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ABSTRACT

The World Wide Web has developed as the de facto standard for computer based learning. However, as a server-centered approach, it confines readers and learners to passive nonsequential reading. Authoring and Web-publishing systems aim at supporting the authors' design process. Consequently, learners' activities are confined to selecting and reading (downloading documents) with almost no possibilities to structure and arrange their learning spaces nor do that in a cooperative manner. This paper presents a learner-centered, completely Web-based, approach through virtual knowledge rooms. Based on this concept, the goal of the presented work is firstly to develop a theoretical framework to explain the design potentials of technology-supported learning processes (distinguishing individual and cooperative primary media functions). Secondly, a technical framework (cf. www.open-steam.org) should be developed to allow for study of different technical configurations within the traditional university setting. Considering the systems design, the concept of virtual knowledge rooms is to combine event-based technology of virtual worlds with the classical document management functions in a client-server framework. Knowledge rooms and learning materials such as documents or multimedia elements are represented as a fully object-oriented model of objects, attributes and access rights. The paper does not focus on interactive systems managing individual access rights to knowledge bases, but rather on cooperative management and structuring of distributed knowledge bases. (Author)

sTeam- Providing Primary Media Functions for Web-Based Computer-Supported Cooperative Learning

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Abstract:
The WWW has developed as the de facto standard for computer based learning. However, as a server-centered approach it confines readers and learners to passive non-sequential reading. Authoring and web-publishing systems aim at supporting the authors' design process. Consequently, learners' activities are confined to selecting and reading (downloading documents) with almost no possibilities to structure and arrange their learning spaces nor do that in a cooperative manner.
This paper presents a learner-centered – completely web-based – approach through virtual knowledge rooms. Based on this concept, the goal of the presented work is firstly to develop a theoretical framework to explain the design potentials of technology-supported learning processes (distinguishing individual and cooperative primary media functions). Secondly, a technical framework (cf. www.open-steam.org) should be developed allowing us to study different technical configurations within the traditional university setting. Considering the systems design the concept of virtual knowledge rooms is to combine event-based technology of virtual worlds with the classical document management functions in a client-server framework. Knowledge rooms and learning materials such as documents or multimedia elements are represented as a fully object oriented model of objects, attributes and access rights. We do not focus on interactive systems managing individual access rights to knowledge bases, but rather on cooperative management and structuring of distributed knowledge bases.

Introduction

Discussions about the role of technology in teaching and learning center on two basic paradigms. Firstly on hypermedia systems that aim to support individual learning processes, here special emphasis is being placed on new didactic qualities, attributed to the interactive combination of different media types such as text, graphics, audio, video, etc. The second paradigm embodies the notion of "delivering education" that is networking technology being used to distribute and access study materials as well as to establish communication channels between students and teachers. Although the idea of utilizing net services has strong collaborative connotations, the main argument in favor of networking is the temporal and spatial independence it offers and, consequently, the independence from close collaboration with others.
Now, students can learn individually at their own pace and at a location chosen by themselves.
However, many studies evaluating the role of technology in learning processes have yielded conflicting results, indicating that there is no general, clear-cut connection between the effort required to produce high-quality multimedia educational materials and improvements in the learning process. The problem is to attribute certain benefits to a single variable – say, the specific technology used. Mostly, the results are a combination of different variables such as didactic style, educational strategy, technology deployment, appropriate selection of content and the personal qualities of teachers and students. (see [Hesse 1997] and [Keil-Slawik et al. 1996]). Thus, the widely accepted idea that learning can be improved by the individualization of learning processes using hypermedia and networking technology is not generally borne by scientific research.

Instead of using technology to individualize learning processes, we have chosen the opposite approach – namely, using technology to support cooperative learning processes within the framework of traditional university education. Rather than trying to do away with the need for physical presence in the learning situation, we seek to support social processes in which students and teachers meet for a specific time at different places. Apart from practical considerations, theoretical research reveals that, ultimately, the social embedding of learning is a crucial factor for success.
Furthermore, our approach is based on the general assumption that technology can only solve technological problems, didactic problems requiring didactic solutions. Hence, teaching activities cannot be replaced by technological functions, and the embedding of technology into teaching and learning activities must be studied carefully.

Media Functions
Media are generally viewed in terms of communication, based in most cases on the classical transmitter/ receiver or producer/ consumer model. The integration of different media types such as text, image and sound (multimedia) in combination with the fusion of transmission channels and services (Internet), make it necessary to extend our concept of media. Media are no longer simply means of communication; they are – and have always been – both means of expression/ cognition and means of organization. Without media our cultural achievements are inconceivable. Complex social processes based on the division of labor are just as reliant on media as they are on science and education. Media, for their part, require technology to create an objective, mostly symbolic world. To determine the potential and possibilities offered by new media, we must first remind ourselves of what constitutes, in technical terms, the benefits they provide.
Keil-Slawik and Selke at first distinguish three classes of media functions, called primary, secondary and tertiary media functions. They closely examine the relevance of technology in human learning processes. Primary media functions describe fundamental functions to place artifacts in the perceptual space of a person (a group of persons). Secondary media functions extend them taking the learning process itself into account, thus they refer to applicable didactic models. Tertiary media functions consider methods of self-adapting and artificial intelligence, that means, now the medium itself is subject matter (see [Keil-Slawik & Selke 1998] and [Hampel 2001]).
The next important step is to differentiate between primary *individual* media functions and primary *cooperative* media functions. Concerning the primary cooperative media functions the primary individual media functions such as Creating, Deleting, Arranging and Linking are seen in the context of the cooperative learning process. Consequently, the primary cooperative media functions are realized through the options of Transmitting, Accessing and Synchronizing. To sum up, we distinguish four primary individual media functions and three primary cooperative media functions as follows:

Primary individual media functions:

- *Creating, Deleting* - Media serve to create or delete a perceptual space. Concerning the first allowing conception and reality to be correlated by action and the relevant conclusions to be drawn. Scientific instruments, experimental apparatus, models and simulation programs are just as much instances of artifacts that perform this function as are symbolic descriptions, diagrams, images, formalisms and visualizations of large data sets.
- *Arranging* - To attain new insights it is necessary to correlate different documents. Problem solving and learning invariably involve identifying differences and concurrence, combining different types of descriptions

and representations or weighing statements from different sources against one another. To support these processes, the artifacts to be correlated must be brought into the field of perception, simultaneously if possible. Here, logical connections should be represented, if possible, by spatial connections as well, to enable them to be swiftly identified and processed.

- *Linking* - Arrangements embodying an important connection should be preserved after the act of arranging. In this way, they do not need to be regenerated at a later point in order to continue working with them. Suitable links, for example, enable users – ideally in a single step – to refer to all documents that are of relevance for the respective meaning context.

Primary cooperative media functions

- *Transfer* - The transfer of media between learners. Cultural learning achievements are social processes. Reducing learning to the individual processing of a document, e.g., means failing to realize that the same document has already been used, assessed and passed on in a specific social teaching/learning situation. The primary cooperative media function "Transfer" is meant to describe the exchange of media between two persons or between one person and an object, which arranges an exchange to a person.
- *Accessing* - Giving access rights to shared material, cooperative use of individual primary media functions: With the media function "Transfer" we explicitly address one person, whereas the media function of Accessing describes the access as a process which is not influenced by others, such as the creator. An illustrative example provides the filing of a document in a virtual room. Depending on the access rights to the concerning document it is possible to access it by "reading" and "writing". Another example is the use of a Shared Whiteboard, which offers the possibility to access materials of another person or to access materials from different learning places.
- *Synchronizing* - Conveying shared views on shared objects, coupling, awareness: We can identify the media function of Synchronizing in physical acts of updating presentations. On the one hand these acts are about creating shared views on documents and the report about changes in these documents and on the other hand the awareness of cooperation partners. Primary individual media functions in a cooperative structure require shared views of the partners on their materials.

The rationalization potential of new media lies in the implementation and integration of these primary media functions, concerning the more effective handling of the physical artifacts in terms of the mentioned basic areas of functionality. Here, the new media offer a wealth of new forms for the effective generating, transferring, giving access to, arranging and linking semiotic artifacts, ranging from the integration of different types of media to net-based services and search facilities.
To this extent, learning-supportive infrastructures, like the sTeam-system make use of all materials at any location where learning takes place.

Architecture

The developed basic architecture combines two different approaches. On the one hand the development of document based CSCW/ CSCL-Systems (mostly office motivated) and on the other hand the event-based architecture of MUDs and MOOs. As a result we have a flexible structure of cooperative virtual knowledge spaces which is strongly related to the WWW, but furthermore develops new methods of managing documents and other materials.
Interactions among users and between users and documents are realized as interactions between cooperating shared objects. Shared objects are persistent and are oriented towards a room structure (room metaphor). Access rights control the instance of new objects and the interaction between objects. These interactions may take place between objects in client and server.
The complex design of the basic architecture originates in the need for a scalable and easy to maintain architecture which can easily be suited to exiting and future standards. Design patterns describe recurring patterns in an object-orientated software engineering.

The designed basic architecture is subdivided in a sTeam-server, an external Web Server, a relational database and several clients.
The sTeam-server coordinates the administration of users and groups, provides for the room-structure with its containing objects, organizes the communication between users and realizes the synchronization of the presented contents between the different clients. The Roxen Web Server is used as a gateway to access different Web browsers of sTeam. The relational database guarantees the persistence of the various objects (see [Hampel & Keil-Slawik 2001]).

Core server

The sTeam-core server provides for the necessary mechanisms which guarantee the reciprocal perception and the cooperative use of knowledge structures. As runtime environment, the open source LPC interpreter Pike is employed. Aside from a good performance Pike is equipped with a wide code base and a great number of existing libraries. The native Pike libraries are supplemented by a connection to different open source libraries which are implemented in the programming language C for performance reasons.
The concept of cooperative knowledge spaces demands a special administration of objects, users and different events. Thus the chosen architecture follows an entirely object-oriented design. Objects own different attributes and sometimes in the case of document types a content. Interactions between objects are guaranteed by remote method calls or events. The runtime environment is composed of further modules for the implementation of various protocols. NNTP, POP3, IRC, LDAP and COAL are directly supported. By applying NNTP the annotations of documents are presented as news. POP3 is employed to integrate news that are transmitted within the sTeam platform into the usual working environment. The chat channels connected to rooms are released by the IRC protocol. Finally LDAP permits the access to the user administration within the learning environment of the institution where the system is employed. This way within a certain university students could get access to the cooperative learning environment by using their general identification and password. The communication between server and clients is guaranteed by the implementation of a specific communication layer, the Client Object Access Layer CAOL. Currently COAL-API is implemented for the programming languages Java, C++ and Pike. The COAL-/Java-API allows the login/logout of a client and the subscription and the reception of events from the server, furthermore method calls and the transfer (up-, down-load) of objects. The object structure of the server is reproduced in an analogue way on the client side. For each server object type a corresponding class exists in the COAL/Java-API. Instances of these classes correspond to real objects on the server but they do not contain data and contents of the object. A replication of objects does only reveal a part of the viewed or needed objects. Thus through the generated proxy-objects server objects may be accessed by direct method calls (e.g. in the case of attribute changes).

For different reasons the Web server is separated from the core architecture. We employ the open source Roxen Web server (cf.www.roxen.com). In this way protocols which are implemented within Roxen (e.g. the HTTP-protocol coded by the Secure Socket Layer (SSL) can be immediately used. Beside of the very robust implementation of the HTTP and the FTP protocols the gain in security seems to be an important aspect for the acceptance of the system. The database responds to the generic SQL interface of the programming language Pike. At the present time the free database MySQL is accessed. Through an abstraction layer, referring to papers from Ambler about the mapping of object structures on relational databases, (see [Ambler 2000]), the entire object administration is separated from the database logic. Thus the independence from the really employed database technology is guaranteed.

Evaluation

Designing technology only based on hypothesis calls for empirical confirmation in order to have evidence of the usability of the own results. Therefore we carried out the lecture "Grundlagen der Informatik für Lehrämter" ("Basics of computer science for prospective teachers"). Our evaluation concentrates on the use of virtual knowledge spaces as a structuring and learning platform for cooperative knowledge management. As such it provides the students with diverse possibilities to work in cooperation with others as well as to work for themselves. Technically, we speak of a collection of documents directly assigned to a synchronous communication channel. It is possible for the students to attach comments to all of the documents. The used configuration allows the students to insert documents, to annotate, to copy and to create new links. Furthermore they could create new rooms and link already existing rooms with new exits. The setting for the mentioned lecture is characterized by three groups of virtual rooms. These are private areas of the students, assigned areas for the different learning groups and one central area containing all of the course materials.

The main goal of this setting was to prompt the students to search for additional material, which could be presented to the other students. Comments and annotations, which are connected to the documents should help the students discuss the content of the course with each other and with the lecturer throughout the semester. Thus, the contents of the lecture can be structured in an according way and new insights may be drawn from the different personal styles of structuring information.

Based on observations during the first weeks the students rather annotated any material, thus a new area called "Speakers Corner" was created. The goal was to focus on the possibilities for discussions in only one special area. Furthermore two students were asked weekly to select five slides of a presentation which in their opinion represented main aspects of the lecture. To discuss these slides, the students should as well annotate why they had especially selected the chosen ones. Now all the other students were asked to comment on the selection, to present further arguments or to show other possibilities.

Solutions to the weekly exercises were given as annotations to the respective documents if possible. If the answers were more extensive, another way was to create new documents or even new rooms. It was very interesting to see that the students agreed on publishing their results. Thus it was easier to discuss the results and refer to other solutions. As a first surprising outcome of this experiment, it was observed that the possibilities to structure the learning environment newly were not used as much as we thought it would. Such a lack in the use of provided technical possibilities can be traced back to several aspects, which in the following have to be examined more closely.

One possible hypothesis is that the method of creating new exits, etc. is too complicated (thesis I). Another explanation might be that the students realize only slowly, which new competencies they have while working with the system (thesis II). We have to examine how far this problem is a principal one, that means, how far hierarchical structures are internalized so that the students do not deviate from them (thesis III). One point to confirm the correctness of thesis I is the observation, that students only used annotations where they were forced to do so.

To sum up, the six month practical use may be assessed positively. The concept of cooperative virtual knowledge spaces has mastered its first practical application period.

Conclusions

Virtual knowledge spaces are a new approach towards the extension of traditional hypertext systems in their way of structuring documents with event-based cooperative approaches. At the same time, cooperative knowledge spaces create new design conflicts which have to be handled in a systematical and well-founded way to gain from their inherent creative potential. The main goal of our research is to acquire the necessary knowledge and to develop a theoretical foundation. Therefore we need a basic architecture, which allows us to realize a variety of virtual knowledge spaces with a small amount of time and energy. During the last years we have succeeded in developing such architecture. Another important prerequisite are theoretical concepts which allow us to distinguish between technical and non-technical aspects and furthermore to examine the correlation between them.

To experience the potentials of virtual knowledge spaces the system has been practically tested in a traditional learning situation.

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