Implementing Project-Based Learning in WBT Systems

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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.

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 (Helic, Maurer, and Scerbakov, 2001b). 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 (Helic, Maurer, and Scerbakov, 2000; Dietinger and Maurer, 1998).

Therefore, we implemented a novel WBT system, which we called WBT-Master (Helic, Maurer, and Scerbakov, 2001a; Helic, Maurer, and Scerbakov, 2001b; Helic, Maurer, and Scerbakov, 2001c; Helic, Maurer, and Scerbakov, 2001d; Helic, Maurer, and Scerbakov, 2002; WBT-Master 2002) 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 (Helic, Maurer, and Scerbakov, 2001b)
- Web-based mentoring – supporting the problem solving paradigm with an online mentor (Helic, Maurer, and Scerbakov, 2001c)
- We-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 (Helic, Maurer, and Scerbakov, 2001b; Helic, Maurer, and Scerbakov, 2001b; Helic, Maurer, and Scerbakov, 2001d; Helic, Maurer, and Scerbakov, 2002)
- 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 of project-based learning in a more traditional environment (Thomas, 2000). The third section defines requirements for Web project-based learning system and describes the technical infrastructure provided by WBT-Master to support project-based learning on the Web. The fourth section describes our experience in applying WBT-Master project-based learning in teaching software engineering course with more than 200 hundred university students. 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 students in design, problem-solving, decision making, or investigative activities; give students 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).

Let us look now at an example of a project-based learning course. In a study reported by Barron (Barron et al., 1998), students worked for five weeks on a combination of problem-solving and project-based learning activities focused on teaching students 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, students 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 students and teachers as well. Here is a sample list of such benefits (Thomas, 2000):

- Tremendous gains in student achievements, as a number of research projects show (ELOB, 1999a; ELOB, 1999b)

- Large gains in students' 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 students' 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 students 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.

3. Web Project-based Learning: Requirements and Technical Infrastructure

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 (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.

Therefore, we first want to discuss the requirements that a Web-based system needs to meet in order to support Web project-based learning. The requirements for this system may be defined as follows:

- Teachers must be able to define project plan (curriculum) for a project-based course. The project plan includes definition of project steps, together with actions that students need to take in each project step.
- Teachers should be able to provide a sample project for students.
- Students should publish their results in the system following the project and time plan. For publishing results the system must support current Web compatible formats, such as HTML, PDF, WinWord, Flash, etc.
- Students may work in groups or alone.
- Students may work collaboratively on projects in general and specific project publications in particular.
- Students need to communicate among themselves and with the teacher. Different ways of communication must be supported, such as chats, instant messaging system, online presence lists, etc.
- Teachers should evaluate students' contributions to provide them with a valuable feedback, and further direction for their work.

We implemented these 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 students to chose from. These folders hold also all student contributions.
- A number of collaboration and communication tools, such as online presence lists, chat rooms, discussion forums, etc.
- Evaluation tool for teachers evaluating students work.

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 students just operate their favorite Web browser to work with the tool. The GUI is organized into three parts (see Figure 1.).

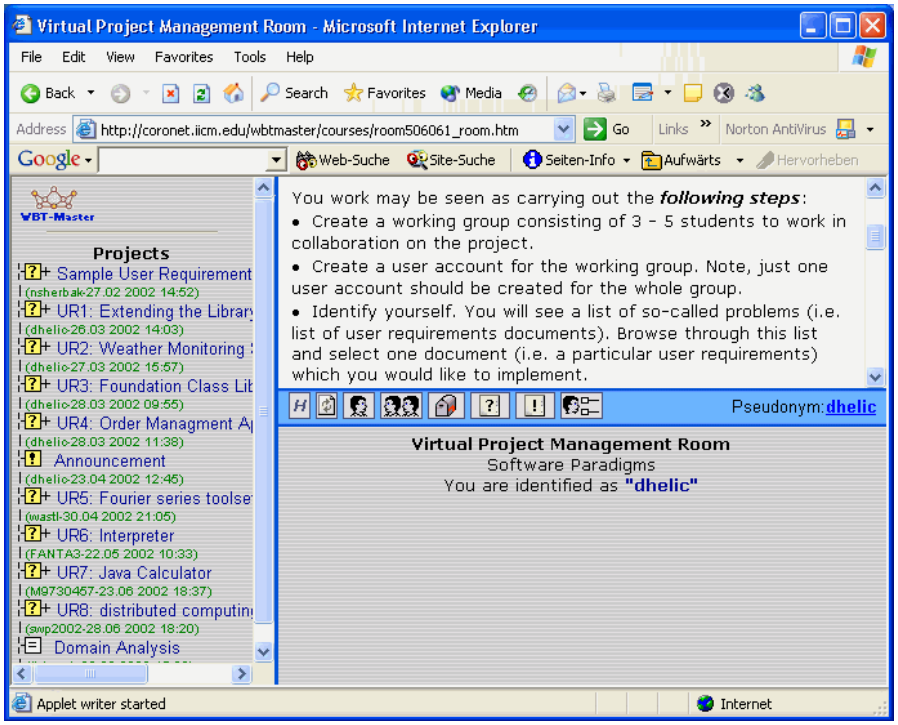

Figure 1: Virtual Project Management Room with Curriculum, Sample and Alternative Projects

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.

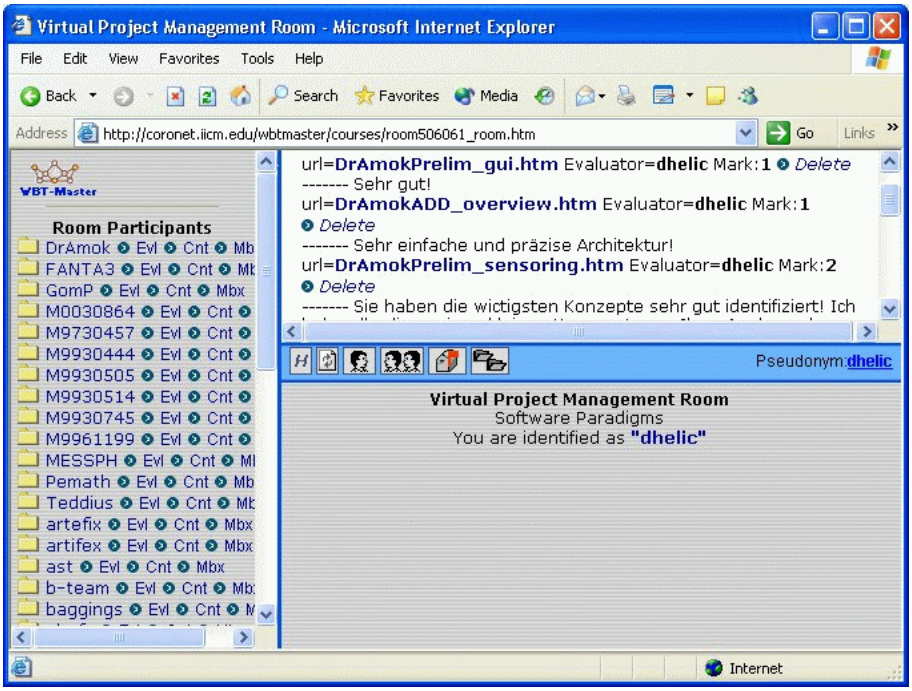

Figure 2: Evaluating of student contributions

The upper right part of the GUI shows the current document, e.g., the curriculum, a project document, a student 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 students. Now, students can create their user accounts and assign these accounts to a number of student groups. Each of these groups is supposed to work on a single project in collaboration. Firstly, students 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 students and the teacher by operating different communication tools in the Room. At each step of the project, the teacher may provide students with a valuable feedback by evaluating their previous work (see Figure 2.).

4. Teaching Software Engineering with WBT-Master

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.

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 results 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 needed 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, since usually teachers need to have 4-5 project meetings with students in the offline mode.

The evaluation of students' answers was a quite positive experience 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 asses 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.

5. Conclusion

The practical results of teaching the Software Engineering course with Virtual Project Management Room lead to a number of important conclusions.

First of all, defining system requirements for 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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