system. These goals could be compatible or incompatible with one another.

During the shaping of the structure, five questions are to raised about the **reasonable complexity of the problem** to be worked on (cp. Klauser, 2002).

- First of all, what level of complexity is in order to model the problem realistically and in a way reflective the domain systematic.
- Secondly, it is to be clarified what level of complexity is required in order to realize the respective objectives and content as well as the planned qualification- and educational-processes.
- Thirdly is the question, to which extent the E-Learning environment covers the required complexity, or whether additional instructional measures would be required along the way.
- Fourthly, we must ask what level of complexity is appropriate for the individual preconditions of the students – for their prior knowledge, cognitive abilities, interests and potential for success. During this process, the use of the "Zone of Proximal Development" has shown itself to be necessary (Wygotski, 1964). According to this concept, a problem is appropriate if the student can solve it with some difficulty and assistance, whereby the assistance can come from a technical system as well as from the teacher. In any case, this assistance should be individualized.
- Fifthly, the didactic expertise of the teacher cannot be ignored. It must be clarified what level of complexity can be mastered by the teachers technically and didactic-methodologically within the curricularly-given time- and condition-framework.

In regards to the technical realization, the following questions in connection to complex problem formulation need to be answered:

- Must a complex problem be formulated for every lesson?

- Can there be several complex problem formulations within one lesson? How do these relate towards each other, and how can these relationships be technically depicted?
- Which components does a complex problem formulation have? What are the structure of the presentation and the processing of the components like?

The following answers have been formulated in response to the questions posed concerning the structure of DTDs:

- A complex problem formulation that is to be formed contains more than one required component – in Diagram Eight, not only the complex problem but also the assignment formulation for the students and the example solution are shown.
- The presentation of a complex problem always directly follows the description of the learning objective and required prior knowledge at the beginning of a learning unit.
- No more content or technical arrangements will be defined for the Advance Organizer. The authors here have substantial room for creativity.
- All structural components can be shaped by the author through either text and/or media objects.

The learning content is represented technically as learning objects and interlinked to one another. One learning object contains the content areas, which can be coherently presented on one screen page, as is dictated by the media pedagogic perspective. Various learning objects are summarized into blocks. Blocks distinguish themselves in that the students can click on and open them during navigation using the Advance Organizer. Learning objects from various blocks can also, from the technical perspective, be interlinked.

The outlining of the learning objects and blocks shows that during the development of this lesson structure, information technical and pedagogical instructions have to be related to each other: The question, which display pages can be controlled from a certain point within the lesson can only be answered using pedagogical criteria and must be student-appropriate. Simultaneously, the learning objects that belong together and are content-related must be technically and organizationally brought together, in this case into "blocks". One lesson can contain as many blocks as necessary – the only technical requirement is that a lesson contains at least one block, or, said pedagogically: at least one learning content has to exist for each lesson.

In this first step for the development of multimedia content, the navigation plan must also be fixed and adopted according to the structure. In the $IMPULS^{EC}$ project, the Advance Organizer is used as the central navigational unit. It is central for the reason that it can be called up from every display page, and on the other hand because the student can call up not only the learning contents, which have been thematically grouped as blocks, but also the various didactic components.

If, for example, students are working on a lesson for the first time, then they will be first informed about what they can expect and what is expected. Next, they receive a solid work assignment from the complex problem, and head for the Advance Organizer. From there, the already-visited lesson pages can be called up, learning content is accessable, or one can choose the didactic components serving the exercise, application, transfer, the systemizer of learning content or the testing of success.

4.2.2 Creation of Learning Content

The second step for the creation of learning content consists therein, that specialist authors use this structure in order to prepare the learning content and objects of their domain (cp. Diagram Six). To this end, an editor – an instrument for text creation – was altered technically for the $IMPULS^{EC}$ project in such a way as to enable the authors to easily create the texts with the help of the DTD structures already introduced. Diagram Nine shows a screen shot from the desktop view of the editor XmetaL.

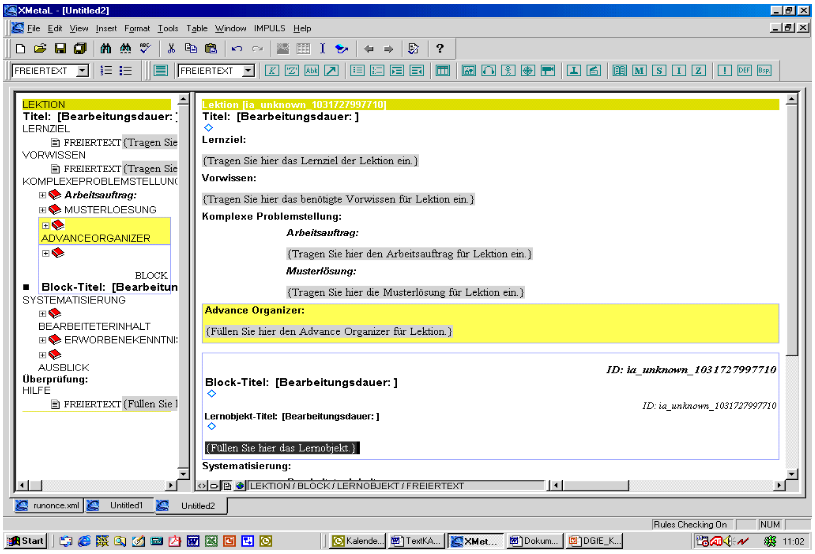

Diagram 9: Production of the lessons using XMetal

The whole structure of the document open for editing is shown on the left side of the display. The area with grey borders shows which components the author is currently working on. In the middle, the author sees the text to a large extent the same way that it will appear later on the display for the student. In the field with the grey background, the author is requested to incorporate the corresponding parts of the course of study. Under "Lernziel" (learning objective), for example; "Tragen Sie hier das Lernziel der Lektion ein" (Please enter here the learning objective for the lesson). If this does not happen, the author will be informed while attempting to save the edited document that parts of the structure are incomplete or missing, and thus that the document as a whole will be saved as invalid (that means, as not in agreement with the guidelines). The author is informed again when he/she loads the document, and this continues until all the elements have been completed in accordance to the structural guidelines within the DTDs. This means that a quality control is already taking place with regards to the completeness of the curricular and didactic elements, components and functionalities. The incorporation of audio- and video-sequences, animations or pictures into the text is already possible at this point as well.

In this phase, the area of assignment for business educators consists in offering the authors complementary, supplementary or explanatory support for the creation of learning content, for example, by giving criteria and guidelines for the work (cp. Klauser, 2002; Jungmann, Wirth, Klauser & Schoop, 2002). But that alone does not usually suffice. Additional training courses were held for the authors of the IMPULS^{EC} project, for the preparation of specialist content as learning content, for requests of the Tele-Tutors or for the question, how the complex problem formulation can be narratively formed and implemented in such a way that it can be prepared level-appropriately for a video. Here it becomes clear that a pedagogical preparation of the learning content cannot happen merely through the offering of a pedagogically-emphasized structure. The authors must put themselves into the educators' shoes in order to fill the structure with content while paying attention to the learning process. In order to do this, according to our experience, it is necessary to have a deep understanding of the pedagogical approaches, a complete grounding and most importantly a systematic training.

In addition, business educators must support the graphic artists and film teams who have taken on contract work for multimedia productions within the project, and thereby ensure quality for the product.

4.2.3 Presentation Using the Learning Management System

Multimedia-prepared learning content that has been approved by its author and checked by educators is managed as technical "content" within the CMS, and can be, after its export into the LMS, offered to the students as learning content connected to other courses, lessons and components. Diagram Ten shows the display view of a course within the LMS.

In the top part of the display is the browser menubar, just like for every other excursion into the Internet; underneath is the navigation bar of the learning platform. Under the signpost symbol, the users can call up the Guided Tour and inform themselves about the teaching-learning philosophy, the construction and the functionalities of the learning environment. The glossary – shown by a book with the letter “G” – contains a complete list of the relevant, interdisciplinary prepared terminology. Under the heading “News”, with the notepad symbol, the students can find tips about discussion forums, events and general information not related to one specific course. The students can sign up within the advising section (Symbol: Desktop) for various courses, and work with these using the button “My Courses” – the suitcase button.

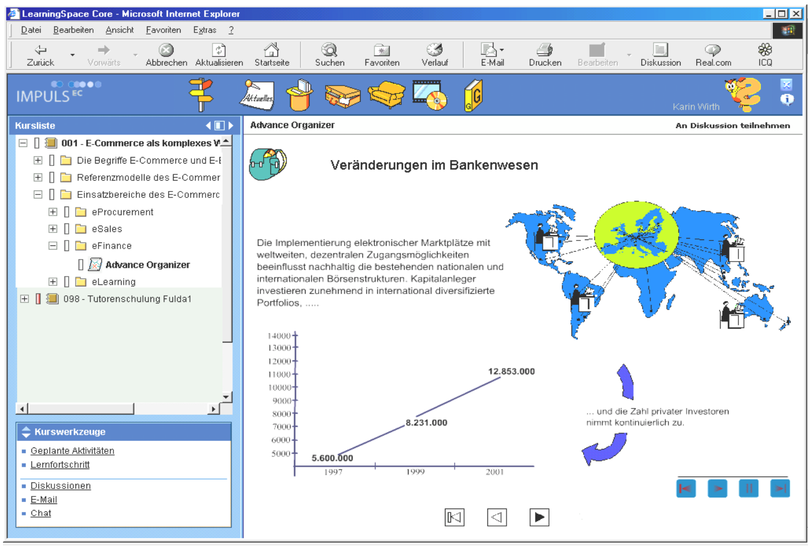

Diagram 10: Presentation using the Learning Management System

The structure of the chosen courses is shown in the left-side browsing area. The diagram shows the structure of the course “E-Commerce as a complex area of knowledge – an introduction” in its protype version. The left column contains the overview of the lessons of the respectively selected course, and the section on the right shows a typical learning object from the area of eFinance with text, diagram and animation.

A majority of the decisions with regards to the optical and functional creation of the visual display was made by the business educators (cp.

Jungmann, Wirth, Klauser & Schoop, 2002 with reference to Jarz, 1997; Schulz, 1998; and the essays in Issing & Klimsa, 2002).

One example for how differentiated the design decisions have to be made is shown by the placing of a video at a certain place within a text. It would have to be decided where on the display the video window should appear, whether the student can activate it him/herself or whether it is to be automatically shown, whether the sequence can be canceled or repeated and how large the window will be.

These decisions can only be made in a pedagogically rational way if they pay attention to research results, among others from the area of the psychology of perception and of cognition, and the area of teaching-learning research. The placing and size of the video window will be decided as well by the attention paid by the observers of the individual display zones, and by the planned directing of attention.

In addition, the following questions (among others) are to be answered:

- where and in which ways can students interact with the learning environment;
- what sort of assistance should be offered, for example, passive assistance to be called up by the student when needed, or active assistance that will automatically appear at certain areas;
- what form and overall structure should the navigation bar have; and
- whether a navigation bar is enough to ensure orientation, or whether various navigation bars are necessary, and how this could be arranged in a media pedagogic rational manner.

Colors, (standard-)forms or sizes must also be decided, the position of windows and animations must be fixed and the media didactic design quality must be certified. Such decisions require knowledge about perception and cognition psychology, as regards to overall display design, asthetic and artistic aspects of the creation of display screen views (cp. Issing, 1993; Schnotz, 1997; 1993; Tergan, 1997; Schulz, 1998; Jarz, 1997; Weidenmann, 1997).

Many of the depicted didactic, methodological and curricular questions posed are not restricted solely to computer-supported learning environments.

Similar questions must be answered by every teacher during the preparation of media material and its use within the classroom or for training courses. In any event, a majority of the learning environments available on the market do not appear to ever have been subjected to rigorous questioning or cross-examination, if indeed that even played a role during their creation (cp. Schulmeister, 2002).

What is new within the questions posed related to multimedia learning evironments is that in comparison to “real” classroom preparation even the first conceptual step centers around its technical realizability, which – once chosen – can only be changed with a great deal of effort.

The production of multimedia content, and most of all of graphics, videos and animations, can no longer only be done by the specialist authors. Quite often, learning content is created separately, and the production of the media components is out-sourced. Structural guidelines have to be worked on for this. They would offer a curricular and didactic-methodological area of action for the specialist authors, and are simultaneously technically realizable while taking full and effective advantage of the potentials offered by new media. Unified development methodology and tools must be envisioned in such a way that they can be quickly and effectively adopted by both authors and employees working for another company. Business educators would assume the role of mediator, advisor and coordinator within this process.

The development of the DTD structures for the IMPULS^{EC} project offers just such an area of action for the creation of learning environments, and they could easily be transferred and used for other projects following the same or a similar teaching-learning philosophy. With the development of stylesheets, guidelines exist for presenting using the LMS, which ensures a unified, student-appropriate layout that has been created according to media didactic knowledge (Jungmann, Wirth, Klauser & Schoop, 2002). Using this, a high technical and pedagogical level can be realized, which ensures the pedagogical intentions not only within the construction process but also during the presenting using the LMS.

However, it must here be noted that,

- these structures, tools and methods are no replacement for the necessary pedagogical expertise for the creation of multimedia learning environments and
- the making available of learning content within an LMS can replace neither a pedagogically prepared and formed learning situation nor a systematic, pedagogical action.

No structure, regardless of how technically mature or pedagogically based, can replace expert, pedagogical action, nor make it superfluous.

The creation of multimedia, network-based learning environments is a process in which technical and pedagogical assignments can only be solved in an integrated way. The developed structures, recommendations and guidelines are instruments both to control qualitatively and to validate this process.

At this point, we must return shortly to the questions formulated from the technical perspective (cp. Chapter Three). From the pedagogical point of view, newly accented or totally new demands have become necessary for the construction of Internet-based learning environments. These demands were summarized in the following diagram into areas of responsibility:

The construction of multimedia, Internet-based learning environments requires firstly a theoretical idea, which would then be implemented uniformly throughout the entire learning environment within all of its levels. The technical architecture must enable and support the implementation of this idea. To a certain extent, a close, interconnected relationship exists between the different areas of responsibility belonging to information managers and pedagogical specialists.

The second area of responsibility refers to the aesthetic design of a network-based learning environment at the center of construction. The design solutions decide how the attention of the students is drawn and which learning processes can take place at which level of quality. For this, research results from the field of psychology are especially important to heed and adopt concretely. For example, a technically unified adaptation of the visual display is required according to psychological and pedagogical yardsticks.

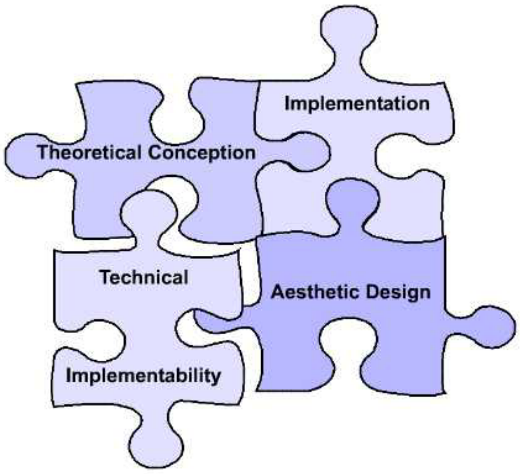

Diagram 11: Broadening of the request spectrum for pedagogy

It is necessary even during the construction to consider and prepare the later learning situations, learning requirements, the learning process, and the respective possibilities of learning assistance. It is also necessary to give the implementation of the learning environment special emphasis during the construction. Such a pedagogically-accentuated implementation term can cover itself only partially with the technically-understood meaning of implementation.

The experience gathered thus far during the IMPULS^{EC} project shows that the level of potential technical realization must be moved into the center of the pedagogical focus from the very beginning of the construction process, and must also be paid attention to during every phase of the construction to ensure that a qualified, high-value product ensues. But the opposite is also true: the pedagogical perspective is to be taken into account by the IT specialists from the very beginning as well.

One more major problem remains to be mentioned: the often underestimated influence of specialist domains upon the shaping- and perception-processes. Students with a focus out of information sciences are interested by totally different aspects, for example, respective to the XML-exchange standards within the digital supply chain, in comparison to students with an academic business background or perspective. Both groups of students have totally different sorts of prior knowledge and have, each according to discipline, various sorts of experience and expectations of the representative forms of learning content (formal/abstract/algabraic versus narrative/theoreticizing). This has consequences for the construction activities and their results in a way corresponding to the student-oriented approach.

The spectrum of new and changed demands can only be mastered by business educators and information managers working together. More exactly, it is to be mastered through an integrating fusion of the different perspectives and work methods as well as their implementation into instruments usable by both camps and a common development methodology.

5 A Quick Look Ahead

If the new media are really supposed to be used in a broader way for teaching and learning, the tension-filled relationship between technology and pedagogy must be controlled. This conclusion relates also and especially to the involved disciplines and people in the IMPULS^{EC} research and development project. The success of the project's work is very dependent on the effort to intensify further communication and co-operation as well as on the critical examination of the work methods and approaches of the respective disciplines involved, and to smooth these over with constructive solutions. In such an effort, much depends upon the business educators ability to prepare their ideas, approaches and content in such a manner that they are capable of being depicted with machine-interpretable algorithms and data structures. Information managers have the following assignments:

- To examine intensely the new pedagogical approaches and ways of thinking, and thereby to integrate their own specific ways of perceiving and working,
- To exhaust the possibilities of technology, in order to adaquately and effectively represent these approaches and ways of thinking and
- To broaden the technical possibilities along the way when the situation allows.

David Perkins (Perkins, 1992) titled his essay in the book mentioned at the very beginning by Duffy and Jonasson: „Technology meets Constructivism: Do they make a marriage?". If we try to balance the results of the IMPULS^{EC} project in the context of this question, we could safely say that information managers and business educators have at least agreed upon their engagement.

Literature

Anders, A., Jungmann, B. & Schramm, D. (2002). XML: Grundlagen und Anwendungen. *WISU, 31,* S. 1051-1055.

Barrows, H. S. & Myers, A. C. (1993). *Problem-based learning in secondary schools*. New York: Norton.

Bogaschewsky, R., Hoppe, U., Klauser, F., Schoop, E. & Weinhardt, C. (2002). *Impuls^{EC} - Entwicklung eines multimedialen Lehrgangs zum Thema Electronic Commerce*. Osnabrück, (Research Report Impuls^{EC} 1).

Boud, D. & Feletti, G. (Eds.) (1994). *The Challenge of Problem Based Learning.* London: Kogan Page.

Bransford, J. D., Brown, A. L. & Cocking, R. R. (Eds.) (2000). *How People Learn. Brain, Mind, Experience, and School.* Washington, D. C.: Academy Press.

Brown, J. S., Collins, A. & Duguid, P. (1989). Situated cognition and the culture of learning. *Educational Researcher,* [10], pp. 32-42.

Bruner, J. S. (1974). *Entwurf einer Unterrichtstheorie*. Düsseldorf: Schwann.

Chi, T. H. M., Feltovic P.J. & Glaser, R. (1981). Categorization and representation of physics problems by experts and novices. *Cognitive Science,* [5], pp. 121-152.

Cognition and Technology Group at Vanderbilt (1990). Anchored instruction and its relationship to situated learning. *Educational Researcher,* [19], pp. 2-10.

Cognition and Technology Group at Vanderbilt (1991). Technology and the design of generative learning environments. *Educational Technology, 31*, pp. 34-40.

Cognition and Technology Group at Vanderbilt (1997). *The Jasper Project*. Mahwah, NJ: Erlbaum.

Collins, A., Brown, J. S. & Newman, S. E. (1989). Cognitive Apprenticeship: Teaching the Crafts of Reading, Writing, and Mathematics. In L. B. Resnick (Eds.). *Knowing, Learning and Instruction. Essay in Honor of Robert Glaser.* Hillsdale, NJ: Erlbaum, pp. 453-494.

Donovan, M. S., Bransford, J. D. & Pellegrino, J. W. (Eds.) (2000). *How People Learn. Bridging Research and Practice.* Washington, D.C.: Academy Press.

Dörig, R. (1994). *Das Konzept der Schlüsselqualifikationen - Ansätze, Kritik und konstruktivistische Neuorientierung auf der Basis der Erkenntnisse der Wissenspsychologie*. Hallstadt: Rosch.

Dörner, D. (1989). *Die Logik des Misslingens*. Reinbek.

Dubs, R. (1998). Scaffolding - mehr als ein neues Schlagwort. *Schweizerische Zeitschrift für kaufmännisches Bildungswesen, 92* [5], S. 282-287.

Duffy, T. M. & Jonassen, D. H. (Eds.) (1992). *Constructivism and the technology of instruction: A conversation.* Hillsdale: Erlbaum.

Friedrich, H. F. & Mandl, H. (1997). Analyse und Förderung selbstgesteuerten Lernens. In F. E. Weinert & H. Mandl (Hrsg.). *Enzyklopädie der Psychologie, D/I/4, Psychologie der Erwachsenenbildung.* Göttingen: Hogrefe, S. 237-283.

Frieling, E. & Sonntag, K. (1999). *Lehrbuch Arbeitspsychologie*. 2. Aufl., Bern: Huber.

Gersdorf, R., Jungmann, B., Schoop, E., Wirth, K. & Klauser, F. (2002). Chancen und Herausforderungen bei der Abbildung didaktischer Anforderungen in XML. In K. P. Jantke, W. S. Wittig & J. Herrmann (Hrsg.). *Von e-Learning bis e-Payment. Das Internet als sicherer Marktplatz. Tagungsband LIT '02; 26./27. September 2002, Leipzig.* Berlin: Akad. Verl.-Ges. AKA, S. 339-346.

Gersdorf, R. & Schoop, E. (2001). Content Management for Single Source Multiple Media and Multiple Usage Publishing. *WISU, 30,* S. 991-998.

Gerstenmaier, J. & Mandl, H. (1994). *Wissenserwerb unter konstruktivistischer Perspektive.* Forschungsbericht Nr. 33, Ludwig-Maximilians-Universität München.

Glaser, R. (1991). The maturing of the relationship between the science of learning and cognition and educational practice. *Learning and Instruction,* [1], pp. 129-144.

Glaser, R. & Chi, T. H. M. (1988). Overview. In T. H. M. Chi, R. Glaser & J. F. Marshall (Eds.). *The Nature of Expertise.* Hillsdale: Erlbaum, pp. XV-XXVIII.

Glowalla, U. & Schoop, E. (Hrsg.) (1992). *Hypertext und Multimedia: Neue Wege in der computerunterstützten Aus- und Weiterbildung.* Berlin: Springer.

Goldfarb, C. F. & Prescod, P. (2000). *XML-Handbuch*. 2., akt. und erw. Aufl., München: Addison-Wesley.

Gruber, H. & Mandl, H. (1998). Das Entstehen von Expertise. In J. Hoffmann & W. Kintsch (Hrsg.). *Enzyklopädie der Psychologie, C/II/7, Lernen.* Göttingen: Hogrefe, S. 583-615.

Issing, L. J. (1993). Wissenserwerb mit bildlichen Analogien. In B. Weidenmann (Hrsg.). *Wissenserwerb mit Bildern: instruktionale Bilder in Printmedien, Film/Video und Computerprogrammen.* Bern: Huber, S. 149-176.

Issing, L. J. & Klimsa, P. (Hrsg.) (2002). *Information und Lernen mit Multimedia und Internet. Lehrbuch für Studium und Praxis.* 3., vollst. überarb. Aufl., Weinheim: Beltz.

Jarz, E. M. (1997). *Entwicklung multimedialer Systeme. Planung von Lern- und Masseninformationssystemen*. Wiesbaden: Gabler.

Jungmann, B., Wirth, K., Klauser, F. & Schoop, E. (2002). *IKURS: Integrative Konzeption und Umsetzung curricularer, didaktisch-methodischer und informationstechnischer Aspekte in Richtlinien und Strukturmodelle für die Ausgestaltung multimedialer Lehr-Lern-Arrangements*. Osnabrück, (Research Report Impuls^{EC} 2).

Klauser, F. (1998a). "Anchored Instruction" - Eine Möglichkeit zur effektiven Gestaltung der Lehr-Lern-Prozesse in der kaufmännischen Ausbildung. *Erziehungswissenschaft und Beruf, 1998* [46], S. 283-305.

Klauser, F. (1998b). Effektive Gestaltung von Lehr- und Lernprozessen in der kaufmännischen Ausbildung - Erfordernisse, neuere Befunde und künftige Forschungsaufgaben. *Zeitschrift für Berufs- und Wirtschaftspädagogik, 94* [2], S. 248-264.

Klauser, F. (1998c). Problem-Based Learning - ein curricularer und didaktisch-methodischer Ansatz zur innovativen Gestaltung der kaufmännischen Ausbildung. *Zeitschrift für Erziehungswissenschaft, 1* [2], S. 273-293.

Klauser, F. (1998d). Problem-Based Learning - ein innovativer Ansatz für die kaufmännische Ausbildung. *Schweizerische Zeitschrift für kaufmännisches Bildungswesen, 92* [5], S. 330-354.

Klauser, F. (2000). Erwerb von Expertise - eine curriculare und didaktisch-methodische Leitidee zur effektiven Ausgestaltung lernfeldstrukturierter Curricula in der kaufmännischen Ausbildung. In Lipsmeier, A. & Wilbers, K. (Hrsg.). Lernfeldorientierung in Theorie und Praxis. *Zeitschrift für Berufs- und Wirtschaftspädagogik, Beiheft* 15, S. 183-196.

Klauser, F. (2002). E-Learning problembasiert gestalten. In A. Hohenstein & K. Wilbers (Hrsg.). *Handbuch E-Learning. Expertenwissen aus Wissenschaft und Praxis - Strategien, Instrumente, Fallstudien.* 1. Ergänzungslieferung - August 2002, Köln: Deutscher Wirtschaftsdienst, 4.12.

Mandl, H., Gruber, H. & Renkl, A. (1994). Zum Problem der Wissensanwendung. *Unterrichtswissenschaft, 22*, S. 233-242.

Mandl, H., Gruber, H. & Renkl, A. (2002). Situiertes Lernen in multimedialen Lernumgebungen. In L. J. Issing & P. Klimsa (Hrsg.). *Information und Lernen mit Multimedia und Internet.* 3. Aufl., Weinheim: Beltz, S. 139-150.

Michel, T. (Hrsg.) (1999). *XML kompakt.* Bonn: Hanser.

Perkins, D. N. (1992). Technology meets Constructivism: do they make a marriage? In T. M. Duffy & D. H. Jonassen (Eds.). *Constructivism and technology of instruction. A conversation.* Hilldale: Erlbaum, pp. 45-55.

Preiß, P. (1999). *Didaktik des Rechnungswesenunterrichts*. München: Oldenbourg.

Reimann, P. (1998). Novizen- und Expertenwissen. In F. Klix & H. Spada (Hrsg.). *Enzyklopädie der Psychologie, C/II/6, Wissen.* Göttingen: Hogrefe, S. 335-365.

Schnotz, W. (1993). Wissenserwerb mit logischen Bildern. In B. Weidenmann (Hrsg.). *Wissenserwerb mit Bildern: instruktionale Bilder in Printmedien, Film/Video und Computerprogrammen.* Bern: Huber, S. 95-148.

Schnotz, W. (1997). Wissenserwerb mit Diagrammen und Texten. In L. J. Issing & P. Klimsa (Hrsg.). *Information und Lernen mit Multimedia.* 2., überarb. Aufl., Weinheim: Beltz, S. 85-106.

Schoop, E., Glowalla, U. & Witt, R. (Hrsg.) (1995). *Hypermedia in der Aus- und Weiterbildung. Dresdner Symposion zum computerunterstützten Lernen.* Konstanz: UVK-Universitätsverlag.

Schoop, E. & Schraml, T. (1996). Vergleichende Buchbesprechung. Dokumentenstandard SGML. *Wirtschaftsinformatik, 38* [2]*,* S. 246-253.

Schoop, E. & Strobel, K. (1998). Strukturorientiertes Dokumentenmanagement. Aufgaben, Methoden, Standards und Werkzeuge. *Dresdner Beiträge zur Wirtschaftsinformatik*.

Schraml, T. (1997). *Operationalisierung der ökologiebezogenen Berichterstattung aus Sicht des Informationsmanagements. Konzeption eines Vorgehensmodells zur formalisierten Explikation logischer Dokumenttypmodelle im Rahmen der Umweltkommunikation von Unternehmen.* Dissertation. Technische Universität Dresden, Lehrstuhl für Wirtschaftsinformatik, insbesondere Informationsmanagement.

Schulmeister, R. (2002). *Grundlagen hypermedialer Lernsysteme*. 3., korr. Aufl., München: Oldenbourg.

Schulz, A. (1998). *Interfacedesign: die visuelle Gestaltung interaktiver Computeranwendungen*. St. Ingbert: Röhrig.

Tergan, S.-O. (1997). Hypertext und Hypermedia: Konzeption, Lernmöglichkeiten, Lernprobleme. In L. J. Issing & P. Klimsa (Hrsg.). *Information und Lernen mit Multimedia.* 2., überarb. Aufl, Weinheim: Beltz, S. 123-138.

Weidenmann, B. (1997). Abbilder in Multimedia-Anwendungen. In L. J. Issing & P. Klimsa (Hrsg.). *Information und Lernen mit Multimedia.* 2., überarb. Aufl., Weinheim: Beltz, S. 107-122.

Wygotski, L. S. (1964). *Denken und Sprechen*. Berlin.

ISBN 3-936475-15-6