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ABSTRACT

This paper introduces a multimedia-based educational system on logistics developed at the University of Magdeburg (Germany), reports on development and implementation of the prototype, and discusses ideas for redesign. The system was tested, used, and evaluated at the university and within a European network of 24 universities, colleges, and training centers from 13 countries. Students were interviewed and completed questionnaires regarding opinions, criticisms, and wishes in relation to the system. The development process, including guidelines, story board, navigation, calculation exercises, layout, integrated notepads, language-independent components, and language-specific components, is discussed. Ideas for expansion and modification of the educational system include: increasing user-friendliness by reorganizing and reworking the interface; supporting more flexible teaching and learning processes by providing learner-specific interaction and feedback; and expanding use by integrating the module into distance courses, adapting to student needs, and facilitating alternate forms of communication. Possibilities for more effective authors' support focus on: expanding and explaining conventions for structuring and designing the system and its elements; putting further knowledge of facts and methods into modular form according to content and formal aspects and documenting them in a way that is easily searchable; and supporting the collection, management, and finding of resources by a resource pool with a comfortable management system. (DLS)

It's Easy to be Wise after the Event: Concepts for Redesigning an Educational System on Logistics Derived from Reflecting its Development and Use

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Abstract: Often the development of an attractive multimedia-based educational system is a long-lasting and lavish process. Especially, if the authoring process is primarily in the hand of the educational system's potential users (the teachers) who are often not very experienced in developing those systems, their support by design guidelines and easy-to-use authoring tools becomes more significant. Besides this, it is necessary to concern oneself repeatedly with the own way of action and its results for deriving experience. Following the example of an educational system on logistics, the contribution will show, how this self-reflection of the educational system's development and use has led to a concept for its future-orientated redesigning and also for a more efficient author-supporting infrastructure.

Initial Situation

As result of a developmental process lasting several years, the first component of a multimedia-based educational system on logistics was created by prototype implementation of a module on warehousing in German and English language [see Neumann, Ziems, and Höpner 1995, or Ziems and Neumann 1997]. The system is tailor-made for the specific interests of university-level logistics education. It imparts the fundamental knowledge of facts and methods as well as the integrated logistical thought and action orientated towards success. Above all, it presents knowledge concerning possible applications and easily to comprehend by means of procedures enabling experiments. Besides this, the student is supported in using his/her knowledge actively. The methodical-didactic structuring and alternative presentation of logistics knowledge as well as the design of navigation and interaction possibilities are suited to the system's use for self-studies and as a work of reference as well as to support lectures, exercises, and practical training.

The educational system is tested, used and evaluated at the University of Magdeburg but also within a European network of at the moment 24 universities, colleges, and training centers from 13 countries. For the most part, the students met multimedia-based educational systems for the first time. Their opinions, critics, and wishes recorded within interviews and by questionnaires were analyzed together with pedagogical experts to recognize acceptance problems and needs for the educational system's further developments as well as for the way of its integration into the educational process. During the developmental process we gained an increasing experience from our work and improved our knowledge about ideas, approaches, activities, and results from other people's work. Because of this, demands and request for the educational system's functionality and design as well as for the authoring process's way of action and support by appropriate tools were grown as well. Finally, these experiences led to the decision to redesign both the educational system according to contents, methodical-didactic, functional, and design aspects and the concepts and infrastructure supporting the developmental process by making use of the improved hardware and software basis as well as of ideas and concepts derived from the system's development and use.

Experiences from Developing and Using the Educational System

The educational system on logistics was developed by a team of logisticians and computer scientists. As a first step the knowledge available in one's own scripts for lectures, available technical literature as well as graphics, photographs, video and animation sequences was sifted through, selected and structured. Even in this phase, there was a number of questions e. g. for

- the appropriate proportion between texts and pictures, between static and dynamic knowledge presentations,
- the sensible integration of possibilities for a user-specific interaction,
- the appropriate handling and use of the many and diverse photographs and videos, or
- possible ways to avoid conflicts with third-party copyrights of material.

Unfortunately, there was no media expert in the team and guidelines related to this kind of questions were difficult to find, to understand, and to handle. In addition to this, their application in different methodical-didactic scenarios and their effects to varying types of learners as described in [CSUP 1992] were seldom taken into account. Before this background, a repeated reflection to the following fundamental question was of great help for the developmental process: *What are the advantages, and what are differences in knowledge presentation and use of multimedia-based designs in comparison with the traditional print medium?*

To guarantee an efficient authoring process a joint communication basis had to be developed for the cooperation of authors from different fields of knowledge and different worlds of thinking like logisticians and computer scientists. Here, simple *guidelines and a story board* were very helpful for structuring screen pages and designing their elements, for drafting, discussing and implementing basic layouts, their multimedia elements as well as for integrating all links and possibilities for user-interaction required. About it, the use of only four different *basic layouts* for the pages has proved to be positive. The students were quickly quite well acquainted of the new media and have used the educational system with curiosity, inquisitiveness, and interest. This process was also supported by providing *alternative possibilities for navigation* like hyperlinks, search functionality, or navigation buttons and for acquiring additional information about particularly highlighted keywords. *Calculation exercises* of a varying complexity and with many and diverse possibilities for experiments were offered in relation to a particular context or could be chosen from a separate pool of exercises. That has achieved the educational system's intensive use for self-studies and in phases of preparing for examinations. But the students explained also additional wishes to have more comfort and support. Amongst other things they were related to provide possibilities for a context-specific adding of *user-own comments, remarks or questions* on integrated note-pads and to give a better on-line support to the student for solving complex exercises.

During the authoring process *language-independent components* like e. g. graphics, photographs, videos, or animation without additional explanations and *language-specific components* like e. g. texts, tables, formulae, or explanation elements of graphic presentations were separately saved. This has produced just as positive effects as the concept to separate elementary multimedia resources strictly from possible relations and links that was consequently pursued at any time. This way of action was of considerable importance for developing the German and English versions in parallel. It also guarantees that the educational system is open for a translation into further languages. On the other hand this concept of putting all software components into separate modules of external files made it also clear that the chosen authoring system (Multimedia Toolbook 3.0) was inadequate for supporting those ways of actions. Import and export functions necessary for embedding these modules are only partly provided in a satisfactory form. For that reason a time-consuming development and implementation of own import filters became necessary.

In retrospect we can consider that the integration of alternative forms of knowledge presentation (e. g. text vs. picture vs. video), of alternative technologies for search and navigation (e. g. chapter-based structure, structure map, search) and of alternative tests and exercises has had an exceptional favorable effect. According to our experience, in this way there is a constant demand for user decisions and interactions corresponding to his/her individual learning habit. As a result it is possible to contradict very effectively the still existing image of educational systems to be just "page-turning machines" and to consider that the time, staff, and technical effort needed for their development is justified. Finally, the work done for the first module has shown that the complete integration of an entire field of knowledge into a multimedia-based educational system represents a tremendous effort. Because of the greater range of possibilities for presenting knowledge and for giving access to the learner, it is clearly more substantial than writing a comparable textbook. Before that background the developmental infrastructure must be able to support a future joint authoring process of several distributed logistics educators and experts. For this, the present state of information and communication technologies as well as net services

offered to the customers already provides a main pre-condition and opens up new possibilities for organizing this process in a cooperative way.

Once Again from the Beginning: Ideas and Concepts for Redesigning

On the basis of results from evaluation, reconstruction and self-reflection the general concept for an educational system on logistics was newly thought over. In addition to this, the warehousing module's redesign was planned to increase its rate of acceptance. Also a concept for a more efficient way of actions and a better support of the developmental and authoring process by the improvement of existing or the development of new tools was worked out. This process of looking for ideas and developing concepts was carried out not only by the previous team of authors and developers, but it was also supported by the educational system's user group as well as by a group of interested pedagogical and psychological experts, designers, media experts, linguists, computer scientists and multimedia authors for different fields of knowledge organized in a regional association for research on the development and use of educational multimedia. With that, a process of fully redesigning and expanding the educational system as well as developing components for a computer-based integrating authoring infrastructure was started and has already led to first prototype implementations tested and evaluated successfully. Within the following sections the special features of examples for those implementations are presented and discussed.

Expansion and Modification of the Educational System

Works to expand and modify the first component of the educational system on logistics are mainly focused to

- increase the acceptance and user-friendliness by reorganizing the educational system's structure and reworking its user-interface,
- support more flexible teaching and learning processes by providing learner-specific possibilities for navigation and interaction and producing individual feedback,
- extend the group of users by integrating the module into distance learning courses, by adapting it to the demands of a non-university qualification and training, and by creating the pre-conditions for alternative forms of learner-learner and teacher-learner communication.

Since the previous concept followed strongly the structure of traditional textbooks it is less suitable for supporting the use of particular pages or sequences of pages in flexible educational processes with individual learning paths. Instead of this page-based approach the knowledge is now organized in a *structure of nodes and edges* of different levels of detail similar to the concept map approach described in [Zeiliger, Reggers, and Peeters 1996]. The nodes represent knowledge units of definite complexity, whereas the edges describe the relations between them. Nodes of a higher degree of complexity like e. g. knowledge complexes consist internally again of structures of nodes and edges. The smallest knowledge unit represented by a node includes the knowledge of a screen page, which results from placing elementary multimedia objects like e. g. texts, graphics, photographs, videos, or animation in standardized layouts by setting parameters. The main advantage of this approach consists in the fact that the knowledge can be structured now both top-down and bottom-up. Besides this, knowledge units of different levels of detail can be combined according to educational targets and levels. In addition to the effects on the authoring process the modified structure of the educational system opens up new possibilities for learner navigation and guidance. Depending on the educational targets and levels as well as interests of the learner, a node could also be excluded from the learning process.

The degree of guiding a learner and if necessary also the degree of one's freedom in navigation as well as the tests' and exercises' degree of difficulty are established as usual by the *learner's self-classification* when starting a session. Learners are classified according to both his/her familiarity with the software (beginner, advanced level, expert) and his/her prior knowledge as well as with respect to his/her learning target (overview over a wide range of knowledge or over particular fields of knowledge, detailed knowledge about particular fields of knowledge or about a specific fact etc.). In addition to this, the learner's behavior according to the frequency of using helps (e. g. in the form of looking for definitions of terms) and preferring alternative or complementary presentations (e. g. textual or pictorial information) is recorded in a log-file. These information are graphically

presented, analyzed by using statistical methods and interpreted by taking the learner's self-assessment (prior knowledge, preferences, learning target) as well as information from previous sessions into account (investigation of preferences). As a result the form of presenting knowledge is automatically suited to the learner's subjective preference of getting access to the knowledge.

In addition to the automatic recording in a log-file, the learner's behavior but also his/her progress in learning can be determined from comments, questions, or extracts from content formulated by the learner himself/herself. This *unplugged, context-specific expression of the learner's opinion* is directly linked to a particular screen page either by bookmarks or by using the NOTICE button depending on the kind of information. Whereas bookmarks only identify certain knowledge units interesting, important, or necessary to be examined from the learner's point of view, the NOTICE button enables to write down and save any notes within a separate window. As a standard the corresponding screen page's long name is copied to the note-pad. By use of a guiding dialogue the learner can now add further information about the context as well as his/her notes. Those notes can

- refer to the *authoring process* if including comments to the author about the screen page's design, presentation, clarity, or comprehensibility,
- concern the *educational process* if summarizing questions or remarks about the subject for being answered or furnished with a commentary by the teacher,
- serve the collection of *knowledge about facts* in the form of extracts, e. g. for own study works or presentations.

This kind and purpose of a note is also described within the guiding dialogue by selecting it from a menu to clearly relate each particular note. First, all notes are private and belong to the learner. It is always up to the learner whether to make further use of them or not. As a matter of principle no note is automatically forwarded to anybody else. If the learner wants to submit some or all notes to an author or teacher he/she can print them or send them electronically via an integrated communication interface.

Amongst other things the possibility for printing something out was also considerably extended according to functionality and user-friendliness. Instead of producing snapshots by printing the screen as it was in the educational system's first version, the learner is now able to select any element of the educational system and copy it into a different MS Windows application or into a standard printer's copy. These elements, i. e. text phrases, graphics, or photographs as well as notes or results of exercises and tests (but now snapshots from video or animation sequences), could come from different screen pages. In this way the learner can now build simply designed, individual presentations of selected parts of content (e. g. for a study paper or a talk). The implementation of this functionality was deliberately done without providing the pre-conditions for developing lavish presentations or many and diverse printer's copies, because there are already several professional commercial software packages for this purpose. On the contrary, it is just a simple way to support exchange and discussion. In future, the system should also receive a *flexible communication interface* adaptable to the student's hardware and software basis as well as to his/her pre-conditions in infrastructure. In this way, the student will be able to communicate electronically with other students (e. g. by e-mail, on-line fax, or other net services) or to send questions or comments put together in notes as well as solutions of test questions or exercises to the teacher. If a student has no direct access to a communication network he/she can fall back on conventional, paper-based forms of communication (e. g. mail or fax services) or phases of personal presence at the university by using the improved print function.

Possibilities for a Better and More Effective Authors' Support

Our experience from developing the educational system on logistics have clearly shown that the authoring system used for that purpose often did not cope with the demands resulting from the educational system's development and use. In this way bad authoring systems enable only the development of bad educational systems that are organized as supporting infrastructure for turning screen pages and for confronting a learner with multiple-choice questions [see Korcuska 1996]. In comparison with that good authoring systems enable the development of good and action-orientated educational systems (learning by doing). They are able to capture the author's knowledge and experience to be slipped into the authoring process. Before this background, in [Korcuska 1996] authoring systems existing at present (especially those which belong to the HyperCard category) are assessed as bad and not very suitable to really support the author during the authoring process, because these systems mainly understand computers and not education. In opposite to this he promotes "software

factories" providing highly complex do-it-yourself objects that also contain pedagogical knowledge and guide authors through the whole process on the conceptual level. In addition to this, it is helpful if an educational system's components and modules created by an author could be managed effectively and made them reusable. For that reason our work for creating a comfortable developmental infrastructure supporting the authoring process mainly concentrates on

- expanding and explaining those conventions for structuring and designing the educational system and its elements, which were used up to now and have proven to be good,
- putting further knowledge of facts and methods into modular form according to content and formal aspects and documenting it in a way that one can search for it, as well as
- supporting the collection, management and finding of resources by a resource pool with a comfortable management system.

The *resource pool* as kernel of this developmental infrastructure contains different classes of resources necessary for the development of multimedia-based educational systems [see Subrahmanian and Jajodia 1996]:

- *Knowledge resources* of varying complexity contain modular knowledge within presentation objects (complete multimedia data that can be presented by use of tools for reproducing media) and application modules (executable software that generates presentable multimedia data with the help of suitable tools).
- *Concept resources* include on the one hand methodical-didactic basic conceptions for the educational process and on the other hand completely described, problem-specific teaching concepts (concept maps, story boards).
- By *layout resources* e. g. user-interfaces are understood that are standardized for different functions and that can be described by setting parameters.
- *Navigation resources* are modules of a specific authoring system for controlling an educational application in various forms (e. g. history, summary of contents, buttons).
- As *management resources* e. g. modules for managing a user's status, routines for evaluating and analyzing user-interactions, or models for restricting interactions are described.
- *Tools* summarize help functions like e. g. equation interpreter or calculator.

To guarantee its applicability and searchability each resource has to be completed by a *detailed description*, which is adapted according to content and structure to the characteristic specific to the corresponding class of resources. For example, a knowledge resource's description contains at least file name, knowledge characteristics (on the basis of related descriptors), characteristics of presentation form or knowledge (including the author's copyright). If necessary, different purpose-orientated views specific to the corresponding author can be related to a resource. During the authoring process the developer of a particular educational application can use existing resources and link them according to the point of view of content and methodical-didactic aspects. In this way single screen pages are formed by linking knowledge resources with layout resources, navigation resources and tools. If these pages are linked in sequences or networks by use of a concept resource and completed by the appropriate management resources learning paths are built.

For saving and selecting resources the author uses a *management system*, which forms the resource pool's interface to the developmental infrastructure. This interface includes amongst others

- the *link management system*, which manages links between resources as separate objects with individual characteristics,
- *control functions* for guaranteeing data consistence for the resources,
- comfortable *search functions* for a user-friendly access to resources,
- *safety functions*, which check the access to resources and links by controlling user-rights.

In addition to this, in the *developmental infrastructure* itself there functions for

- adapting elementary knowledge to texts, pictures, animation, or videos by logisticians (editor),
- developing interactive teaching and learning applications that includes knowledge separated for defined target groups (learners) by use of available knowledge units (authoring system),
- supporting communication between distributed authors within a cooperative authoring process (communication infrastructure),
- using applications developed before individually by teachers and learners in lectures, exercises, self-studies, or as book of reference (presentation system)

are integrated. With that authors can effectively develop educational systems on the basis of their own content, methodical-didactic and design concepts. But as the main pre-condition the resource pool must offer a substantial as well as many and diverse stock of resources. Because of the existing network of European logistics educators this problem is solved for the logistics field of knowledge and a permanent use, expansion, and updating of the resources is guaranteed.

Conclusions

When using this developmental infrastructure for redesigning the educational system on logistics the effects occurred as expected. The main advantage consisted in the fact, that the authors mainly could concentrate on activities like searching for, selecting and editing elementary resources and knowledge units of varying complexity as well as putting modules resulting from this together by use of an authoring system. Because of this, time necessary for the developments during the authoring process could considerably be reduced, although the educational system contains now more flexible learning paths, a more substantial knowledge of facts and methods, and a larger number of multimedia illustrations. The resource pool as kernel of the developmental infrastructure has been proved to be a central source and store of special knowledge within a cooperative authoring process. Now elementary and complex multimedia resources and modules of educational systems can be purposefully saved and reused from different users' points of view. This possibility opens up a variety of applications nearly unlimited according to content, target group, purpose, and technical demands, which goes far beyond the development of educational systems.

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