Enabling Project-Based Learning in WBT Systems

Abstract: It is our experience that many Web-based training (WBT) systems do not take into account the latest advancements in teaching or learning paradigms – they simply reflect Web technology. We believe that such a technical approach to building WBT systems has a number of drawbacks, since WBT systems are primarily about teaching and learning, rather than about technology. Thus, WBT systems should actually combine conventional and innovative tools compatible with the current Web technology to support well-known, well-tested techniques, and also to enable implementation of new and innovative teaching and learning paradigms in a Web-based environment. Therefore, we built a novel WBT system called WBT-Master as a Web-based platform supporting a wide range of different teaching and learning paradigms. In this paper we present a WBT-Master tool that implements the well-known and highly accepted project-based learning paradigm. Further, we present results when applying this tool to conduct a project-oriented software engineering course with more than 200 university students. Also, evaluation results in applying WBT-Master in a corporate environment are presented as well.

1. Introduction

Nowadays, many organizations apply Web Based Training (WBT) systems extensively to improve their current teaching, learning and training practices. Universities, faculties, research departments and other higher educational facilities usually offer some kind of WBT courses for their students as a supplement or sometimes even as a complete replacement of their classroom courses. A similar situation can be observed in corporate environments where WBT systems usually provide online training material for on-demand Web based training of the work force.

Regardless of the environment the ultimate goal of WBT applications is always to achieve improvements in teaching people by replacing or supplementing more traditional ways of teaching. To achieve this goal, WBT systems need primarily to support current classroom teaching and learning paradigms in a Web-based environment. Secondly, WBT systems should adapt and extend these paradigms to meet the challenges of the new technology. And last but not least, WBT systems should support new and innovative teaching and learning paradigms which result from applying those new technologies for teaching and learning. In all cases, the focus of WBT systems lies in supporting a wide range of current, advanced and innovative teaching, learning and training paradigms on the Web.

However, the current state of WBT systems shows a different picture. Usually, WBT systems do not take into account recent advancements in teaching or learning paradigms. Rather these systems just reflect the current Web technology. Technically, current WBT systems usually support the so-called online course model. According to this model, WBT systems provide remote access to courseware “anytime anywhere” by means of Web technologies. Usually, courseware in WBT systems is prepared as a number of Web pages interrelated by means of hyperlinks into a navigable structure. Teachers prepare such courseware, publish it on WBT systems, and after that learners may access and browse the courseware by using their favorite Web browser.

Additionally, WBT systems offer Web-based discussion boards, chat rooms, and similar Web communicational tools to improve somewhat the teaching and learning experience of participants of Web-based training. In any case, authoring, browsing of Web pages or using simple Web communication tools may be hardly seen as an implementation of any, and especially not of any advanced or innovative teaching or learning paradigm.

Nevertheless, we strongly believe that the primary goal of WBT systems should be to combine conventional and innovative tools compatible with the current Web technology to support well-known, well-tested techniques, and further to enable implementation of new and innovative teaching and learning paradigms in a Web-based environment.

Therefore, we implemented a novel WBT system, which we called WBT-Master (Helic, Maurer, & Scerbakov, 2001) to meet the above requirements. Thus, WBT-Master provides a number of Web-based tools, each of them supporting a particular teaching or learning paradigm. All such tools are combined together to form a Web-based integrated teaching and learning platform, that can meet teaching and training requirements of a wide range of different organizations. Currently, WBT-Master supports the following teaching and learning paradigms:

- Web-based learning – traditional Web-based teaching paradigm reflecting the above mentioned online course model
- Web-based tutoring – supporting the well-known goal-oriented and situation-oriented learning
- Web-based mentoring – supporting the problem solving paradigm with an online mentor
- Web-based brain-storming – supporting the collaborative problem solving paradigm within a moderated online discussion
- Web-based knowledge mining, profiling and delivery – supporting the knowledge exploration paradigms
- Web project-based learning – supporting the collaborative project based learning paradigm in a Web environment.

This paper presents the last paradigm from the list – Web project-based learning. The paper is organized as follows. The next section discusses issues and didactical requirements of project-based learning in a more traditional environment (Thomas, 2000). The third section defines technical requirements for Web project-based learning system. The fourth section describes the technical infrastructure provided by WBT-Master to support project-based learning on the Web. The fifth section describes our experience in applying WBT-Master enabled project-based learning in teaching software engineering course with more than 200 hundred university students and our experience in applying WBT-Master in a corporate environment. Finally, we present some conclusions and remarks for further work in this area.

2. Project-based Learning

Traditionally, project-based learning is a model of learning that organizes learning around projects. According to the definitions found in numerous research papers on project-based learning, projects are complex tasks, based on challenging questions or problems, that involve learners in design, problem-solving, decision making, or investigative activities; give learners opportunity to work relatively autonomously over extended periods of time; and culminate in realistic products or presentations (Jones, Rasmussen, and Moffitt, 1997; Thomas, Mergendoller, and Michaelson, 1999). Other defining features found of project-based learning paradigm include authentic content, authentic assessment, teacher facilitation but not direction, explicit educational goals (Moursund, 1999), cooperative learning, reflection, and incorporation of adult skills (Diehl, Grobe, Lopez, and Cabral, 1999).

Crucial for a successful and effective application of project-based learning paradigm is careful developing and planning of effective projects. The basic properties of such effective projects might be summarized as follows (Thomas, Mergendoller, and Michaelson, 1999):

- Learners should be put at the center of the learning process.
- The project work is central to the curriculum.
- The project must motivate learners to explore important topics on their own.
- Project management should be accomplished by using appropriate tools, such as computer-based project management tools.
- The project outcome or the result that learners need to produce must include learning techniques such as problem solving, in-depth investigation of topics, research, reasoning, and so on.
- The project should include outcome alternatives that are a number of project results that learners might choose from, or that they can work on one after another applying the experience they gained before.
- The project must be collaborative, that is learners might work together in small groups, or they can present and discuss their partial and complete results with other learners at any time.

Let us look now at an example of a project-based learning course. In a study reported by Barron (Barron et al., 1998), learners worked for five weeks on a combination of problem-solving and project-based learning activities focused on teaching learners how basic principles of geometry relate to architecture and design. The problem-solving component involved helping to design a playground in a simulated computer aided environment. The project-based component involved designing a playhouse that would be built for a local community center. Following experience with the simulated problem, learners were asked to create two- and three-dimensional representations of a playhouse of their own design and then to explain features of each in a public presentation to an audience of experts.

Recently, numerous research papers on project-based learning have been published showing the benefits of this learning paradigm for learners and teachers as well. Here is a sample list of such benefits (Thomas, 2000):

- Tremendous gains in learner achievements, as a number of research projects show (ELOB, 1999a; ELOB, 1999b)
- Large gains in learners' problem solving capabilities (Gallagher et al., 1992; Stepien et al., 1993; Williams, Hemstreet, Liu, and Smith, 1998; Gallagher, Stepien, Sher, and Workman, 1995)

- Gains in learners' understanding of the subject matter (Boaler, 1997; Boaler, 1999; Boaler 1998a; Boaler 1998b)
- Gains in understanding relating to specific skills and strategies introduced in the project (Boaler, 1997)
- Perceived changes in group problem solving, work habits, and other project-based learning process behaviors (Tretten and Zachariou, 1995; Tretten and Zachariou 1997).

Thus, the tremendous benefits for both learners and teachers show that project-based learning is a successful, innovative, and highly accepted teaching and learning paradigm. Following our strategy for building WBT systems as systems that should support such new and advanced teaching and learning paradigms we decided to provide Web-based tools to support project-based learning in WBT-Master.

However, there are a number of didactical and technical requirements that need to be discussed before Web-based tools supporting project-based learning paradigm can be implemented. A number of research studies were conducted trying to identify and propose solutions to problems in implementing, applying and planning project-based learning in a more traditional environment. Since such studies provide an insight in the learning process conducted by means of project-based learning paradigm we used these results to define didactical requirements for Web-based project-learning tools. Summarizing, the results of these research studies are divided into two groups (Thomas, 2000): problems and challenges encountered by learners and problems and challenges encountered by teachers.

Learners usually had no problems in generating project plans and carrying out individual project steps. Rather they had problems in following the generated project plan, and managing their time due to the absence of a more systematic approach to carrying out the project. From the learning point of view learners had problems in managing properly the data that they collected during the project. For example, learners tend to draw conclusions or create project results not directly from the data they collected but rather from outside sources. To overcome such problems learners need to be supported by teachers in multiple ways. For instance, teachers can help learners in better anticipation of the complexity of particular project steps, thus resulting in an early adjustment of the project plan and better project management. Further, teachers might point learners to data chunks which are important for drawing conclusions to guarantee that learners analyze the data properly and are able to draw conclusions from their own data (Krajcik et al. 1998). Thus, Web-based tools that want to support project-based learning paradigm need to incorporate a number of possibilities for teachers to provide feedback and support for learners. This support should at least include support on project management, and support on data analysis.

On the other hand teachers implementing project-based learning in their classrooms encountered following problems (Marx et al. 1997). Firstly, classroom management, i.e., balancing of how much of the work is conducted by learners on their own and how much is predefined by teachers was reported to constitute problems in project-based courses. Secondly, improper teachers' feedback to learners caused serious problems. Usually, teachers did not provide enough feedback for their learners resulting in bad project management or bad project results on the learners' side. Again, from the results of these studies we can identify new requirements for the future Web-based tools for project-based courses. For example, classroom management must be very flexible, i.e., it should be possible for teachers to balance on-the-fly what learners need to do autonomously and what they need to do because of teachers' recommendation. The second problem reported in the study refers basically to the same requirement that we had before, i.e., teachers need to have a wide range of possibilities to provide feedback and support to learners.

The next section of this work discusses technical requirements for Web-based project learning in more details.

3. Web Project-based Learning: Technical Requirements

Currently, there exist few Web-based tools that support project-based learning, most notably CAMILE (Guzdial and Kolodner, 1996) and CSILE (Cohen and Scardamalia, 1998). Although both of these tools provide support for some aspects of project-based learning (e.g. collaboration), they still lack few other important issues related to project-based learning. For example, neither of these tools supports any kind of project management. Thus, it is not possible to define project plans, time schedules for the plan, to present sample projects, etc. However, we believe that a Web-based tool claiming to support project-based learning must meet the requirements for project-based learning to their full extent.

Let us now discuss technical requirements of a Web-based system which could enable project-based learning by taking into account all of its defining features, as well as its didactical requirements. We believe that a Web-based system supporting project-based learning should incorporate at least the following facilities:

- Support for project management. Teachers must be able to define the curriculum in the form of a project plan. Each project plan consists of several steps (milestones) that learners need to take to reach the final goal (e.g. to create a realistic product or a presentation) of the project. Each step of the project plan can be defined as a number of actions that learners need to accomplish. The project plan incorporates also a time schedule which sets a time frame for finishing each particular project step. The granularity of the project steps and the time schedule should be adjusted according to the knowledge level, preferences, and maturity of the learners. For example, the teacher might create more project steps with a smaller time frame for younger learners (e.g. younger school pupils) to be able to provide them with more feedback more often. On the other hand, for university students the teacher can define the project plan with only a few project steps that require a longer time frame to accomplish, thus relying upon the maturity and the knowledge level of the university students in accomplishing the project steps on their own. In the case of such project plans it is necessary for the teacher to provide a sample project accomplished by following the project plan with all the project steps thoroughly documented. This sample project provides learners with important information for planning their project and estimating the time needed to accomplish each project step. Also, in the case of projects done by a group of learners the sample project might help learners in allocating responsibilities for particular members of the group because the sample project provides information on the time frames needed to accomplish particular project steps.

- Learners are central to the learning process. In project-based learning the project reflects the goals of the curriculum. However, learners must be supported in many different ways in achieving these goals. This support includes the teacher providing an immediate feedback to learners for both their results published in the system, as well as their project plans. If learners fail to follow the project plan, the project plan must be adopted to the knowledge level and preferences of learners. For example, this can be achieved either by a better description of project actions or by providing an additional milestone. Further, taking into account different cognitive models, preferences, and interests of learners the teacher should offer a number of project alternatives for learners. Each learner or each learner group might then select a project alternative that suits their preferences. Further, the system should not make any restrictions on the technical environment, or the file formats that learners might use. Thus, the system should support all Web compatible formats, such as HTML, PDF, WinWord, Flash etc.
- Support for learners' collaboration. Communication between learners working on the same project (between learners from the same group and between learners from different groups) must be supported. Also, communication between learners and the teacher should be supported as well. Standard Web communicational facilities such as discussion forums, chat rooms, instant messaging, online presence lists, etc. must be supported by the system. Further, collaborative work between learners should be supported as well. Such collaborative work could include collaborative writing of project publications, or collaborative preparing of the project presentations, etc. To provide these facilities the system must support uploading and downloading of files from and to local drives, a versioning system to track changes made by learners, etc.
- Support for data analysis. Teachers should evaluate learners' contributions to provide them with a valuable feedback, and further direction for their work. In certain situations such data analysis is essential for estimating and adjusting the project plans and to keep learners on the right way to solve problems and achieve the curriculum goals. Further, it can also help learners to better understand, present, and apply the results that they achieved.

4. Virtual Project Management Room

We implemented the above presented didactical and technical requirements in WBT-Master as a special tool called Virtual Project Management Room. Virtual Project Management Room integrates the following components into a single tool:

- Special document (curriculum) describing in few words the course and project motivation, problems that need to be solved, goals, etc.
- Special discussion folder providing a sample project with the definition of project plan, i.e., number of project steps and the time table for these steps. Each step is documented with a number of publications.

- A number of project discussion folders, which provide project alternatives for learners to chose from. These folders hold also all learner contributions.
- A number of collaboration and communication tools, such as online presence lists, chat rooms, discussion forums, etc.
- Evaluation tool for teachers evaluating learners work.

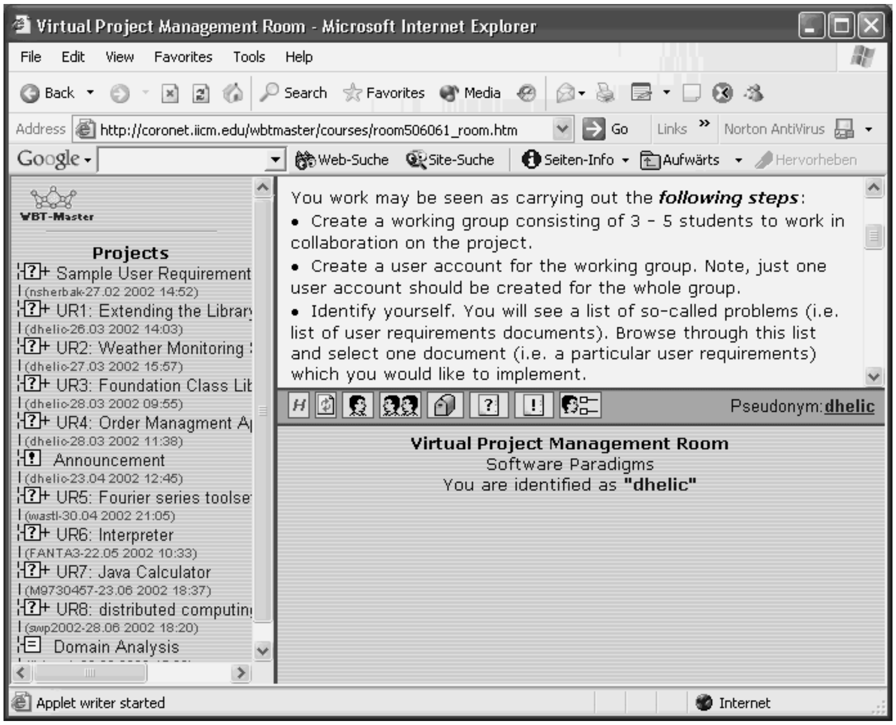

Figure 1: Virtual Project Management Room with Curriculum, Sample and Alternative Projects

Note, that each discussion folder has a basic contribution which defines a topic for all contributions placed in this folder, and a number of other contributions which are made as follow up contributions to the basic one.

A Web compliant GUI was designed to integrate all the above tools into a single Web browser window. Thus, teachers and learners just operate their favorite Web browser to work with the tool. The GUI is organized into three parts (see Figure 1.).

On the left side there is a tree-like structure showing all projects as corresponding discussion folders. The tree may be used to navigate to a certain project, or any other contribution included in a project discussion folder.

The upper right part of the GUI shows the current document, e.g., the curriculum, a project document, a learner publication, etc. The lower right part of the GUI is used for communication, collaboration, evaluation, etc.

A sample project-based session with a particular Virtual Project Management Room looks as follows. First, the teacher writes the curriculum document and attaches it to the Virtual Project Management Room. At the next step, the teacher defines a sample project, and publishes it in the Virtual Project Management Room. Finally, the teacher defines a number of project alternatives for learners.

Now, learners can create their user accounts and assign these accounts to a number of learner groups. Each of these groups is supposed to work on a single project in collaboration. Firstly, learners access the Virtual Project Management Room and work with the sample project trying to get acquainted with the project steps and actions they need to accomplish on each step of the project. After working with the sample project they chose one of the offered project alternatives and work on this project following its project plant. During their work they collaborate and communicate with other learners and the teacher by operating different communication tools in the Room. At each step of the project, the teacher may provide learners with a valuable feedback by evaluating their previous work (see Figure 2.).

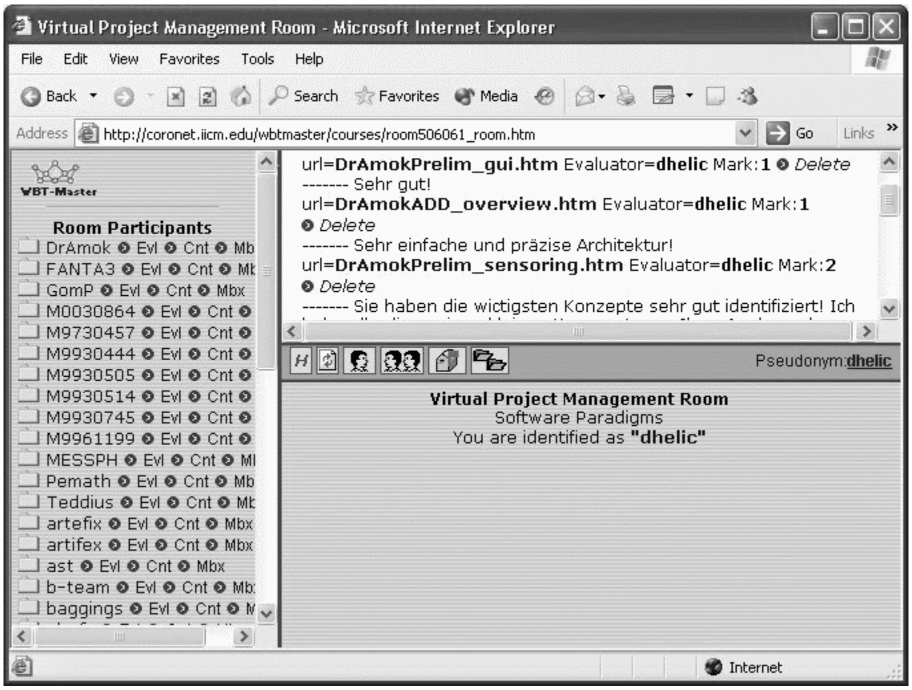

Figure 2: Evaluating of learner contributions

4. Teaching Software Engineering with WBT-Master

4.1 WBT-Master in Academic Environment

We applied Virtual Project Management Room to conduct the 2002 summer term course in Software Engineering at the University of Technology in Graz with more than 200 students. The Software Engineering course in our university consists of:

- Lecturing on basic software development paradigms and vocabularies applied to describe the development paradigms and development processes.
- Software development project where students develop a software application following one of the presented development methods.

Thus, the practical part of this course is already project-oriented. Consequently, we wanted to conduct this project by means of WBT-Master. Thus, we prepared a special Virtual Project Management Room for the Software Engineering project. The room included the following items:

- Curriculum for the project, where we described the learning goals, learning mode, presented time schedules, etc.
- A sample software development project clearly identifying the development method, development process, and all steps that students needed to accomplish to successfully finish their projects.
- Four software development proposals, from which students chose their own projects.

The Virtual Room provided all necessary tools needed to conduct a Web-based software development project, for both teachers and students. Thus, students made their accounts, groups, and assigned their accounts to the groups. They posted their results as multimedia replies to a particular project folder, following the steps from the sample project. Communicational tools were available for them at any particular time. Teachers were able to track students' progress, evaluate the students' results and provide them with valuable comments. Discussion forum was used extensively to discuss project related issues among students and among students and teachers.

4.1.1 Evaluation Results in Academic Environment

After the course was finished we provided students and all involved teachers with a simple evaluation form to evaluate the results of applying this tool in practice. Here are some of the highlights that we got from this evaluation.

First of all, there were no additional efforts on the teachers' side to prepare and conduct the course. The sample project and the alternatives for students had to be prepared anyway, regardless of the environment where the course was conducted. However, there was a need for a special lecture to explain students how to work with the tool. No other session with students were needed, because all the communication was going on in the online mode. This greatly reduced the time effort on the teachers' side because otherwise teachers would need to have 4-5 project meetings with students in the offline mode.

The evaluation of students' answers was a quite positive as well. Firstly, they were asked if accomplishing a Web-based project was more difficult than accomplishing an offline project, which is a project with face-to-face project meetings. Since these students already had a number of projects in other university courses, which were accomplished in the offline mode, their answers might be seen as relevant. Only 5% of students answered that a Web-based project was more difficult to accomplish than similar projects that they had during their classes.

Secondly, they were asked if they see advantages in using communication and collaboration tools to work together on the project with other students. 80% saw such advantages and stated that the communication using the tool was in the most cases even better than in the offline mode, where the communication is usually restricted to the project meetings.

On the question if accomplishing such a Web-based project helped them to acquire additional skills, 90% students answered that they acquired additional skills, and that there was no negative difference in the skills acquired comparing it with the more traditional projects they had before. 85% of those 90% answered that they acquired these skills because Virtual Project Management Room provided an integrated environment needed to accomplish their task, e.g., they had communication with teachers and other students, possibility to discuss their results, to share their ideas with others, etc.

Finally, they were asked to assess the course and their overall assessment was 1.4, where 1 is the best possible mark on the scale from 1 to 5. The average assessment on the university is 2.5, and the average assessment on our institute is 2.

4.2 WBT-Master in Corporate Environment

WBT-Master was developed within the scope of CORONET (Corporate Software Engineering Knowledge Networks for Improved Training of the Work Force) project funded by the European Union. The CORONET project was running from Mai 2000 until Mai 2002. The project consortium consisted of:

- Center for Advanced Empirical Software Research, the University of New South Wales, Sydney, Australia
- Atlante, Madrid, Spain
- DaimlerChrysler, Ulm, Germany
- Fraunhofer Institute for Experimental Software Engineering (IESE), Kaiserslautern, Germany
- Fraunhofer Institut for Computer Graphics (IGD), Darmstadt, Germany
- Highware, Paris, France
- Institute for Information Processing and Computer Supported New Media (IICM), the University of Technology, Graz, Austria
- Centro de Computacao Grafica, Coimbra, Portugal

WBT-Master was mainly developed by IICM. The application partners in the project were DaimlerChrysler, both Fraunhofer institutes, and Highware. These institutions deployed WBT-Master and evaluated it in a wide range of possible applications.

The CORONET project evaluation activities were performed through the following 3 phases (CORONET, 2002):

- Phase 1 (June – August 2001): In-depth assessment of the first WBT-Master prototype. The results from this evaluation were the main input for the enhancement of the CORONET methodology and infrastructure during the 2nd cycle of the CORONET project.
- Phase 2 (September 2001 – April 2002): Continuous evaluation studies performed with the WBT-Master prototype in parallel with incremental enhancements of the product.
- Phase 3 (February – April 2002): In-depth assessment of the improved WBT-Master prototype.

The three phases were performed in a systematic way during the project according to a detailed evaluation plan developed during cycle 1 of the CORONET project. The evaluation approach was fine tuned with the contribution of software and learning evaluation experts involved as member of the CORONET Pedagogic Advisory Board. Furthermore, the evaluation activities during phase 2 and 3 were monitored by additional requests derived from phase 1 results and from the comments of the 2nd and 3rd CEC in-depth project reviews in Paris (June 2001) and Madrid (March 2002).

General goals for WBT-Master evaluation were:

- Analysis of learning effectiveness: Evaluating the effectiveness of WBT-Master system in supporting knowledge sharing and collaborative learning.
- Usability analysis: Evaluating the perceived ease of use and the perceived usefulness of WBT-Master system, i.e. documentation and WBT-Master functionality.
- Cost-Benefit Analysis (CBA): Evaluating the cost-benefit ratio of using WBT-Master system.

Here we will concentrate on the analysis of learning effectiveness evaluations. In order to evaluate WBT-Master, the four partners that conducted the evaluation chose a "mixed evaluation" approach, where not each partner focused on all of the goals, but selected one or more focus areas in which individually tailored evaluation processes were applied.

To analyze learning effectiveness DaimlerChrysler, consistent with its role of software development organization, focused on evaluating the effectiveness of WBT-Master in supporting continuing, self-directed, collaborative learning supported by means of a number of WBT-Master tools. Among these tools was also the Web-based project-oriented tool. The evaluation process was based upon the cognitive load theory and relied on a series of specifically designed evaluation sessions that were conducted in a specifically established evaluation laboratory setting, involving members of the research group as well as members of a business unit. Fraunhofer IESE, consistent with its role of research institute, focused on evaluating the effectiveness of WBT-Master in supporting collaboration and knowledge sharing among researchers. Again a number of tools was tested, among these tools also tools supporting problem-solving in Web-based environment. This was done by conducting two quasi experiments that compared the efficiency and effectiveness of conducting similar tasks with and without using WBT-Master. Highware, consistent with its role of training service provider, focused on evaluating the effectiveness of WBT-Master in supporting web-based learning by training and web-based experience sharing by using among others the project-oriented tool. Evaluation data was collected with the help of specifically designed questionnaires.

4.2.1 Evaluation Results in Corporate Environment

The first evaluation goal focused on the effectiveness of learning with WBT-Master from the perspective of software organizations, software engineering research organization, and software training service providers, i.e. DaimlerChrysler, Fraunhofer IESE, and Highware. In accordance with the findings related to the first goal, all partners appreciated the innovative concepts offered by WBT-Master.

Nevertheless, the results of the evaluation studies related to learning effectiveness were not fully consistent. The data reported by scientists, software engineers, and software trainers at Fraunhofer IESE, Highware, and Highware’s partner and customer organizations generally indicated improved learning effectiveness when using WBT-Master. The analysis of learning effectiveness conducted by DaimlerChrysler was partly influenced by negative judgment of the usability of the WBT-Master platform. This was reflected by the data received from DaimlerChrysler system users who expressed the feeling that the cognitive load associated with tool usage prevented them from learning in the proper sense.

As a by-product of the analysis of learning effectiveness, some observations and conclusions on cultural and organizational aspects could be drawn from the associated evaluation studies. The analysis of WBT-Master user profiles clearly showed that there was a positive predisposition to work with a web-based learning environment as most of the users had been familiar with ICT for more than two years. However, some cultural factors were detected as being critical. They should be taken into account when introducing and operating WBT-Master.

First, shifting to e-learning clearly requests changes in the behavior of nearly all the roles involved. The changes are mainly related to:

- Learning approach: shifting from the conventional presence learning mode to using the internet is not obvious for learners who have not yet had experience with or have not been prepared to using the new learning and knowledge transfer processes offered by a web-based learning environment.
- Pedagogical approach: replacing interpersonal relations typically occurring in conventional classroom settings by interactions between the learner, the tutor and the teacher in the web-based learning environment requires new competence on the part of trainers, tutors, and authors of learning materials.

Using a learning environment like WBT-Master is not a one-shot experience: it is highly recommended to properly introduce both the methodology and the infrastructure to all types of users in order to facilitate the adequate use of the learning environment. It clearly appeared from all evaluation studies that system users need some time to handle the new environment before focusing on any specific learning activity.

Here are some highlights from the evaluation at DaimlerChrysler. In total, forty individuals were involved in DaimlerChrysler's evaluation studies. Twelve of them actively participated in thirty-four in-depth evaluation sessions. The qualitative analyses applied to the "think-aloud protocols" and recorded video tapes of the evaluation sessions indicated that the concepts offered by WBT-Master (e.g. to combine collaborative problem-solving and document work) were generally appreciated by system users. The following functionalities were considered most beneficial for the specific setting of DaimlerChrysler's evaluation study:

- Self-paced worker's exploring of problems and projects,
- Synchronous communication facilities for the experts to give advice, and
- Various collaboration tools, i.e. forums and chat rooms for collaborative problem-solving with peer learners, and collaborative knowledge building.

Some highlights of the Fraunhofer IESE's evaluation are as follows. In total, seven individuals actively participated in Fraunhofer IESE's evaluation studies. The results of the evaluation studies show that knowledge sharing activities in a research department setting can be performed more efficiently and more effectively with using the collaborative aspects offered by WBT-Master.

Finally, some of the results of the evaluation at Highware are as follows. In total, thirty-two individuals actively participated in Highware's evaluation studies. The results of the evaluation studies were in its majority positive. The main findings can be summarized as follows:

- The concepts contained in the learning methodology of WBT-Master are presented in a clear and concise style so that learners, trainers, tutors, and authors can easily identify the right learning scenario for their particular learning/training needs.
- The collaborative and communicational functionality provided by WBT-Master offers a viable alternative to classical in-class training settings. The effectiveness of virtual classes was judged of being at least as effective as conventional in-class sessions.
- Regarding the effective support of web-based knowledge and experience sharing during collaborative work WBT-Master successfully helped establish a network of geographically distributed learners. From the point of view of the management, the establishment of such a network, facilitating learning at the workplace by connecting people to a network of distributed learning resources (documents, courseware, peers and experts) was considered as one of the main strengths of the CORONET system.

5. Conclusion

The practical results of teaching the Software Engineering course with Virtual Project Management Room and using of WBT-Master in corporate environment lead to a number of important conclusions.

First of all, defining the didactical and technical requirements for a Web project-based learning tool properly, i.e., in accordance to all defining features of traditional project-based learning was of the primary importance. By doing so, we implemented Web-based tool that allowed achieving all benefits of traditional project-based learning, but now in a Web-based environment. The results of our evaluation clearly show these achievements.

Secondly, the idea to build WBT systems around teaching and learning paradigms, rather than around technology proves to be a proper direction for building WBT systems. Thus, WBT systems should be composed of a number of tools, each of them built according to requirements of a particular teaching or learning paradigm. In that way, by just applying a proper tool, teaching or learning sessions in WBT systems may be conducted in correspondence with the best suited teaching or learning paradigm. Consequently, the results of such session will tremendously improve, which can only lead to a brighter acceptance of WBT systems and their better success.

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