Experiences in Collaborative Distributed Learning across Geographies and Heterogeneous Student Populations in a Graduate Engineering Course

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Abstract*

The primary challenge in distance and distributed education lies not in the choice of technology for content delivery, but rather in building an effective learning community. We contend that this is done most effectively by combining both synchronous and asynchronous methods. This paper describes the author's experience in teaching a graduate course to a heterogeneous student population and the results we obtained in encouraging students to work across geographical boundaries. In this course, we adopted an approach of strongly encouraging interaction during and after lecture and requiring students to collaborate in geographically dispersed groups, utilizing the appropriate technologies to enable this collaboration. The paper describes students' reactions and lessons learned regarding the use of technology in course delivery and collaboration across geographies.

Keywords:
Distance learning, asynchronous education, group activities, graduate education

I. Introduction

It is well known that distance delivery of courses imposes additional logistics for distribution of assignments, grading, proctoring of exams, general communications, etc. (see, for instance, Crossman,1997). Yet, overcoming these logistical issues is by itself insufficient to ensure the success of a course. The real challenge resides in building an effective learning community. Flugrad *et al.* (2000) suggest some techniques for achieving this in a distributed learning environment.

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This paper describes the author's experience in teaching a graduate course to a heterogeneous student population and the results we obtained in encouraging students to work across geographical boundaries. In this course, we adopted an approach of strongly encouraging interaction during and after lecture and requiring students to collaborate in geographically dispersed groups, utilizing the appropriate technologies to enable this collaboration. In the next sections, we will discuss our experience, students' reactions and the main lessons learned.

II. Synchronous and Asynchronous Methods

In recent years, numerous models (Bourne, 1997) have been proposed for incorporating asynchronous methods into engineering education. Such methods nowadays rely heavily on the World Wide Web for dissemination of content as well as for interactions among students and with the instructor. Potential advantages include better tailoring of content delivery to diverse learning styles, anytime/anywhere learning, and the availability of a variety of tools for presenting information, including videos, animation, guided exercises, etc.

Asynchronous methods are particularly appropriate to address the growing demand for continuing education. The rapid pace at which technology evolves requires constant re-learning in most engineering disciplines, and universities are increasingly addressing this need through graduate programs directed at part-time students, certificate programs, short courses, etc. This non-traditional student population is often geographically dispersed (especially as compared to traditional students organized around a university campus), has clear learning objectives that relate to their perceived opportunity for advancing their careers, and faces strong demands on their time due to job-related activities. The geographic distribution and time issues in particular can be mitigated by asynchronous, web-based course delivery.

One important question is whether we can realize the benefits of asynchronous education while maintaining some of the important characteristics of traditional,

synchronous delivery, such as live interaction among students and with the instructor. Anecdotal evidence seems to indicate that many students value the option of learning on their own time and place but still would like to preserve occasional synchronous contact with colleagues and instructor. When such interaction is not feasible to be conducted in person, chat rooms and web-based videoconference provide alternative methods for synchronous discussion.

A combination of synchronous and asynchronous methods arises as a possible compromise. Lectures can be conducted synchronously, streamed live over the Web and stored for asynchronous viewing. Office hours can be conducted using readily available web-based chat software with audio and document-sharing capabilities. These can be augmented by threaded discussion, email and digital drop boxes to support asynchronous discussion and collaboration.

A number of questions arise in such a mixed (synchronous/asynchronous) environment, among which:

- Does the availability of lectures for streaming over the web result in decreased attendance by traditional (on campus) students to the live lectures?
- Do students who only have access to the asynchronous aspects of the course perform any differently from those who participate in synchronous activities?
- Are there ways to encourage both groups of students (traditional on-campus students and part-time off-campus students) to collaborate? Are there any benefits from doing so?

We address these questions through a case study, in which we describe our experience in teaching a graduate course in Computer Engineering to two distinct populations of students using the mechanisms mentioned above. The mix of traditional full-time and part-time students, who typically held full time jobs, provided a unique opportunity. It has been observed (Prusak, 1999) that this type of population mix can enhance the overall learning experience, with each group contributing with its own strengths. Non-traditional students typically bring a higher level of maturity, work ethic, and in-depth knowledge of

practical implications of the subject; full-time students tend to have fewer time constraints and therefore are better able to focus on the tasks at hand, and are generally more familiar with theoretical and analytical methods. The risk exists, however, that when both on-campus and remote students are present in the same course, one of the groups may feel disenfranchised and therefore have a much less positive view of the overall course than the other group, as reported by Lewis (1997). The challenge is to take advantage of the potential for mutual learning among the entire student population while minimizing any resentment about the extra level of effort required to overcome the additional obstacles. In an attempt to maximize interaction between the two groups (which were, for the most part, geographically separated), the final project for this course required mixed groups, with members in multiple locations. We discuss the course further in the next section.

III. Case Study

In this section, we describe our experience in teaching a large section of a graduate course in Computer Engineering and students' reactions to the mix of synchronous and asynchronous techniques and to collaboration among students in various locations.

III.A. The Course

The course being discussed here is a graduate-level course on computer networks that can satisfy degree requirements for the Electrical Engineering, Computer Engineering, Computer Science, and Information Technology programs, among others. A total of 149 graduate students were enrolled in one section of this course. The student population consisted of a heterogeneous mix of traditional full-time students, government and industry professionals and active-duty military personnel; they had the opportunity to attend lectures in real time from eight locations throughout Virginia. The main concentration of students occurred at Virginia Tech's main campus in Blacksburg, VA (64%) and at Virginia Tech's Northern Virginia Center (25%), with the other six locations making up the remaining 11%. We can roughly classify students into two groups: full-

time students (mostly on the main campus) and part-time students (mostly at remote locations). The exact geographical dispersion of students is shown in Figure 1. The student population mix was approximately 73% full-time students to 27% part-time.

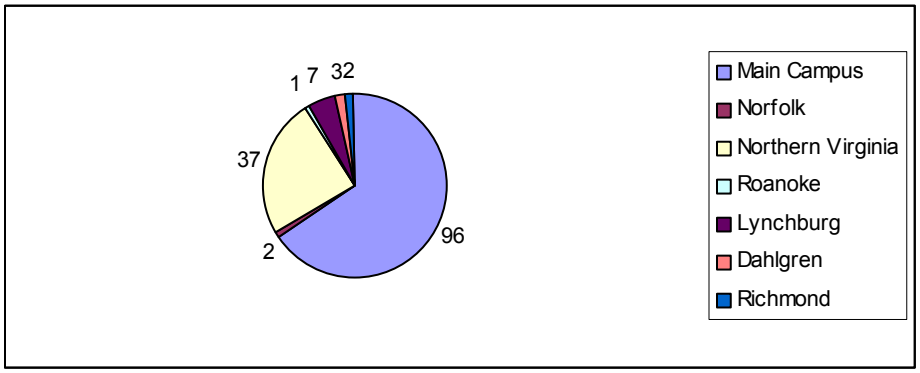

Figure 1 - Geographic distribution of student population for the course.

The unusually large number of students for a graduate level course prompted us to look for new ways to support content delivery and collaboration. It also provided the opportunity to assess the effectiveness of these methods on a statistically significant population. The primary mode of delivery was real-time two-way video, allowing students to interact live with the instructor from any of the locations. All lectures are also tape recorded, with tapes made available at the library at some of the locations. In addition, all lectures were also available via streaming video live on the web; the streaming video was archived and could be accessed at any time by all students.

IIII.B. Attendance

One question to be asked is whether the availability of alternate delivery mechanisms causes any decrease in attendance to live lectures. In other words, did the fact that students had access to lecture in both synchronous (live streaming video on the web) and asynchronous (archived streaming video, video tapes in the library) form decrease the likelihood or their coming to class?

There was no noticeable decrease in attendance as compared to our experiences in teaching other (fully synchronous) sections of the same course. Although roll call was not taken and attendance was not mandatory, 79.7% of the students reported attending 80 to 100% of the lectures live, 15.7% reported attending 50 to 80% of the lectures, and only 4.6% reported attending fewer than half of the lectures. Although it is difficult to assess the reliability of self-reporting on this question, these results seem consistent with informal observation.

III.C. Collaboration Requirements

Collaboration among geographically distributed coworkers is increasingly common in industry, and it requires specific skills: communication at a distance, without the aid of informal cues provided by personal contact; development of a consensus for the distribution of responsibilities; emergence of group leadership. An important component of this course was a final research project carried out in groups of seven to ten students; all groups had participants at multiple locations. A different topic was assigned to each group, and the group was asked to develop a single, cohesive set of web pages relating to the topic. These typically contained a collection of student-developed HTML pages and tutorials, annotated list of useful links, simulation interfaces, etc. Each group had access to a set of resources for distance collaboration, including email lists, shared folder capabilities, threaded discussion, a chat area and a web-based audio conferencing tool with whiteboard capabilities. These resources were accessible by the group members only. Students were challenged to use these in order to effectively replace in-person group activities that were precluded by the distributed character of the project.

III.D. Student Feedback

Students in the course were asked to complete a survey, meant to assess reactions to the delivery mode for the class as well as to the distributed nature of the final project. Numerical results presented in this paper are taken from that survey; subjective

feedback was obtained both from comments to various questions in the survey as well as from informal discussions with students during and after the course.

The survey was web-based and available to all students during the week prior to the end of classes. Participation was voluntary and anonymous; a small incentive for participation was provided in the form of a modest amount of extra credit (a list of students who participated in the survey was provided to the instructor, without any links to individual responses). Return rate on the survey was 96.6%, providing high confidence that the opinions of this group of students were well represented. The return rate compares very favorably to those reported in similar surveys of students' perception of asynchronous learning methods (Finkelstein, 1998).

The survey had two main groups of questions: one dealt with the technology used in the course delivery and the other with experiences in distributed group collaboration. The next two sections discuss the lessons learned on each count.

IV. Lessons learned

The delivery of this course employed a number of synchronous and asynchronous methods: traditional live lectures, live streaming video of the lectures on the web, VHS tapes of the lectures available from the library, archived streaming video of all lectures, a very active listserv, online posting of all notes, assignments and solutions.

Both full and part time students attributed great value to the web-based video streaming of the lectures, used both to make up for missed lectures and for the purpose of reviewing key concepts. Whenever they missed classes, most students reported using video streaming as a substitute, as shown in Figure 2. In a separate question on the survey, students were asked whether they referred back to the streaming video to review or consolidate concepts, even when they had been present during lecture: 58% of students reported they did.

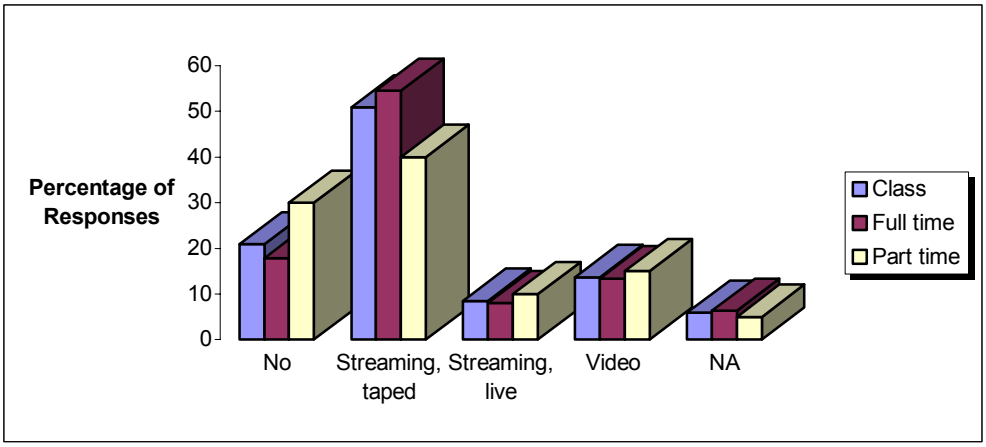

Figure 2 - Responses to the survey question: "Whenever you did NOT attend lecture, did you watch the taped lecture or the streaming video on the web?" Students who attended all lectures chose the "Not Applicable" category.

Our original expectation was that part-time students would be the primary audience for lectures on streaming video. Several of the off-campus students told the instructor that they received the lectures through the web while away on business trips. Somewhat surprisingly, the survey indicates that full-time students made use of some of these resources even more frequently than part-time students, mostly for review of topics discussed in class.

Several asynchronous mechanisms were used for communication between the instructor and the teaching assistants and the students. These included:

- Course web site - contained all lecture slides, homework assignments and solutions, project assignments, previous and current exams and solutions, and links to other resources;
- Online grade book - contained individual grades for homework assignments, projects and exams;
- Listserv - was extensively used for general announcements, answering questions about lecture content and homework problems;

- Email - there was no limitation on the number or frequency of email messages the students were allowed to send to the instructor. This was the preferred method for addressing specific technical questions, administrative procedures, discussion of individual grades, etc.

It was clear from the results of the survey as well as from informal feedback that students valued each of these aspects of the course. Their view of the usefulness of each of these mechanisms is shown in Figure 3.

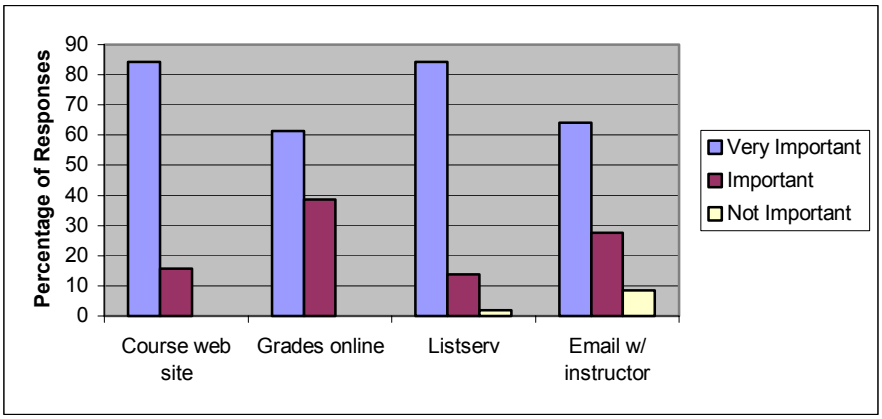

Figure 3 - Students' responses to asynchronous technologies used in the course.

Students were required to participate in a semester-long group project, accounting for approximately one-third of the final grade. The instructor assigned groups of seven to ten students; by design, each of these groups included students in multiple locations. The stated learning objectives associated with the final project included both technical (to further students' understanding of topics in computer networks) and non-technical (to increase interaction between full and part-time students, to hone skills in distributed collaboration) objectives.

Full-time and part-time students exhibited markedly different attitudes regarding group projects. As shown in Figure 4, on-campus students clearly preferred group work to individual projects, while the reverse was true for off-campus students. Two main factors can explain off-campus students' reluctance towards group projects: very

constrained work schedules make it more difficult for part-time students to handle the overhead involved in group work (scheduled meetings, coordination, division of tasks, etc.); and since off-campus students were the minority in all groups, some felt they had little control on decisions.

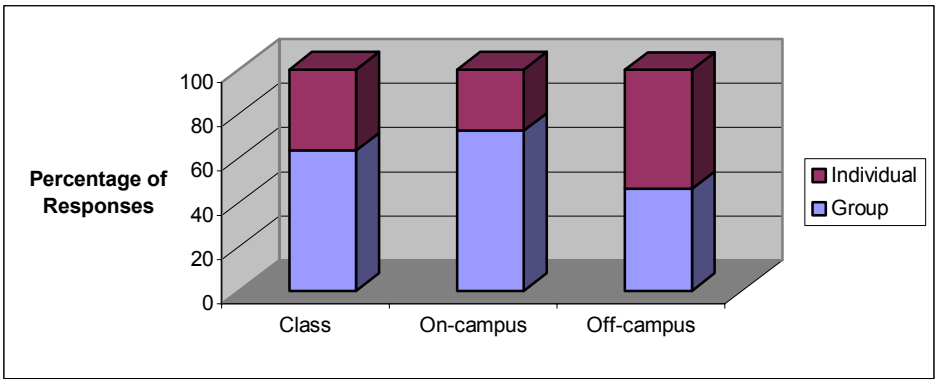

Figure 4 - Students' preferences for group versus individual project work.

There was consensus regarding the idea that students would be likely to encounter this type of distributed group collaboration in their future professional lives. When asked whether they expected to face this type of work in the future, 88.4% of students responded that would be very likely or somewhat likely, 11% responded that would be somewhat unlikely, and a single student believed it was very unlikely.

There is no question that this type of group work imposes new challenges to students. These were large groups that ultimately had to produce a seamless web-based resource; there was the need for careful planning and integration of content produced by multiple students. Nevertheless, the majority of students felt they were able to work well in a group (Figure 5a).

Each student was asked what was the biggest obstacle they faced in completing the project. The distributed nature of the work was the most common response, closely followed by lack of communications among group members. A small percentage of the class referred to inappropriateness of the tools for distributed collaboration as the biggest obstacle (most of the tools used were well received; however, it was clear from

student feedback that the chat tool adopted did not live up to expectations). The breakdown of responses is shown in Figure 5b.

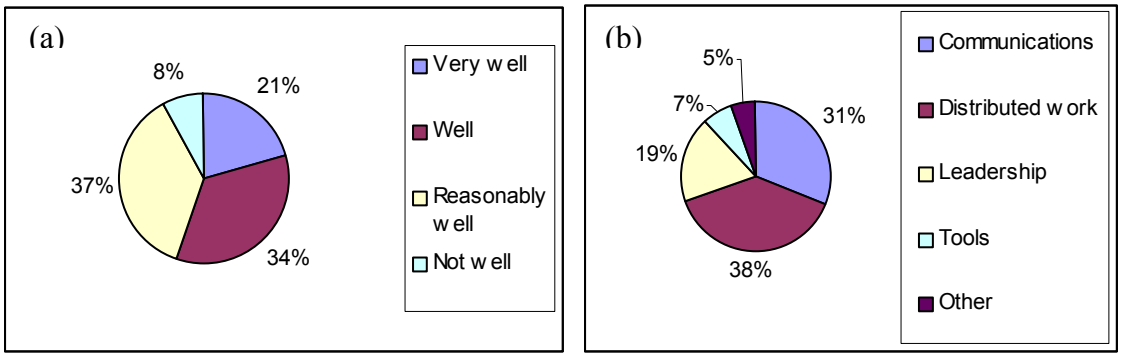

Figure 5 - (a) Students' impressions of how well they worked in a group; (b) biggest obstacle for their group work.

We encouraged students to comment on any difficulties they may have encountered in the project. We found that these free-form comments were split more or less evenly between difficulties due to the distributed nature of the project and difficulties that are likely to arise in any group endeavor, even in a more traditional classroom setting. Examples of the former included difficulties created by psychological distance among group members, which made it harder in some instances for leadership and a strong sense of motivation to emerge; examples of the latter include challenges in coordinating schedules for a large number of group members and difficulty in gaining familiarity with the subject.

As for what worked in communications among group members, the lesson was to "keep it simple." Plain old electronic mail appears to have been the most useful tool for communications, followed by in-person meetings at each site (see Figure 6). We believe a more robust chat tool would have helped, although with large groups and heterogeneous student profiles scheduling for any real-time activity becomes a major obstacle.

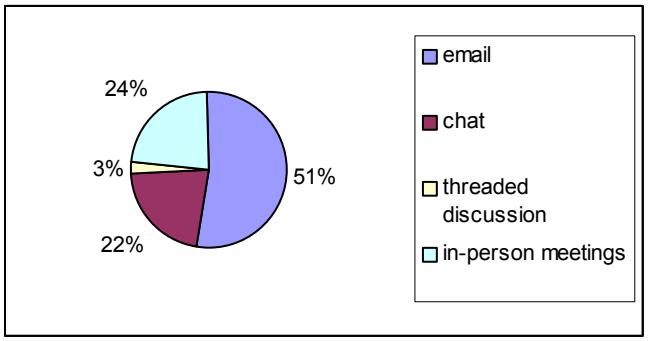

Figure 6 - Responses to the question: " Which of the following was the most useful for group communications?"

Although the instructor assigned students to each group, there was no instructor interference in how each group managed its work. In particular, no group leader was explicitly appointed. According to students, in most cases (56%) group members shared duties evenly, while in 29% of cases a clear group leader emerged and in 15% of cases there was one group leader in each location.

When asked whether they felt they played an integral part in all group decisions, 82% of the students responded that they did. However, these responses did show strong correlation to geographical location: only 11% of students on the main campus felt left out of the decision making process, compared to 35% of students in other locations. These results are consistent with informal interaction with the groups throughout the semester: since most off-campus students were in the minority in their groups, they sometimes felt they had little influence on group decisions. In the few instances when the instructor was asked to intercede, it was to resolve disputes between on-campus and off-campus students in the same group. In many of these cases, a few comments from the instructor via email or in class was enough to attenuate the polarization between sites; however, we suspect that in some groups the "us versus them" mentality persisted. Clearly, this kind polarization is undesirable; it is, however, not unusual in professional group endeavors (for instance, between headquarters and remote sites of a company, among partnering companies, among different departments in the same company, etc.).

We recognize that the distributed collaboration in this classroom set-up does not mirror exactly the types of distributed work that often take place in the industry. In industry, it is likely that the group members (or, at the very least, leaders from each location) would occasionally meet and interact in person. In order to at least partially make up for this, we reserved the first half hour of one of the lectures for brief introductions from each of the students; it was the first time that some of the students saw some of their group mates, some of whom lived and worked two hundred and fifty miles apart. The experiment was well received by the majority, and it was well worth the time. In the future, as web-based video conferencing becomes more widely available, it will fulfill the role of allowing group members to be able to associate faces to the names of their colleagues.

The survey results indicate an overwhelmingly positive overall experience with the group project, as indicated in Figure 7. This is a very encouraging result, given the additional obstacles that had to be overcome by students likely translated into additional hours spent on the project. The outcome of most projects was quite impressive: web sites created by the groups looked professional, material was well integrated and exhibited both breadth and depth of knowledge.

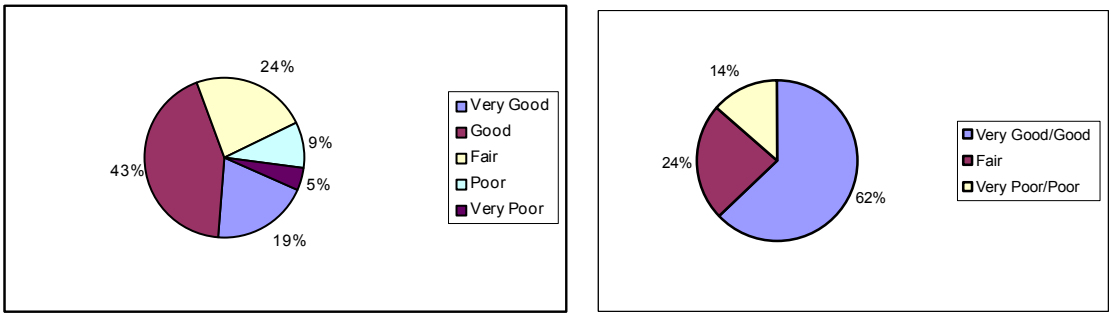

Figure 7 - Student perceptions of how well they were able to work in groups.

V. Discussion and Concluding Remarks

The primary challenge in distance and distributed education lies not in the choice of technology for content delivery, but rather in building an effective learning community. It is our view that this can be done most effectively by combining both synchronous and asynchronous methods. The ubiquity of access to the Web (often through high-speed connections) and ready access to software such as chat servers and collaboration tools are making this possible. It has been our experience that, when both synchronous and asynchronous methods are adopted, the asynchronous delivery mechanisms tend to complement, rather than substitute for, the synchronous ones. In particular, we saw no noticeable decrease in attendance to the live lectures.

In our experience, students embraced the wide range of technologies made available with very little need for guidance as to how to employ the technology. It must be said that this was a very computer-literate group of students, mostly composed of graduate students in Computer Engineering, Electrical Engineering and Computer Science. As such, they are likely to be more receptive of new technologies than some students in other disciplines.

When a course includes a mixed student population, both on-campus and off-campus students are often asked to adapt to the distance learning model. On-campus students typically have to sit through longer, once-a-week lectures and have less access to the instructor during in-person office hours; off-campus students have to coordinate schedules with those on-campus for synchronous group activities. In addition to the course described in this paper, the author taught courses in this format in the fall of 2001 and spring of 2002. In all cases, students emerged with an overall positive view of the course, as reflected by informal feedback and formal student evaluation of the course. We believe the key is that students see some value in interactions across the two groups, which make up for the extra effort required.

We believe that the variety of opportunities for interaction among students and with the instructor helped mitigate the feelings of psychological distance that are sometimes associated with distance education. The instructor, while primarily located in Northern Virginia, lectured from and held office hours at the main campus about 25% of the time. Questions and answers during lecture were actively encouraged and, with time, students seemed to become more confident with the technology and with the prospect of asking a question "on TV." And finally, the distributed group work requirement forced all to expand their horizons beyond their locality. This is not to say that all obstacles have been conquered, but the increase of interactions is a move in the positive direction for both learning outcomes and student perception of the value of the course.

Now, if given a choice, would students *choose* to work in geographically distributed groups? This is unlikely: the perceived and actual challenges intrinsic to this type of work are still large enough that students would prefer to work in co-located groups. As technology progresses, we will be able to more efficiently incorporate increased collaboration among remote students and between those and students on-campus. We strongly believe that both groups have much to gain from such interaction, resulting in a much richer education experience.

VI. Acknowledgements

The author would like to thank Mark Raby, at IDDL, for his invaluable help with the numerous distance learning tools needed to support this course. One hundred and forty-nine thanks are also in order for the students who took the course: their feedback and understanding as we all learned our way were fundamental to the success of the course.

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