

Web-Based Collaboration Tool in Engineering Design Courses

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Abstract

In our capstone design courses, a team of senior engineering students works on a problem specified by an industrial partner. The course goals are to develop a solution and to demonstrate its feasibility in a 15 week semester. A web-based bulletin board system was integrated into the courses as an on-line collaboration tool in the spring of 2005. Although the students required little encouragement to start using this system, many project teams quickly learned to use it productively and obtained good results. The system allowed sponsor mentors to share project information with a broader audience within their organization. It enabled them to provide better and timelier feedback to students and faculty; therefore, the students were able to explore more realistic design solutions. The faculty advisers were also able to assess a team's progress, problems, and individual contributions more effectively by monitoring information posted by the team. The system made a significant impact on the project outcome and students' learning experience.

Introduction

The O. T. Swanson Multidisciplinary Design Laboratory (MDL) at Rensselaer Polytechnic Institute (RPI) is an educational laboratory that supports capstone design courses. A multidisciplinary team of senior engineering students works on an open-ended design problem specified by an industrial partner that is typically a global company¹. The course goals are to develop a solution to a problem and to demonstrate its feasibility within a 15-week semester. A project typically consists of two or more semesters. Therefore, it is essential for students to prepare well-written documentation of their results so that a new team can extend their work. A faculty adviser and a sponsor mentor assigned to the team serve as coaches and consultants.

On-line collaboration tools, also known as groupware, are widely used in many industrial organizations to improve their productivity and the quality of their products. The benefits of using bulletin boards in traditional teaching and e-learning were reported by Santos and Wright². Types of collaboration tools include bulletin (discussion) boards for threaded discussions, public folders for sharing documents, Wiki, and version control systems for concurrent editing source codes or CAD files.

Our experience has shown that organized teams tend to perform well in the courses. RPI's intranet and students' notebook PCs, which are mandatory, help the students to work on the project both inside and outside of the scheduled class time. To let students be better organized, the MDL has been using an on-line discussion board system as a web-based collaboration tool for managing project related information since the spring of 2005. Learning to use the tool effectively also contributes to ABET's program outcome (k):

- (k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.³

In this paper, we present our experience in selecting and deploying the MDL Projects Forum, a web-based discussion board, and ways to use the system for enhancing the course work and assessing students' performance.

Choosing a System

Since each university has a unique set of computer/network policies and support capabilities, there is no ready made recommendation that fits every school's needs. Key IT issues in selecting a tool are summarized as follows.

The first issue in selecting a system (software) is to determine whether an individual, who is not a member of a university, such as a sponsor mentor, needs to access the system. For example, an educational tool, such as Blackboard Learning System (www.blackboard.com), provides discussion boards, but the access is typically limited to the students and their instructors only. Hence it can be used for design courses that do not have external partners but may not be beneficial for projects that require close collaboration with external mentors.

The next issue is availability of technical support on campus. IT groups are typically comfortable with either Microsoft or Unix/Linux technologies. Successful deployment of a system often depends on the availability of technical support.

Another issue is the cost, including hardware, software licenses, and efforts, for deploying a system. Commercial collaboration systems are expandable and support many users. On the other hand, they might require multiple servers, such as a database server and web server, and a variety of software licenses to get started. Thus, even a pilot project requires a decent budget. On the other hand, open source-based solutions are typically inexpensive to build but may provide limited customer supports.

Important features that must be provided by a system are as follows:

- Create private work spaces, which cannot be accessed by unauthorized people (non-members)
- Provide means to add new members and to assign them to appropriate work spaces quickly.
- Allow the users to post files. To support reports and presentation slides containing many photos, a minimum of a 4MB file should be allowed¹. Our system currently allows students to post up to a 10 MB file.
- Provide threaded discussions that are useful in configuration management, defect tracking, etc.
- Allow the users to search messages using a key word. This feature is extremely useful for a student working on an on-going project to find information left by the previous team(s).
- Show summaries of users' activities.
- Allow instructors to see all messages posted by a particular user.

Our System and Its Structure

To allow sponsor mentors to access the system, a dedicated discussion board system was built to run the pilot project held in the spring 2005. It consisted of Simple Machines Forum (www.simplemachines.org) running on a LAMP (Linux, Apache, MySQL, and PHP) server driven by a surplus Intel Pentium 4 desk top PC having 512MB memory and 40GB hard disk. Hence, there was almost no cost to get started. Later, the secured transmission (SSL, HTTPS) was enabled to improve sponsors' confidence in communicating with students using the system.

Currently, over 250 students use the system each semester, and it must be available 24/7 during a semester. To meet the needs, the system has been upgraded and now consists of a production server and a back up server.

Figure 1 depicts the structure of the system. The Course Documents and its sub-boards contained information useful to all students, such as a course syllabus and report templates, and are available to everyone. On the other hand, project specific boards were restricted to the project members. For example, students who were working on Project Y had access to their working board, i.e., Project Y Spring 2006, and a board containing past work, i.e., Project Y Fall 2005.

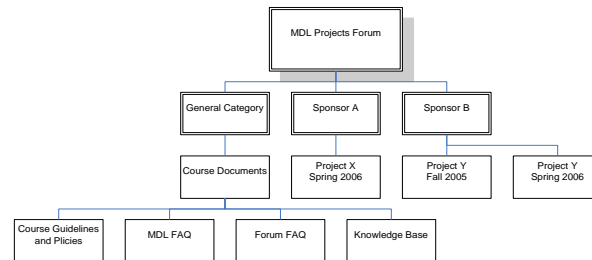


Figure 1. Structure of the MDL Projects Forum

Users are allowed to start (post) new topics (messages), read messages, reply to a message, and attach files up to a total of 10MB to a message. On the other hand, users cannot create a sub-board by themselves; they are created by the system administrator upon a team's request.

It is often confusing to manage all information in a board. High performance teams requested sub-boards and utilized them to organize information more efficiently. Based on their experience, all teams receive the following pre-established sub-boards and are encouraged to use them wisely:

- Background Information – Store a problem statement, references, etc.
- Meetings & Progress – Post minutes of meetings and progress memos
- Design – Use the space as a shared design notebook
- Proposal – Prepare a proposal
- Mid Term – Prepare a mid-term report and presentation (Power Point file)
- Final Deliverables – Prepare a final presentation, final report, and other deliverables.

Students' Behavior and Productivity

The MDL Projects Forum is a tool. Its contributions to the outcome of a project depended on how well the students used it. Many students are accustomed to sharing information by sending it through e-mail. On the other hand, few students are familiar with sharing information using a collaboration tool. Hence, all students receive a 10 minutes tutorial on the forum use on the first day of the class.

High performance teams took advantages of the system as follows:

- Students shared the status of a project and kept track of their progress by regularly posting the minutes of meetings (progress report), including progress made, problems and mitigations, and individual assignments that must be completed by the next meeting.
- A digital camera became an important companion tool. Students posted photographs to the board and shared information quickly and clearly. For example, taking a photograph of a white board having notes eliminated the need for a note taker and allowed all members to focus on the discussion.
- Similarly, mechanical engineering students typically sketch their ideas in their design notebooks. Such sketches were digitized by a camera or scanner and posted to the system. Although almost all students recognized the value of sharing their sketches, not many students actually practiced it because it took two steps.

- Students conducted informal design reviews and made suggestions by posting comments on partial design documents posted to the board. It allowed them to collaborate outside of the scheduled class hours.
- By sharing the latest information among all team members using the system, they were able to minimize any delays when a critical member was not available.

On the other hand, low performance teams typically only use the system for preparing milestone deliverables, such as reports and presentations.

Introduction on Software Engineering Processes

Excluding students who focus on Software Engineering, students typically learn to write programs but do not learn software development practices and the use of specialized tools. Projects that require small software development, such as programming a micro controller, were often performed by students without knowledge of software engineering. For a large scale software development project, it is essential to have a revision control tool, such as subversion (<http://subversion.tigris.org/>), a bug tracking tool, such as bugzilla (www.bugzilla.org), and so on. Yet, students without prior exposure to such tools typically find the learning curves are steep. Moreover, such tools are often overkill for small software development.

At the MDL, a sub-board called Code Repository shown in Figure 2 and the following simple rules are used to teach good software development practices without introducing new tools.

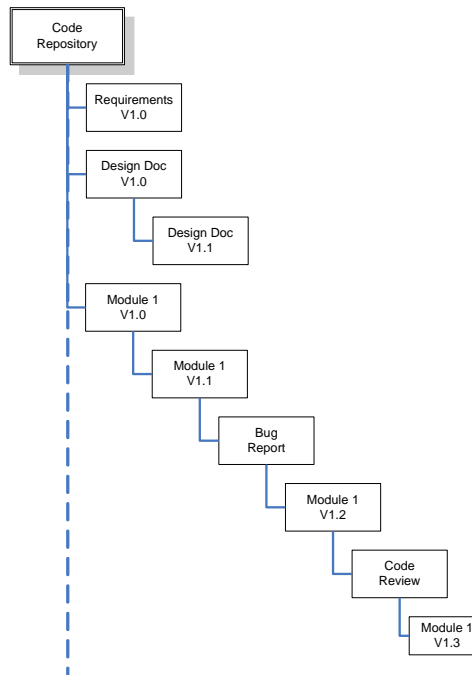


Figure 2. Software Development using the Forum

- A programmer posts the specification of a software module as a new topic.
- The programmer posts the latest version of the corresponding code and/or test program using the thread.
- Anyone who reviewed the code posts the results comments and/or questions. The programmer replies to the message as needed.

- Anyone who found a bug must report it using the thread. The programmer must post the corresponding bug fix.

Enhancing Sponsor Mentors' Interactions with Students

The on-line system allowed sponsor mentors to monitor the students' progress from anywhere and at any time. It was especially useful for mentors who were out of town; not only distances but also time differences made communications difficult.

On several occasions, sponsor mentors invited their colleagues, and the system allowed them to share information about the project with a broader audience within their organization. It enabled them to provide better and timelier feedback to students and faculty about the problem. Therefore, students attained solutions that were more realistic.

It also helped the mentors to promote benefits (achievements) of the project with a broader audience within their organization. It enabled them to justify supporting the project further and to come up with a new project.

Enhancing Faculty Advisers' Effectiveness

Understanding students' individual personalities is often helpful in advising them. To use the MDL Projects Forum, students must activate their user accounts. As shown in Figure 3, approximately 10% of the students did not activate their accounts until the second week in the fall 2005 and the spring 2006. In other words, these students did not study project information posted to the board during the first week. On the other hand, students who were self-starters joined the board before the beginning of the semester (Day 0) or in the first couple of days. Monitoring account activation activities allowed the faculty advisers to identify students who might need attention and guidance early in the semester.

Before the coloration tool was available, faculty advisers heavily relied on face-to-face meetings in scheduled classes to assess students' progress and problems. Implementing this on-line system allowed faculty advisers to monitor the students' thinking processes and progress made between classes. Thus, in classes, the students and faculty advisor were able to focus their attention on important design issues without spending time on trivial housekeeping issues. On the other hand, the system was also helpful for faculty advisers in identifying teams that might need guidance because of a lack of forum activity.

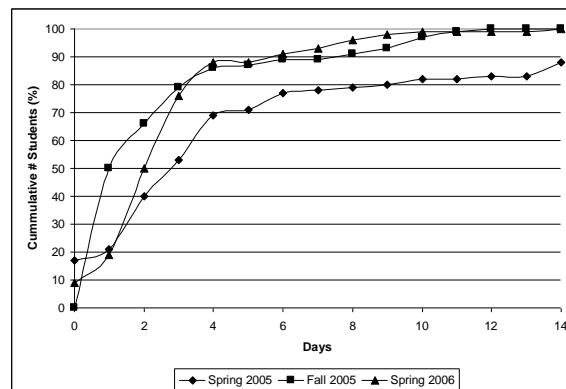


Figure 3. Cumulative Number of Students Activated their Accounts Since the Beginning of a Semester

When students posted their design ideas and plans, not only teammates, but also faculty advisers were able to review the information and provide any necessary feedback to the students without waiting for the next scheduled class. Similarly, faculty advisers can respond to students' questions and concerns. This quick turnover of information had a significant impact due to the limited time of 15-week semester.

Similarly, it was important for students to post their design of an experiment to be reviewed for safety and other issues. Sharing the information allowed faculty advisers to invite additional reviewers as needed in a timely manner. In addition to the students, sharing the raw data allowed faculty advisers and sponsor mentors to analyze the data. Such flexibility was useful in evaluating students' ability to design and conduct experiments corresponding to ABET's program outcome (b)³.

Assessing students' communication skills is required by ABET's program outcome (g)³. The system provides the following two means for assessing their written communication skills. First, reviewing messages posted to the board often revealed their skills. In some cases, the messages clearly showed that the authors did not understand what was appropriate in business (professional) communication. These students received advice on improving this skill.

It is often difficult to determine individual contributions made to prepare a group report. To overcome this problem, the following procedure has been used:

- Post the outline of a report and individual assignments.
- Post individual contributions.
- Compile and post an assembled draft report.
- Post comments and/or a revised report.
- Submit a completed report.

Maintaining the revision history of a report has been a valuable tool for assessing individual contributions and skills.

The board titled Knowledge Base under Course Documents shown in Figure 1 contains frequently asked technical questions and the corresponding answers. Although students have full access to the board, they rarely search for information on it. Hence, students do not get any benefit from the information directly. On the other hand, this board assists both new and seasoned faculty advisers in providing appropriate information to students in timely manner.

Caution

The web-based collaboration tool is a powerful and useful tool. Yet, the faculty advisers agreed that some types of information might not be appropriate for the board. For example, reports with the advisor's comments and negative comments to a team must be private and should not be shared with sponsor mentors. Such information should be communicated with the students by e-mail or in a face-to-face meeting. If a sub-board that can be accessed by the students and the advisor only could be created, it could be used for this purpose.

Conclusions

We presented our experience in deploying the bulletin board system as a web-based collaboration tool and showed how it enhanced the design courses. It was useful for the students to get organized and achieve their goals. The system also enabled the sponsor mentors and faculty advisers to provide timely feedback to students. The system also assisted the faculty advisers in gaining better insight into students'

performance. It was also helpful in assessing students ability in terms of ABET's program outcomes (b), (g), and (k).

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Biographical Information

Junichi Kanai received his B.S. in EE, and an M.Eng. and Ph.D. in CSE from Rensselaer Polytechnic Institute (RPI) in 1983, 1985, and 1990, respectively. He is currently Associate Director of the O.T. Swanson Multidisciplinary Design Laboratory in the School of Engineering and Clinical Associate Professor in the department of Electrical, Computer, and Systems Engineering at RPI. His research interests include engineering design process improvements and the application of IT technologies in engineering education.