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ABSTRACT

Researchers at the Institute for Information Processing and Computer Supported New Media (IICM) at Graz University of Technology, Austria, are currently developing GENTLE, an electronic lecturing system combined with a digital lecture library, for teachers and students. The system contains collections of lessons, synchronous and asynchronous discussions, an annotation system that allows teachers and student to make remarks, and a background library consisting of static (e.g., digital books, journals) and dynamic (e.g., indexed World Wide Web sites, discussion forums, and a human expert knowledge database) components. Modules of the background library include an information gatherer, content analyzer, cross reference generator, knowledge integrator, background library manager, and knowledge broker. The background library represents a knowledge repository that is automatically enlarged and improved by the users themselves according to their needs. The gained relevant information is used to improve the learning process and to support the courseware authoring. GENTLE has already been used by hundreds of students at the University; feedback gained during the lectures is leading to continuous improvements of the system as well as new research concepts. (Contains 15 references.) (AEF)

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Intelligent Knowledge Gathering and Management as New Ways of an Improved Learning Process

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Abstract:
This paper gives a short description of a working prototype of an intelligent background knowledge broker as an enhancement module of the Web base training system GENTLE [Maurer and Dietinger 97a, Dietinger and Maurer 98a]. The dynamic and the static library represent a most relevant knowledge repository, which is automatically enlarged and improved by the users themselves according to their needs. The gained relevant information is used to improve the learning process and to support the courseware authoring.

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1. Introduction

At the Institute for Information Processing and Computer supported new Media much research has been done in the field of information and document management, computer based training, digital libraries and electronic publishing over the last two decades [Maurer and Schmaranz, 94, Marchionini and Maurer, 95, Maurer and Scherbakov 96, Maurer 97a , Gütl et al. 98a]. Research results and intense co-operation with the industry even led to commercial products like e.g. Hyperwave [Kappe et al. 94a, Maurer 96]. Based on these experiences a group is currently developing GENTLE [Maurer and Dietinger 97a, Dietinger and Maurer 98a], an electronic lecturing system combined with a digital lecture library for teachers and students. GENTLE has already been tested by hundreds of students at the Graz University of Technology. The feedback gained during the lectures is leading to continuous improvements of the system as well as the new research concepts.

One of the experiences we made was that the introduction of new technologies like multimedia or hyperlinked objects alone does not necessarily lead to more effective and more efficient learning. The technology should be used as a cognitive tool to enable entering into the area of creativity, problem-solving, analysis and evaluation [Watson and Tinsley 95, Pivec and Rajkovi□97a] . Cognitive tools are in fact any technology that enhance our thinking, problem-solving and learning [Reeves 97a]. When computer programs are used as cognitive tools, students use software to analyse problems, tasks, organise unique knowledge representations and share what they have learned with others. For that learners need interpersonal communication, the opportunity to ask questions and discuss problems with the tutors and co-learners. On the other hand technologies are also very useful and necessary for finding proper information, creating courseware and providing a digital background library.

A future oriented collaborative learning system has to provide a smart workspace for teachers and learners. Collections of lessons as well as asynchronous and synchronous discussions related to specific lessons or topics

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are represented on the learning platform. Additionally an annotation system allows teachers and students to make remarks to sections of lessons. One lesson we had learned from former projects is that such a collaborative learning system also has to provide a digital background repository. Such a background knowledge system should consists of a static library (e.g. digital books, journals) as well as a dynamic library (e.g. indexing web sites, discussion forums and human expert knowledge database). The combination of above mentioned elements to a huge knowledge repository allows teachers and students to get additional and much more detailed information for each lesson. This includes, of course, enlarging the annotation system to make arbitrary references to the background repository as well as annotating the background information itself. On the other hand particularly the dynamic background library gives teachers a smart possibility to update lessons or even extract and combine information to new one.

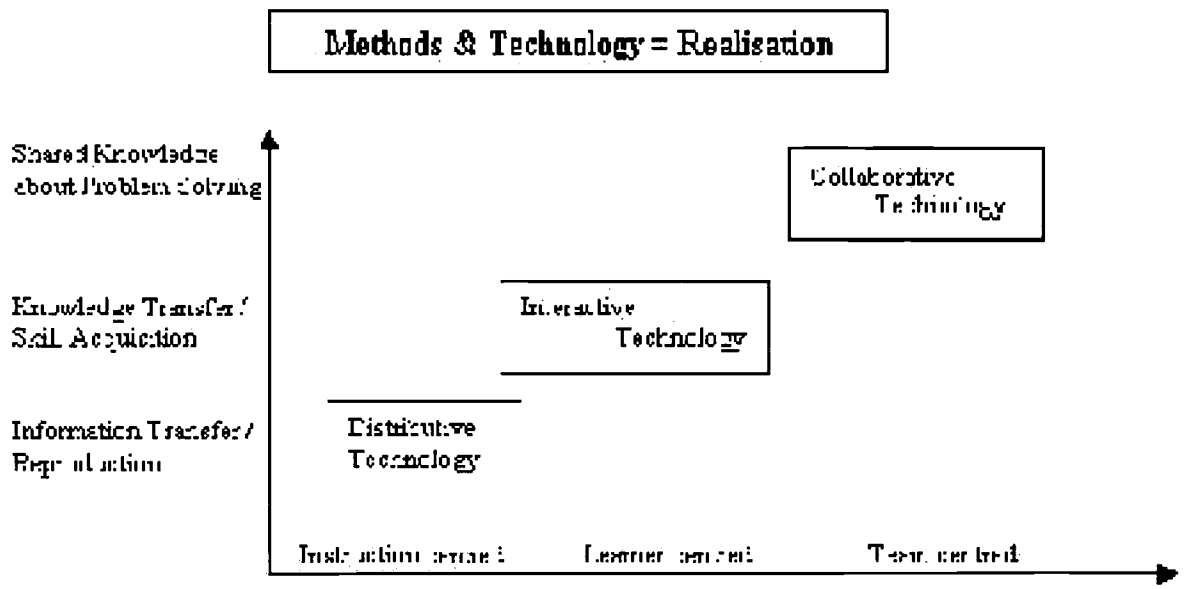
The background library based on HIKS (hierarchical interactive knowledge system) [Gütl et al. 98a] as a necessary and important part of a future oriented collaborative learning system will be described in more detail in the following sections. Aspects, related to the dynamic component by web sites and human expert knowledge are especially highlighted.

2. The Background Library and the Interaction to Learning Process

Learning is a goal oriented process. By methodology we can distinguish between following types of learning methods:

1. Instruction centred (learning by telling)
2. Learner centred (learning by doing)
3. Team centred (learning through discussion & reflection; team – work seminars, case studies, field studies, projects, simulations, discussions)

Combining these methods shown above with available techniques allows to deduce varieties of realisation concepts to reach the postulated goal.



(**Figure 1:** Interaction of learning methods and knowledge transfer)

Generally the knowledge acquisition is a bottleneck in the construction of proper knowledge base. Therefore re-using and re-modelling the already existing modules and knowledge for educational purposes brings certain advantages for developing courseware. Knowledge Based Courseware (KBC) is per definition a courseware with a separate knowledge representation and is considered as an innovative approach which applies established

techniques from the field of AI in order to overcome some of the limitations of the standard CAL (computer aided learning) or CBT(computer based training) approach [Anderson et al., 90, Valley 95a, Pivec and Rajkovi□97a].

However all those techniques need a proper information structure for preparing knowledge or allow to search and inquiry answering open questions and solving problems. Nowadays our society could be described by the so-called information society. It is characterised by a very huge unstructured information repository as well as the rapid increasing of information. In the last few years the internet has become a very interesting area for publishing and gathering information and must be included in such a future-oriented learning environment. The current number of web pages can be estimated to exceed 150 million [Gütl et al. 98a] but only gathering these information do not satisfy the users' needs. The main problem is to get the right information with proper quality, reliability and actuality and to get only that information that has been requested (knowledge). Rieder [Rieder, 97] addresses this deficit by saying *"Not only is the gathering of information demanded; this information must also have meaning ..."*. So we must change from information society to knowledge society [Gütl et al. 98a].

The introduced background library should be an important step into direction of knowledge society. Teacher and learners are motivated to rise the creativity level by using the knowledge for problem solving and generating new concepts as well as to use it by adding more details to each lesson. Therefore the learners e.g. may inquire on background knowledge base for solving concrete exercises. On the other hand teachers e.g. are allowed to add references on their lessons. The system includes digital books and journals as well as human-based knowledge databases and indexed relevant web sites. Former experiences have shown that the static component (digital books and journals) provide a solid base but e.g. rapid increasing of information claims also for a dynamic component (human-based knowledge database and indexing of relevant web sites).

The human-based knowledge database could be seen as a collection of specific information related to lessons, topics or terms. The sources of such information could be an answer-question process between learners and teachers, former exercises and additional explanations as well as problem solutions, studies, etc. An important point related to the learning process is that a most relevant knowledge repository is provided and will be continuously enlarged and improved by users' needs. On the other hand indexing of relevant web sites provides a huge and always up-to-date repository. Most relevant web sites (first named by teachers) related to lessons or topics are gathered and indexed periodically. Learners and teachers are allowed to name further web sites and assess the quality of information. An important feature related to the learning process is that always a wide range of additional information is available and up-to-date. Teachers e.g. can get latest know-how or can update lessons. Learners are highly motivated inquiring on such repository to solve problems or get their additional information.

The introduced system combines the already common courseware, synchronous and asynchronous discussion and a smart annotation system with a highly-sophisticated static and dynamic background library, explained in much more detail as follows.

3. An System Overview

The collaborative learning system provides a smart working environment for learners, teachers and courseware authors. The learners can use courseware lessons as well as discussion and annotation systems. The synchronous and the asynchronous discussion system allows collaborative working between learners and teachers as private, group-oriented and public communication. Most relevant discussions corresponding to specific topics could be included in the background library assigning keywords and an information level (beginner, advanced, expert). E.g. a student who does not understand some parts of a lesson and discusses with the teacher about the problem. In case of relevant information to others, it can be added to the knowledge repository. Therefore further relevant information is provided and can be used for inquiring by other students. Quite similar is the question and answer process related to courseware lessons. This information is directly embedded or marked concerning to the corresponding subject of the lesson. Of course this information could also be added to the knowledge repository.

The annotation system allows remarks to lessons and other documents as well as remarks to background libraries and even to annotations themselves. The system provides private, group-oriented and public annotations and a proper information level could be assigned. These information could also be added to the background library

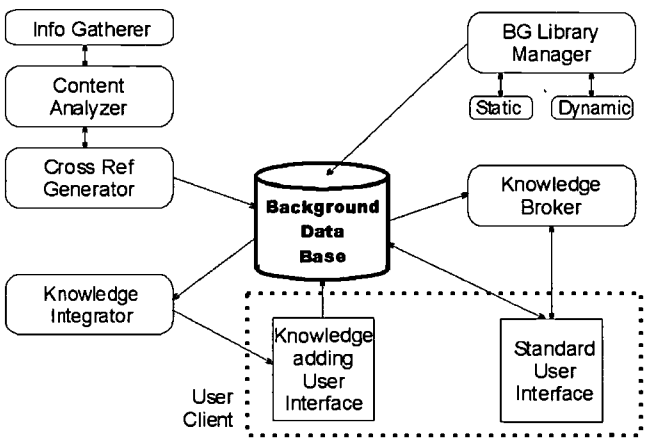
including keywords and an information level. Another tricky feature allows to include pieces of the background knowledge as parts of annotations. The teacher e.g. adds an annotation related to a subject (a definition for beginners) by including information from a digital book and by assigning the information level "beginner" to it.

Of course the system also provides a private workspace and a virtual learning environment. Learners can copy (much more exactly it is a symbolic linking) actual lessons as well as integrate additional information from the background library and prepare their own documents. The learning environment supports co-operative learning and problem solving. E.g. one student is going to provide a presentation by publishing it digitally on the system. Students can include always up-to-date knowledge from the dynamic library by defining predefined queries. The private workspace allows teachers to create new courseware, presentations and so on. One system's tricky thing is that the static background library as well as the dynamic background library could be used to deduce lesson content and thus produce new or update already existing courseware. When integrating such a lesson the system parses for keywords and suggests possible links to further information. Both features are provided by modules of the background library and a tool allows to choose the right keywords and the proper links combining with the information level (see also next Chapter).

The background library represents an important and useful module of the collaborative learning system. There are more points of contact as already shown. The background library will be discussed in more detail as follows.

4. The Background Library

The introduced learning system uses a background library which consists of a static and a dynamic component. The static library provides electronic books, journals, etc. and represents a set of information which has been already reviewed but must be kept up-to-date. The dynamic library provides the human-based knowledge database as well as the indexed web sites. The human-based knowledge repository is composed by most relevant discussion contributions, question-answer processes, former exercises, studies, etc. Usage and work of the learning system guaranties for such information users are needed at their learning process. The information quality will be determined by persons who are allowed to record new information into the system. The gathered web sites represents an additional information repository. Only indexing pre-selected sites could be seen as first steep to higher-level quality of such information. Further quality assessment, annotations and revised indexing will improve the quality too. Like the courseware, all components of the background library are searchable. Also the system allows to annotate specific information at the static library as well as the background library.



(**Figure 2:** Background library and modules interaction)

The modules function and interaction will be considered on the basis of (Fig. 2). The *info gatherer* gets information of selected sites and follows embedded links restricted by host and URL filters. Each gathered page is added by a time-to-live attribute to guarantee up-to-date information. Not only the content and embedded meta information are indexed; the content analyser extracts keywords as well as the description automatically and

adds this meta information to each object. Furthermore the extracted keywords are filtered by relevance. Only keywords with low frequency in a specific course may become relevant keywords. To make this point clearer let us have a look at an example: in a Javascript course it does not make sense to include "Javascript as keyword" and therefore have to be filtered; on the other hand a HTML course may include the keyword "Javascript" as a relevant one. A tricky thing is that relevant keywords (corresponding to a specific course) may be used to create new lessons in two ways. First is that the new lesson will also be parsed by the content analyser and the system suggests a set of keywords and a description. The second is that the new-lesson-tool provides references or links to further information related to relevant keywords (see also following paragraph). With that the creation of courseware is supported and on the other hand a smart set of information is built, inquiring background knowledge. Of course full-text search as well as keyword and title search is provided. Besides the content and meta information there is another source of information taken into account: the description of the web server or the whole site itself.

The system has also implemented a special *cross reference generator* that automatically detects potential hyperlinks and inserts them if the course authors themselves have not already done it. We are speaking of a so-called vocative hyperlink. One of our future work is to combine this vocative hyperlinks with information levels. Therefore learners can define the level settings of their own user preferences. This technique allows the learners to get in touch with the subject by selecting the beginners level. Advanced learners however only get links to higher-level information to prevent getting bothered by uninteresting basics.

The *knowledge generator* allows to deduce new knowledge by recycling in the background library already existing material as well as including relevant information out of discussion forums, question-answer processes, studies, etc. A group could be defined by user rights to create new or edit old ones. This user group gets an additional interface, the knowledge-adding user interface. This set of collected knowledge represents the human-based knowledge database. Learners' problems and interests as well as teachers' established priorities influence this set of knowledge. Like the gathered web sites also the human-based knowledge database provides full-text and keyword search. This source of knowledge could be perfectly used by learners following the shown learning process (see " The background Library and the Interaction to the Learning Process")

The *background library manager* handles all necessary activities concerning the dynamic and the static components. An overview of functions concerning the dynamic library (gathered web sites and human-based knowledge repository) was described in former paragraphs. As already mentioned the static background library consist of electronic books and journals. By including a new electronic book also keywords and descriptions to each document (book's paragraph or chapter) are built. Both, additional meta data combining content and other available meta information, are indexed and therefore searchable. Further work will be done on using information levels to provide level depended references at courseware environment. The collection of journals are working quite similar as described above. Both components of the knowledge repository provide a relevant base for learners.

The *knowledge broker* represents the user interface inquiring and searching in the background library. Of course the courseware and annotations search are also provided but in this paper the background search should be closer examined. Let us consider one learner who is going to solve a problem. The system allows to search on a limited scope, e.g. to search only in human-based knowledge databases. Considering another example: one is preparing a presentation and is looking just for brand-new information about a specific topic. Therefore the search scope could be set to gathered web sites. The combination of the set of different knowledge sources results in a highly-sophisticated inquiring tool for teachers and learners.

5. The Users' View

The introduced future-oriented learning system provides a set of tools supporting courseware authors and teachers as well as learners. Not only a courseware environment is needed; also a smart background library providing many features as shown in former Chapter.

The courseware author can use background libraries inquiring specific information to create new or update existing lessons. The system supports authors by suggesting keywords, description, links and references.

Furthermore relevant information by discussion or question-answer process can be used to deduce "recycled information".

Learners can use courseware itself as well as the annotation system and discussion forum. Also the background library provides a huge source of knowledge. In addition different views and different sets of functionality are controlled by the so-called user preferences. Preferences like information level, multimedia component selection (text, sound, videos), language information and group information are taken into account. For example one learner could be described by a beginner, preferring textual information, wants to get only German-language information. Setting proper attributes the user only gets specified information. Getting only that information prevents frustration to the user.

6. Conclusion and Future Work

As we have seen above simply combining multimedia material and hosting it on the Web does not lead to a good WBT system because it lacks interactivity and moreover is difficult to manage and keep up to date for a longer period of time.
By adding static and dynamic background libraries we do not only provide a profound additional knowledge base for learners to widen their horizons but also a huge data collection for courseware authors to create new courses.
Apart from that the contents of these libraries are automatically organised and updated by providing contributions through the users or through the system by gathering information from other relevant sites and by adding vocative hyperlinks within the information structure.
One of our future works is to combine these features with information levels according to the users preferences (e.g. talent, learning style, language, etc.), to increase the relevancy and quality of the provided knowledge.

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