ON THE COGNITIVE TRANSFER IN CBL ENVIRONMENTS

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ABSTRACT
In this paper we report on a longitudinal study of a Leonardo da Vinci program about the application of a Computer Based Learning environment in three EU countries, Greece, Germany, and the Netherlands. Firstly we clarify the notion of CBL environments, in comparison to multimedia and distance learning ones, and then we provide some theoretical background about these environments. The main research question we tried to answer was whether the application of the environment could perform adequately without the presence of a domain expert as a «teacher», but relying on a «tutor» who had five main tasks to perform during the instructional phase, as described in the paper. In order to answer this question, we designed and constructed an integrated environment and, in addition to this, an instructional methodology for it. The application of the environment by the partners showed our hypothesis to be correct, moreover we elicited results about the different user groups that worked with the environment and their performance under different circumstances. We studied the combination of CBL training and real practice in real environments, among some other issues concerning the application of CBL environments in general, and we provide some statistical facts as observed and reported during the two pilot studies and the five applications of the environment in the three participating European countries. We conclude by arguing that the tutor, as described in this paper, performs more than satisfactorily and demands far fewer resources than a real domain expert. We also pinpoint some points of concern about CBL environments as well as their applicabiltiy in real circumstances with or without a tutor.

KEYWORDS
Computer based learning, cognitive transfer, tutor

INTRODUCTION

Computer Based Learning (CBL) environments have been used since the early days of the utilisation of computer technology in education. A CBL environment is a piece of software that cognitively covers a particular domain and provides the student with all the means to gain knowledge on the domain. This definition implies two assumptions: The cognitive coverage and the presentation of the domain is sound (theory, exercises, simulations) and the learner can interact with the piece (interactivity with the software, multimedia elements); in other words, there is a communication channel in order for the student to acquire the offered knowledge.

The cognitive transfer, namely the ability of every educational environment to facilitate the acquisition of knowledge, is an issue of paramount importance. In CBL environments the communication and computation technologies play a major role in the storage, process and presentation of educational related information. Moreover, these technologies establish an interaction mechanism in order for the user to communicate with the software. This definition may be adequate to define CBL environments in a technical manner, it does not however answer the question of cognitive transfer, since the technology by itself can not guarantee it.

CBL environments are often confused with multimedia environments, with web-based educational resources, or with distance learning environments. However, there is a great difference that separates these kinds of environments from distance learning ones. In CBL environments there is only limited support for the learner, enough to facilitate the transfer of knowledge, eg. a help function. These environments assume the presence of a teacher and their aim is to support and scaffold him in his work. Alternatively, they can be used on a domain that the user is already familiar with, in order to enhance his/her knowledge of it, eg. a knowledge database for the employees of a firm. The great advantage of such environments is the relative ease and low cost of production, since they only have to provide the student with a basic support structure. CBL environments include de facto the notion of multimedia and they can be web-based or in CD form.

Moreover, educational software in general underlies some basic educational approaches and theories that must be taken into serious consideration during the design phase. Let us first take a closer look at the underlying theories.

BACKGROUND

As theories of learning have developed and educationalists have gained more experience in using computer-based technology, there has been a shift of emphasis from the behaviourist paradigm, through the weak artificial intelligence approach, as described by Atkins (1993), to a constructivist view. For most educationalists, constructivism offers far more scope for realising possible learning benefits of using information and communication technology. In fact Reeves (1994) refers to the claim by Gagné & Glaser (1987) that virtually all self-respecting instructional design theorists now claim to be cognitivists (Squires & Preece, 1999).

Many writers have expressed their hope that constructivism will lead to better educational software and better learning (e.g. Jonassen, 1994). They stress the need for open-ended exploratory authentic learning environments in which learners can develop personally meaningful and transferable knowledge and understanding. The lead provided by these writers has resulted in the proposition of guidelines and criteria for the development of constructivist software and the identification of new pedagogies. A recurrent theme of these guidelines, software developments and suggestions for use is that learning should be authentic, on a cognitive and contextual level. A tenet of constructivism is that learning is a personal, idiosyncratic process, characterised by individuals developing knowledge and understanding by forming and refining concepts, which finally leads to the five main socio-constructive learning criteria (Squires & Preece, 1999) that must be met in order to characterize an educational piece as socio-constructive: credibility, complexity, ownership, collaboration and curriculum.

As regards the use of technologies, such as hypermedia and the web in CBL environments, Marchionini (1990) argues that the use of them allows the learners access to vast quantities of information of different types, control over the learning process and interaction with the computer and other learners. A pilot study performed at Cornell University (Fitzelle & Trochim, 1996) had as its primary research question whether the web site enhanced student perceptions of learning. The research findings showed that students thought that the web site significantly enhanced their learning of course content. Student perceptions of performance in the course were also predicted by variables of enjoyment and control of the learning pace.

Every web-based instructional program is a collaborative environment on its own, allowing users to communicate and interact with all participating entities, therefore, in common with current thinking, cognition is “distributed” between users, the environment and learning artefacts, including computers, when learning takes place (Brown et al., 1989; Salomon, 1996). The distribution of cognition leads to learners constructing their own concepts which they use to learn.

Ester (1995), in reviewing literature on computer assisted instruction (CAI) and learning style, found that CAI can significantly improve student achievement and attitudes while decreasing necessary instructional times. A meta-analysis of the effects of CAI on student academic achievement and performance by Khalili and Shashaani (1994) found that in 151 published comparative studies, the use of CAI raised student performance on exams by an average of 0.38 standard deviation. Kulik et al.

(1991) in examining a large number of studies found that computer based tutorials produce improvements in learning outcomes on an average of 20 percent greater than average. Simulation, interactive video instruction, hypertext programs, bulletin boards and networks have also all been found to be effective in enhancing learning. Finally, Bagui (1998) refers to several studies showing that computer-based multimedia can help people learn more information and learn it more quickly compared to the traditional classroom lectures. So to summarize, there is good research for demonstrating that instructional technology often optimizes learning. However, nagging questions remain, such as what features work best, differentiating effects between subgroups of learners, determining how the content of the information makes a difference and specifying how outcomes may be more systematically evaluated, as well as the question of how one should evaluate the learnability of an on-line learning course.

Educational psychology provides many theoretical principles to be applied in the development and evaluation of on-line instructional technology. Milheim and Martin (1991) in studying learner control motivation, attribution and informational processing theory, identify learner control as an important variable in developing the pedagogy of web sites. It is beneficial to generally maximize learner control as it increases the relevance of learning, expectations for success and general satisfaction contributing to heightened motivation (Keller & Knopp, 1987). This research looked specifically at the control of pace by the student as a factor in building on existing theory. A tenet of constructivism is that learners direct their own learning either individually or through collaborative experiences. This implies that learners need to find their own pathways through learning; a philosophy that under-pins hypertext and many web-based instructional systems (Murray, 1997). E-mail, listservers and web browsers also support this approach by enabling students to search for information and discuss issues with others around the world. So, one can infer that the collaborative and interactive nature of the web supports learning mainly by means of augmented motivation of the student. It is common that students make wrong assumptions or possess a false mental model of the domain they study.

THE RESEARCH QUESTION

CBL environments may become very complex, in order to completely cover the cognitive domain they deal with. On the other hand, the needs of the potential users must be taken into consideration as well. Some studies, like Rappin et al., (1997) have showed that students needed a system that would encourage them to examine their assumptions as they worked through problems in their domain. Students also need motivation in cases of educational software, such as simulation environments, which provide students with realistic experience, even in domains where realistic activities are too complex to be performed by novices, too expensive or too dangerous to allow students to make mistakes. This makes the presence of a teacher inavoidable.

However, CBL environments are built for repetitive use, for use over a long period of time, or, as already stated, as knowledge repositories, where students should be able to work on their own and «on-demand», namely to study only the needed chunk of the offered knowledge. Under these circunstances, the presence of a teacher could be too expensive, or simply impossible.

On the other hand, CBL environments contain all the required information to be applied successfully. This implies a certain overlapping in roles between the teacher and the environment, since both can offer knowledge. From a motivational perspective, most CBL programs are designed to serve as a self-study environments with frequent feedback. This tends to be a highly effective and efficient method for delivering some instruction (Keller, 1983, p.412). So it is a pity to abandon their use because of the lack of an appropriate teacher, or because a teacher over a long period of time would be too expensive. In practice, this is what really happens: distance learning environments are designed and applied (whatever it means), because they don't preassume a teacher, while CBL environments are rarely constructed, although they are much cheaper and easier to produce, because organisations cannot afford a teacher to utilize them. So, in this work we stated two null hypotheses: H_1: in a CBL environment, no teacher is needed, and H_2: in a CBL environment a domain expert is needed as a teacher.

We wanted to study following alternative hypothesis H_a: Instead of employing a teacher, we use a "tutor", who has only basic knowledge on the cognitive domain under consideration, yet he is an expert in the use of the environment. By utilizing a previously designed educational path through the software, is he/she able to "lead" the students through the environment?

To prove this hypothesis we worked on a Leonardo da Vinci EU-Program, described in the next chapter, which we designed as a self-study complete environment. In addition to this, we designed a detailed presentation methodology for the tutor, which was more a «time-scheduled navigation» through the software. The coverage of the cognitive part of our experiment was completely left to the CBL environment.

DESCRIPTION OF THE SOFTWARE

The «Orestis» CBL environment is part of the Leonardo da Vinci project «Abilities and skills enhancement of minors offenders and minors at risk», and was a collaboration between many organizations in four European Countries, Greece, Germany, the Netherlands and Hungary.

The main CBL software was designed and constructed in the Multimedia Laboratory of the Aristotle University of Thessaloniki in Greece. Four identical versions in four languages, Greek, German, Dutch and Hungarian were produced.

The «Orestis» CD-ROM was a multimedia CBL environment aimed at teaching young offenders the basic and advanced skills for the use and maintenance of a photo-copy shop. The complete project consisted of three phases: construction of the CD-ROM, application of the instructional methodology in the participating countries and evaluation of the outcome.

Part 1. The «Orestis» environment

The «Orestis» CD-ROM simulates a photo-copy shop with the basic machines (black and white photocopier, phototyper, spiral-binder, thermo-binder and laminator) and consuming materials (papers, transparencies, toners, graphite etc). The knowledge offered is structured in theory, exercises and practice. The theory is offered with text and multimedia elements, such as audio, video and images. Through a series of «chapters» and «paragraphs» the student is provided with the complete theory on the particular domain. There are three kinds of exercises:

- Simple exercises of type «multiple choice» or «true – false». They aim as self control exercises, since there is scorekeeping, in order for the student to assess his/her own progress. From a cognitive perspective, these exercises aim to assess the *aquisition* of the knowledge offered by the student.
- Constructive exercises where the user is asked to perform a task by «drag and drop» on the screen or by manipulating some variables. From a cognitive perspective, these exercises aim to assess the *synthesis* of knowledge by the student. That is, the tasks that the students are asked to perform are similar, but not identical, to the material already presented in the theory.
- The third kind of exercises is also the third structuring modul of the environment: the practice. In a separate simulation environment the student has to control a photo-copy shop on his/her own. Customers give orders, choosen among the most common real orders in real photo-copy shops. The student now has to fulfil the customers request by applying all he/she has learnt. From a cognitive perspective, this environment aims to assess the *transfer* of knowledge, namely the ability to rely on previous acquired knowledge and apply it to an environment outside of the instuctional one, constructing thus his/her own experience.

In addition to this, there are two levels of assisting facilities. One, which is screen sensitive and is available throughout the whole program, and a second which applies only to the exercises and depends on them, so that the student is always supported to complete them.

Part 2. The instructional methodology

As already stated, this was the main research point of the environment. The core point of the work with CBL environments is the non-linear structure of the course. The knowledge offered may be organzed in logical chapters, however the instructional methodology may have a very different logic. In our example the knowledge was organized into four main chapters: the machines, the materials, problems and technology. Some secondary utilities were also presented, such as guidance for newcomers, a lexicon, help and historical facts, but they played a less significant role as the instruction proceeded.

The instructional methodology, on the contrary, follows the logic of completing a «cognitive chapter», for example the black and white photocopier. So the students were asked to navigate through the machines-chapter, but only the paragraphs that affected the black and white photocopier, then through the materials-chapter but only through the paragraphs that affected the materials for the black and white photocopier, continuing, the corresponding paragraphs in the technology-chapter and so on. Obviously, the same methodology was applied to the exercises of every chapter.

An important person in the application of the software was the tutor – we no longer call him/her «teacher» because of the alternate role he had to play during the instructional period. The tutor was given a booklet with detailed instructions and a detailed time schedule with the chapters and the exercises he should guide the students through, for every day of the instruction. It was made completely clear to the tutor, that he/she should NOT give any cognitive help to the students, a task that was left to the software alone. The tutor could only give advice, on how the student could find the solution to his/her problem. Example: «The copy is too light. What went wrong?» Answer: «Why don't you look at the chapter about the adjustments on the control panel?».

A second task the tutor had to perform was the observation of the students' progress and the adaptation of the instructional pace for every student. As it may be obvious up to now, the targeted users were a special user group, namely young offenders. They provide in general some special characteristics, common for this user group that should have been taken into consideration through the design phase of the software as well as through the application phase. It is outside of the scope of this paper to present the complete design methodology. We only mention here that the main characteristics we took into consideration were *impatience*, *disorganization*, *distraction* and *fragmentation* of the thought and actions of this user population, and secondly the fact of their low cultural status and the possibility of illiteracy or different mother language. The influence of these characteristics in the application of the software was that the tutor had to face a variety of performance paces in the «class». So, he/she had to assess up to a certain level the success of the exercises for every student and, if nessecary to provide him with easier tasks, or, for «good» students, to guide them to more detailed information or to additional exercises to lead them further.

To conclude this point, the tutor had four main tasks:

- *Guidance*. He/she had to guide the students through the software.
- *Scheduling*. He/she had to keep the correct pace in the class, so that the time schedule was respected.
- *Support*. He/she had to help the students in user interface issues, such as the manipulation of the mouse or its «click and drag» function.
- *Observational/assessing role*. This role was indispensable, because of the evaluation of the program that performed in parallel.

THE APPLICATION IN PRACTICE

We applied a longitudinal study in three countries, Greece, Germany and the Netherlands. Unfortunately, there has no been any report from Hungary. The reporting here is based on one report from Germany (Report 1, 2000) concerning the application in one prison, one report from the Netherlands (Report 2, 2000) concerning the application in two prisons and two applications in Greece.

We firstly applied a pilot study in Germany. Four subjects were asked to work with the program, without a teacher or a tutor and without any further support. In this phase we wanted to exclude our first null hypothesis H_1, as we believed that no user belonging to this special user group could work with a CBL environment without any support. Indeed, the first null hypothesis was quickly excluded by the observations in the usability laboratory of the Technologiezentrum at the University of Bremen. A second pilot study to validate these results was then applied in Greece. Four subjects were asked to work with the environment without any further help. Here we observed different results with the same conclusion. This is how: in two days the subjects declared to have completely studied the environment. In a test that followed, with simple questions that were handled in the software, the failure was almost complete: of the 10 stated questions only one subject answered one and another three, that is a percentage of 90% failure. So, although it seemed here that the use of the software could take place without any support, the cognitive transfer was negligible. This again leads to the conclusion that the use of a CBL environment, by novice users in the domain, cannot take palce without a tutor.

After this pilot phase, the main application begun. The partners in Germany applied the environment in a prison, under realistic circumstances for twelve days with the participation of five subjects. Four of them were using drugs before their arrest. One tutor served during the whole period.

In the Netherlands the partners applied the environment in two prisons. In the first prison, seven subjects between 15 and 18 years participated for one week intensive course and in the second four subjects between 19 and 35 years for a three weeks period. In both prisons there was a tutor plus the working personal. Most of the subjects had history with drug consumption.

In Greece, we applied the environment with 5 subjects, 15-19 years old, which were in the category «young at risk»; they were not in prison, yet most of them had history of arrests and drug consumption. The course lasted for two weeks and two tutors were present. A second application of the environment took place with a very different user group. For a one week course twelve unemployed women between 20 and 40 years worked with the environment, as part of a vocational training program and finally evaluated it. One tutor was present during this phase and only two real machines could be used, a black and white photo copier and a spiral binding machine.

RESULTS

The application in all countries showed that there were no problems with the use of the software, nor with the first two categories of the exercises. However, the tutor in Germany had often to intervene during the work with the exercises of the third kind; the subjects obviously had problems in transfering the knowledge, which is partially explainable by their drug history and the special characteristics of the particular user group. However, in complete contrast to the above, these users characterized the exercises of the first kind as extremely simple, as «for children» (their words) (Report 1, 2000).

There are some interesting observations concerning the notion of CBL environments, as perceived by the users. The German users stated their work to be «very serious», while the tutor stated that it seemed to be «the ideal media, in order to wake up the particular user group to some activity in the domains of problem-statement and solution-finding» (Report 1, 2000). In addition to this, they seemed to work without any anxiety on the computer and they established a kind of co-operative work, as they helped each other in cases of uprising problems.

In the Netherlands, 6 of the 7 subjects questioned on whether they should be able to handle the program without the aid of a tutor, answered «yes». This is contrary to the observations of the personel, who pinpointed certain difficulties in the use of the software or in the navigation. However, this statement implies the subjective satisfaction of the users, which is stated also in the question on the overall satisfaction with the program. On the other hand, some users complained that «they could not remain on the same subject», which implies a navigational disorientation. The conclusion of all this is that many times the users' opinions can be influenced by the special characteristics of the particular user group or by other random factors. However, in some issues there was an impressive coincidence. In the question whenever the exercises enhanced their knowledge on the domain, all the answers were 8 and 9 in a 1 to 9 scale (Report 2, 2000). Following this statement, the users declared the whole environment as positive for instructional purposes, aiding thus the use of CBL environments under those particular circumstances, such as special user groups, short-time training or difficulty in providing «normal» training etc. However, the tutors and the aiding personel had a different opinion. In the Netherlands it was not possible to complete the course with real photo-copy machines for practical exercise. So, the personel believes the CBL course to be just a part from the whole procedure. On the contrary, in Germany the subjects worked on real machines and the personel there observed a good integration of the aquired knowledge in real work circumstances. These observations were enhanced in Greece, where during the practical phase with real machines, the subjects faced new problems. So, some quick references to the software were made with the help of a laptop and many problems were solved on site with the help of the tutor always acting as navigator, eg. «Why don't you look for the solution in chapter X?». So, it was apparent that the combination of the software with real practice provided the best results.

During the applications in Greece we studied the issue of motivation as well. We used some questions in the questionnaires to clarify the four main factors of motivation, according to Keller (1983): curiosity, expectancy, relevance, and satisfaction. The main outcome was that the motivation was high, which is in accordance with the observed results in the other countries, yet the coresponding acquisition of knowledge was not as high. The subjects thought they had learned things that they really didn't. This is due to the particularities of the user groups, since this particular result was not observed during the second application with the unemployed women. Here, the motivation was also high, but in any case more in accordance to the cognitive transfer. Here no subject «thought» that she had learned something she really hadn't, just because it was taught by a computer program.

During this second application in Greece, we also collected some interesting statistical results concerning the use of the multimedia elements during the instruction. So, for «normal» users, everybody reads the text, however only 60% do so carefully, therefore not needing to re-read it; only 40% listen to the audio, and only 40% look at all images (if they are hyperlinked, as it was the case in «Orestis»), while 80% watch all the videos. In the case where there is text and video, they prefer firstly to watch the video and after to carefully read the text, in order to clarify the procedure they just watched.

Observations about the process speed of the users showed that 60% of the users proceeded more or less at a logical pace, while 20% were too fast and 20% too slow for the rest of the class. However, all of them showed the same success rate in the exercises.

CONCLUSIONS AND DISCUSSION

Let us at this point answer the three hypotheses we made.
H_1: In a CBL environment, no teacher is needed. This is our first null hypothesis and must be rejected, as the results in Germany showed, where we stated total failure to manipulate the environment and the results in Greece, where there was neglectic cognitive transfer. However, in the case of repetitive use, such as a knowledge database, it is practically impossible to employ a teacher or a tutor, yet in instructional ones it is inavoidable.

H_2: In a CBL environment a domain expert is needed as a teacher. Our research showed that this hypothesis is also not true. Rarely was more knowledge demanded than offered by the environment. A domain expert would eventually be able to add more knowledge or to offer more exercises and questions to the students, however this issue was not within the scope of this research. Our scope is stated through the alternative hypothesis we made:

H_a: In a CBL environment we can use a "tutor", who has only basic knowledge on the cognitive domain under consideration, yet he is an expert in the use of the environment. In addition, he adheres to a former declared instructional approach. This hypothesis has been proved as true in all applications, since none of the tutors in Germany, the Netherlands and Greece was a domain expert. Yet, as reported by all partners, the cognitive transfer was significant, even in cases where no real machines were available for practice, as was the case in the Netherlands.

So, the suggested tutor no longer needs to be a domain expert. It is sufficient for him/her to be a power-user of the environment, he/she could even be a former user of it, or a person who is especially trained in it. The main advantage of this approach is that it demands fewer less resources (time, cost, availability etc.) than required when recruiting a real domain expert. In the survey domain, there are also a number of studies, like Bagui (1998) and Roselli (1995), arguing that hypermedia environments, equipped with a tutor capable to appropriately drive the learner, proved to be efficient learning systems.

The presence of the tutor depends also on the user group. A clear conclusion from all studies was that CBL environments work excellently with «normal» user groups, namely with relative homogen classes. If it is not the case, then a tutor with basic understanding of the domain is inavoidable. This is because an extremely differentiated user group in general provides a great variety of reactions during the instruction, so it is indispencible to have a tutor to handle the issues that arise. However, it is not necessary to be a «teacher», in our studies the personel of the prisons performed without problems. This position is also strengthened by the interaction of the tutor with the subjects during the application in Germany, because of the many questions they asked. On the other hand, for «normal» user groups, as it was the case during the second application in Greece, there is no such need at all.

Another interesting result concerns the long standing discussion about CD-ROM vs. Book. 44% of the subjects stated, reading from a monitor to be better than from a book, «because of the multimedia elements and absence of boredom», 28% thought it is the same, «reading is reading» and 28% thought the book is more «personal». In addition to this, they answered the question if it is better to learn from a book or with the aid of a computer. 72% of the subjects stated the computer to be more stimulating, while the rest preferred the book. The foundation of these statements relies mostly on the augmented attraction and motivation of the medium computer, yet parts of the medium are confused with the whole (Report 2, 2000), eg. «reading from screen is better, because of the multimedia elements». So, these statements, although interesting, can not contribute a lot in the direction CD vs. Book, they just indicate a user preference to CBL.

As regards the special user group for this particular environment, there are some additional advantages of the CBL model. According to Friedrich (2000):

- The prison sentences for young offenders has decreased during recent years and are now in average between some months and a year. This makes a long instructional period practically unapplicable.
- There is a great cultural and intellectual differentiation between the young offenders in prisons which prohibits the structuring of homogen classes. So approaches of modularization of the instruction and of individualisation of the learning environment are demanded.

It seems that for practical skills, the combination of the CBL environment with real practice is the correct solution. Even more, if the software can be used during the practice, as it was the case in the first application in Greece, the results are even better.

The problem of the adequate cognitive coverage of the domain under consideration remains open. In the evaluation of the program, many deficiencies in the cognitive domain were detected, as for example with the colour photocopier. In the Netherlands (Report 2, 2000) the tutors were often asked for cognitive issues the software didn't cover, or for more advanced issues the software couldn't cover. On the usability field, although the program provided few usability problems, there were sometimes problems with the navigation in it. The current work can not address this issue of the cognitive coverage, but it seems that the application of the environment in practice and the revisions of the software according to the notifications of the users is a step in the right direction, an approach that is strongly recommended by almost all authors.

Another observation in the Netherlands was that the subjects preferred to work on their own. This is in contrary to the collaborative model CBL environments are supposed to support. An obvious explanation lies here with the different learning pace of the students and the diversity of the classes. The same phenomenon was observed more or less in all applications of the program, even in the more homogen unemployed women class in Greece. So, this observation brings into question the long standing opinion that, in general, computer-based instructional environments facilitate CSCW. Our opinion is that it may be suitable for distance learning environments, where asynchronous modes of communication, such as mail, discussion forums etc. play a vital role. In CBL environments there is a clear domination of the model «working on the PC on my own». Another observation supports this statement as well. In the Netherlands a great variety in the working mode of the subjects has been observed. The same observation we also noted in Greece, where some subjects, in both applications, relied solely on the audio facilities of the program, barely reading the text, while others relied strongly on the video to understand the procedure under consideration. This diversity in the working mode breaks the coherence of the class and would even cause problems for a teacher in the core meaning of the term.

An interesting issue arose from the questionnaires in Greece. All of the subjects stated in the corresponding questions that the CD provided them with knowledge they couldn't have acquired in practice. This is based on the fact that in the CD many theoretical issues (eg. how the machines operate) or technical ones (eg. operation temperatures or consistence of the materials) or historical ones were exploited. This leads to the known result that any instruction must have a well balanced theoretical background and practical session.

Concerning the research future on the domain, it is interesting to investigate the possibility for an interface agent to replace the tutor. As we described the role of the tutor in this work, it could be an adaptive interface agent as well. The only nagging question is whether it could act in cases not foreseen by the designers, in case of collaboration or an external problem. In addition to this, it is under question whether the contemporary adaptive technology can really produce a capable interface agent to replace the tutor; however we hope that this limitation is only temporary.

To conclude, we strongly suggest the design of CBL systems with a tutor, who has to perform the four tasks we already mentioned: guidance, scheduling, support and observation, but not the teaching of the material. It must be emphasized once more at this point, that this conclusion implies the application of a predefined instructional methodology that aids the tutor in his role, since the teaching procedure will be a task for the hypermedia enriched CBL environment, designed ad hoc for the intended user group and according to the appropriate educational theories. We recognize that this may be a hard task, yet there are no known simple tasks in the fusion of education with the IT technologies.

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