Experiments with Distance Learning in Software Engineering Graduate Courses

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Abstract

This article reports on our experience to date with these two distance graduate courses in software engineering. We experimented with several technological tools to facilitate computer mediated communication: WebCT, electronic mail, a list server, and NetMeeting. We briefly discuss the methods used to evaluate the distance learning environments experienced by the graduate students, and make recommendations for future research and educational practice in distance learning environments.

Introduction

The Software Engineering Research Network (SERN) has designed a research-based masters program with a specialization in software engineering targeted at students with industrial experience in full-time employment [8]. The program's objectives are to develop highly qualified personnel, and to encourage industry-based software engineering research with a focus on good practice. The program philosophy is based on experience with constructivist approaches to undergraduate courses over the last five years where all course material and student assignments have been made publicly available on the World Wide Web. This has involved a restructuring of existing pedagogical approaches, de-emphasizing received wisdom and authority of the instructor, and emphasizing collaborative learning and meta-reflection on learning processes. Students increasingly see themselves as contributors to online knowledge resources rather than regard participation as merely 'taking a course.' Graduates continue to return electronically to use the list server associated with a course, either because they have come across an interesting idea or technology to contribute, or because they wish to raise a question that might be answered within the class.

One of SERN's goals is to increase access to the MSc program by expanding to include a distance model. SERN's graduate program is in high demand; therefore, a distance model will enable us to provide increased access to students who are non-traditional, work full time, have industry experience, and often work internationally. We believe that computer mediated distance methods offer several learning advantages to students that go beyond "anytime, anywhere" [2] access: 1) learning about networks and computers, 2) interaction and contact with experts and others outside of their immediate community or workplace setting, 3) increased self-reliance, and 4) developing independent learning approaches. Although there is an initial increase in resources needed to research, develop and implement a distance model, many have found this approach to be cost-effective in the long run [2, 1, 7].

Computer networks have always been used to enhance and extend the learning environment in the SERN graduate program. All supporting course materials are already made available to the students through the web. The e-mail list server provides a forum for students to communicate with instructors and other students outside normal classroom or office hours, and students are required to submit assignments on the web. Instructors use e-mail and the web for distributing class outlines, supplementary notes, handouts, and instructions.

We are currently addressing the challenge of making the MSc program formally available to students using web-based networking tools while maintaining current levels of interaction and ongoing participation. First steps have included developing and offering parallel sections of SENG 611, a required course in Requirements Engineering. One section of Requirements Engineering was delivered on campus, and the other delivered at a distance using facilities provided by WebCT [3]. A second step was to offer SENG 609.04, an optional course in Software Design Patterns, as a distance education course that was supported with WebCT and weekly chats using
NetMeeting.

We chose to conduct our first distance education experiments with graduate rather than undergraduate students because class sizes are smaller, and graduate students are less "grade-driven" and more independent in their approach to learning, and as a result, tend to be more forgiving of the fits and starts that tend to accompany changed learning envi-

ronments. Thus, although online course delivery approaches and software tools were novel, we deliberately chose a group that would have lower levels of uncertainty with this type of experiment. It is important to note that all of our graduate students were in fact local, and had convenient access to the instructor and other students at all times.

Instructional Design and Delivery of Two Graduate Courses

Prior research has found that faculty spend more time preparing materials and resources for instruction when integrating computers into their teaching and learning on campus [5]. Instructor workload increases, at least initially, for teaching and learning online [4] but tends to approach more normal levels of workload as the instructor gains experience in the online environment. The results from our experiments are certainly consistent with these findings. Although these courses lent themselves to online delivery (i.e., extensive web-based notes and links, information about assignments, requirements to publish on the web), several components required modification. To meet student needs in concurrent local and distance sections of the first course, instructor workload increased. The instructors spent additional time on the following distance-related tasks:

- "repurposing" existing course web pages for use within WebCT - resources had to be expanded on in order to address content gaps that would normally be filled with a conventional lecture and in-class discussion;
- creating detailed web materials for the distance group - Instructions for assignments and hands-on lab activities had be made much more explicit to account for the absence of face-to-face explanations, and the in-class "hands on" exercises that were an important part of these courses had to be redesigned to accommodate the distance model;
- locating and organizing online references and links to additional materials;
- reading and replying to a substantial number of email inquiries - use of the email list server had to be increased for the distance model;
- installing, learning, and deploying new web-based tools - WebCT was used in both courses, and Microsoft's NetMeeting was used to simulate face-to-face class discussions in the second course.

Learned lessons and hands-on experience with distance education has provided insight into refining and improving the processes. For example, concurrent sections of the Requirements Engineering course were offered for the purpose of directly comparing the two learning environments. The Design Patterns course was offered only as a distance section rather than offering concurrent distance and local sections. One reason for offering only a distance section of the Design Patterns course was that students in the first experiment felt somehow disadvantaged no matter which group they were in — the local students felt that allocating attention to creating a lecture summary reduced their opportunity to fully participate in the classroom discussion. The distance students felt they were missing vital information by not being present for classroom discussions and the face-to-face contact with instructors. Finally, both local and distance students perceived that they spent more time per week on course-related activities, although the average time spent by each group per week was not significantly different (see Figure 1). Thus, it was decided to minimize perceived equity problems by offering only a distance section of the second course.

For the Design Patterns course, the first and last lectures were face-to-face, and other classes were at a distance. The course was project-based; students "presented" their projects on the web, then led web-based discussions about their work for the subsequent week. NetMeeting, a computer-based conferencing tool with video, audio, and application sharing features, was used to experiment with real-time, synchronous class discussions at designated "lecture times" employing . The final lecture of the course was a face-to-face seminar, where students presented and discussed their work in a conference-like setting.

Technology Tools

The experiments employed several technological tools to facilitate online course delivery: WebCT, electronic mail, a list server, and Microsoft NetMeeting. Although the course material already existed as web pages, WebCT was chosen as the web-based software tool to support the dissemination of course related information. WebCT offers encapsulation and paths through the existing course content, student presentation areas for groups, individual tools for note-making, and a chat facility for synchronous, online discussions. It was the preferred choice for a number of reasons, including free testing of WebCT with full functionality, inexpensive licenses, a large customer base, proximity of developers, ease of access via common web-browsers, and ease of customization (if needed).

An extensive summary of our evaluation of WebCTs features is available online [6]. In brief, WebCT is designed for non-technical faculty who are new to creating web-based documents. We found that the WebCT designer interface often hampered the HTML-knowledgeable instructor's efficiency in building and maintaining the course material. For example, sequencing course materials requires the designer to set up a "path", which involves a number of intermediate steps that would not be required if the designer was using only HTML. However, for an instructor who is new to creating web-based documents, the structure and tool set offered by WebCT provide valuable supports as they construct course materials.

SERN courses have been developed within an open architecture philosophy and the belief that there should be public access to past and present course materials and stu-

dent work. Inherent to the design of WebCT (and most web-based distance education tools) is a closed architecture philosophy — courses are password protected, and information in courses is not easily accessible to the general public. WebCT's student tools, in particular note-making and group presentation areas, offer useful tools for online courses. The email and chat facilities in WebCT were not used for either course; an external, publicly accessible list server remained in use. The Software Engineering courses share a common list server that allows the students to enjoy input from students in other courses, former students and industry partners who subscribe to the list. An advantage of the list server is that each message is delivered to subscribers, as opposed to the student having to seek out the postings of others by accessing a separate web page "discussion list", threaded discussion or newsgroup, or bulletin board.

The SERN list server proved to be an important communications element in both courses. The instructors were participant observers on the list server, rather than active and directive moderators (except when students appeared to be involved in a non-productive debate or required expert advice). Microsoft NetMeeting was used as a substitute for face-to-face class discussions in the second course. The instructor and students participated in weekly discussions about course topics using a version of NetMeeting running on a local server. The students were highly critical of these sessions and unanimously preferred the list server for discussions. It seems possible to refine and improve the use of NetMeeting for interactive, real-time discussions for an online course by correcting the identified deficiencies (i.e., establish discussion rules, appoint weekly student moderators, and upgrading software).

Evaluation of Distance Learning Environments

The evaluation goals in this project were to describe the nature of the educational experiences and outcomes in the distance learning environments, in the first instance to compare the distance learning environment to the traditional classroom, and determine those conditions associated with what worked well and what did not. To that end, students were asked to submit weekly learning logs in which they recorded three types of information:

- reflections on the outcomes of each lecture/sessions
- notes on what worked particularly well, and what did not
- time spent on various course-related tasks

The learning logs proved to be a rich data source from which students could conduct a comprehensive review and analysis of their personal learning experience in the course. The use of open-ended questions allowed students provide feedback in their own words on the nature of their learning experience. The questions provided an opportunity for students to highlight any ideas, concerns, problems, or suggestions which they considered of relevance to teaching and learning at a distance. The student workload cost to complete the learning log task was at least 0.5 hours per week, with some students reporting they spent 1.0 hours over the week writing their learning log.

The weekly learning logs were a valuable formative evaluation of the course that enabled us to learn about problems, omissions, concerns, and student needs as they occurred, rather than waiting to find out from a summative, end of course evaluation. Consequently, of the weekly feedback from each student, we were able to refine and improve the course materials on WebCT, respond to technical difficulties, and address concerns immediately, which enabled us to better meet student needs.

Weekly time estimates for course-related tasks were calculated using data from weekly learning logs as shown in Figure 1. Local students reported spending a larger proportion of their time in the classroom, reading course material, and conducting online research and reading documents online. Distance students report spending slightly more time on chapter summaries, and a large proportion of their time interacting using email and the list server, constructing and transferring HTML documents, and meeting with their group to work on projects. Surprisingly, local and distance students spent a similar number of hours per week on average for all course-related tasks (Figure 1). This finding contradicts the distance students' perception that they spent more time overall than local students on course-related requirements. An explanation for this difference in perception may be found in how local and distance students spent their time on various tasks.

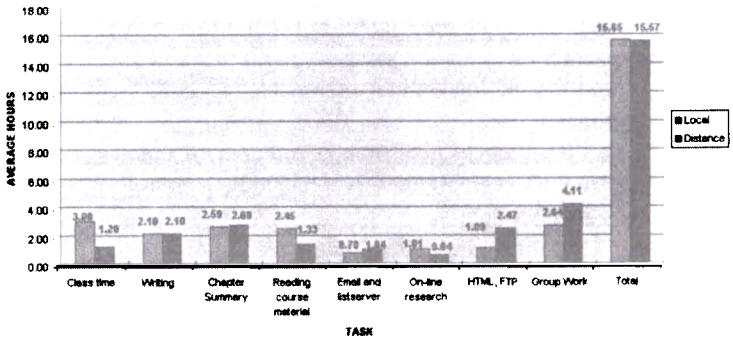

Figure 1. Percent of Total Time Local and Distance Students Spent on Various Tasks (including class time) in SENG 611, Requirements Engineering.

Recommendations Based on Lessons Learned

We will continue to refine and improve our methods for offering courses at a distance. In the form of recommendations for research methods and educational practice, we present some lessons learned from these experiments with a distance education model.

Mechanisms and support systems need to be put in place that allow for cyclical and iterative development and assess-

ment of distance learning environments. Tolerance has to be built into the system for time lags, unexpected barriers, and longer course development periods. Distance education environments and new technological tools constitute a major change in some people's lives. Such change does not happen quickly or easily. Even in the best of circumstances, teachers and students need high levels of support, training, and access to technology. The instructors for both courses spent a significant amount of additional time on the distance courses than would have been required for classroom-based courses. In addition to the instructors, several other specialized individuals provided on-going technical support, instructional design and development, and evaluation and assessment for the distance courses. Therefore, it is recommended that more instructor/design time be allocated for initial distance course offerings. Technical support and help with the technology will be needed if the instructor is not completely familiar with the tools used to support online course delivery.

While computer networking can open up possibilities for teaching and learning at a distance, care should be taken to make sure that the chosen technology fits the core values and goals of the program, and not the other way around. The technology tools used in the present experiment were evaluated based upon the fit between core learning objectives and program requirements, rather than designing courses based upon what affordability and constraints were inherent in the technology. For example, a number of WebCT's features and built-in tools were not applicable to graduate courses, and therefore were not used.

Distance students require very explicit, well-organized, and well-indexed web materials and resources. It is important to structure carefully the entire course before it starts and to be faithful to that structure throughout the course to provide distance students with a stable context in which to learn. We are currently investigating instructional strategies that provide a balance between carefully structured and defined course design, and responsive, flexible learning environments.

Conclusion

This article has described some of the main features of the first two distance-based courses in the masters program with a specialization in software engineering targeted on students with industrial experience in full-time employment. The program is one activity of the Software Engineering Research Network, which is funded by industry and administered by the Industrial Software Engineering Chair at the University of Calgary to support the dissemination of good practice in software engineering. We are involved in extending the approach reported in this paper to support professional development and lifelong learning in software engineering.

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Internet Access

Further information about SERN can be found at its web site: <http://sern.ucalgary.ca>. The SE MSc course material is also linked from there:
<http://sern.ucalgary.ca/courses/SENG/611/F98/> and
<http://sern.ucalgary.ca/courses/SENG/609.04/W99/ > .

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