Teaching Introduction to Geographic Information Systems, Including Laboratory Sessions, using a Combination of Distance Learning and Distance Teaching Techniques.

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Abstract

The primary objective of this project was to teach sophomore engineering students the fundamental concepts of geographic information systems (GIS), but with the teacher and students in different locations.

Introduction to Geographic Information Systems is a 2 credit half semester course with 6 contact hours including 3 hours of laboratory work. At a weekly scheduled time and place, the students asembled to listen to a 1 hour pre-recorded (with audio) PowerPoint lecture. The lecture was followed by a 15 minute chat session, featuring live audio/video, to answer questions and clarify concepts. Homework and laboratory reports were completed by the students outside the class room, on their own time, and submitted to the instructor via e-mail, graded and returned the same way. Blackboard, e-mail, and the telephone were used as communication devices.

Analysis of homework and lab grades indicates that 3 out of 4 course objectives (see figure 1) were comfortably met. Grades associated with the fourth objective, involving a term project, showed that the attainment of objective 4 was uncertain. The students indicated that breaking down the term project into manageable parts would have been helpful. Overall, considering student and instructor evaluations, considerable learning did take place.

Introduction

The primary objective of this project was to create a distance learning course module to teach undergraduate engineering students the fundamental concepts of geographic information systems (GIS). A GIS can be defined as "A fundamental set of automated ideas and concepts rooted in over 2500 years of exploration and geographic research, and designed to provide the answers to questions based on mapped data."[1] A secondary, but important objective, involved the preparation and delivery of this course as a learning laboratory for future distance learning endeavors. With the exception of this course, the University of Hartford's College of Engineering, Technology and Architecture (CETA) has no course that qualifies as a distance learning course. This is not to suggest that every course the College offers should be set up in a distance learning mode. In fact, there are probably only a few courses that can, or should, be offered in that format at this time. That is why the College needed to experiment with this new

form of course delivery, and then determine where or indeed if, the results should be extended to other courses.

The backbone of any distance learning course is the Internet. "The Internet has already become an integral part of much of society. This system has revolutionized journalism (due to online up-to-the-minute news), science (because of the capacity for global cooperative research), publishing (because of the ease with which anyone can publish their ideas) and many other fields. These activities deal with and disseminate truly powerful content. This is where the Internet has its real and lasting value, and why it will continue to grow, develop, and become even more ensconced in society. Geographic Information Systems (GIS) have the potential to be one of these fields ….. Many extraordinary systems have already been built, and over the next few years, an increasing number of GIS applications will go on line"[2]. It is not surprising that GIS would be compatible with the Internet, since all of the data is digital in nature, and easily displayed in visual form. Thus, the course material is already in a format amenable to distance learning.

The Civil and Environmental Engineering Department recognized early on the symbiotic relationship between the Internet and GIS instruction and use. In 1997, under a NSF grant, a web site to aid in the teaching of GIS was developed. The site was named GATE (Geospatial Analysis, Technology and Education - URL - uhaweb.hartford.edu/GATE). In the spring of 1997, the first course to appear on GATE was "Introduction to Geospatial Analysis"[3]. This course was collaboratively taught by Dr. Daniel Civco from the Department of Natural Resources Management and Engineering at The University of Connecticut, and Professor Donald Leone from the College of Engineering at the University of Hartford. The course was delivered using Interactive Compressed Video which required highly specialized video and audio equipment located in a permanent, non-mobile location. The rest of the course mechanics was handled in the traditional manner.

In the fall of 1998, "Introduction Geographic Information Systems", a required course for all Civil Engineering sophomores, was added to GATE. The course involved lab assignments and culminated with a final project involving a local timely problem[4]. The lectures were delivered in the traditional in-class lecture format using a PowerPoint presentation. Students had homework problems assigned out of the GIS text and the answers to these homework assignments were submitted over the internet to the GATE site for grading. The students also were required to come to the GIS computer laboratory to complete their lab assignments which were submitted to GATE. The lab reports and homework assignments were printed out, graded and returned to the students in conventional manner. The reason that the students had to come to the computer lab to complete their labs and term project was that the software to perform GIS analyses was not available to them except as an individual purchase at $2,500. This is an important constraint that has recently been removed – an important factor that will be discussed later.

As noted above, prior to the present project, there has been a great deal of work done regarding the two main components of distance learning – delivery of lectures from a remote site, (either synchronously or asynchronously) and the submission and grading of course work via the Internet.

With the retirement of Professor Leone to Florida, an opportunity presented itself for the distanced teaching of Introduction of GIS. CETA funded the development effort which eventually lead to the distance learning version of Introduction to GIS that was offered for the first time in the Fall 2002 semester. This paper outlines the development and offering of the course.

Discussion

The project was divided into three phases: Phase 1 - The Research Phase, Phase 2 - The Implementation Phase, and Phase 3 - The Course Delivery Phase.

Phase 1 – The Research Phase

The objectives of the research phase were: 1) to define the hardware and software to be used to deliver the course; 2) identify the way in which student work is submitted, graded and returned; and 3) establish communications channels.

1. For objective 1 (to define the hardware and software to be used to deliver the course) there were several delivery modes considered:
    - No lectures or face to face meetings - all correspondence and reading material delivered over the Internet (University of Phoenix Model). This is the format used by the University of Phoenix (which is said to have 50,000 students). The University of Phoenix has an extensive internet support staff and infrastructure. Wide use is made of bulletin boards to facilitate correspondence between the students and the instructor and between students – especially on team projects. There is no audio or video correspondence, i.e. there is no real time or taped audio/video correspondence between the student and the teacher, or between the students. Work is submitted and graded via the Internet.
    - Live broadcasting of presentations - Specialty hardware/software systems such as Eluminate and vClass for instance, allow live broadcasting of presentations (audio and video of the presenter) including PowerPoint slides, a live whiteboard, and live interaction with the slides by the instructor (pointing to some feature on a slide, drawing on a whiteboard etc.). The software is essentially portal software that is loaded onto a dedicated server so that many clients can access the presentation simultaneously. This is by far the system that comes closest to replicating a live classroom presentation; however it's the most expensive. Another less expensive way to deliver material involves the use of the telephone to receive the live broadcast audio. Microsoft's Office Live Meeting, Citrix Corporation's GoToMeeting, Conference Depot, or WebEx, can operate in this mode.
    - Lectures broadcast using Microsoft's free software – NetMeeting. The NetMeeting system, which has been around for a few years and is no longer actively supported by Microsoft, requires inexpensive web cams and speakers and has the capability to project a whiteboard and share applications from both remote locations. Because of limitations, it is really not suitable for lengthy sessions (~ 1

hour) because it uses the Internet exclusively and because of out dated technology, it is prone to gaps and breakdowns and loss of coherence between the video and audio. Performance is better if only audio is broadcast and high speed Internet connections are used. NetMeeting also does not have audience polling or quizzing capabilities.

It should be noted that commercial software, Eluminate and vClass were not prone to the transmission problems of NetMeeting, and did allow for the live testing or polling of students. Multiple choice, T or F, or yes or no answers were entered by the students and immediately graded with instant statistics about how many got the answer, etc. This testing is usually interjected only once or twice, but it does have the effect of keeping the attendees alert.

2. The second objective (the way in which student work is submitted, graded and returned) could be met with several software and organizational possibilities:
   - Students type their answers to lab and homework questions in form boxes on the GATE site. The graded e-mails are returned to the student via e-mail. This elective would require significant web site development.
   - Students type their answers in a WORD document. Submission and graded results are handled by e-mail.
   - Quizzes and tests could be handled the same way as the homework. Verification that the work was that of the individual students' would be difficult.
   - Quizzes and tests could be administered by a "Proctor" at a designated place, forwarded to the instructor, and returned to the students via e-mail.
   - Conduct no quizzes or tests.

3. To satisfy objective three (establish communications channels):
   - Use the University of Phoenix model – all e-mail.
   - Use the features of Blackboard (Announcements, grade posting, live chats, etc)
   - Use the GATE web site.
   - Use the telephone system.
   - Use the Internet to transmit audio/video.
   - Use a combination of any or all of the above.

4. System Selection: At the end of the Research Phase, a decision was made as to the integrated system to be used. Since the project had little or no funds allocated for purchasing hardware or software, customizing a system using inexpensive or free software became the overriding issue. Fortunately, the new PowerPoint in Office 2000 allows for both audio and video inputs synced to the PowerPoint slides automatically. However, if both audio and video are added to the conventional PowerPoint slides, the files become quite large. Since the video for this class is essentially that of a talking head, which adds the least stimulus to a technical lecture of this kind, the initial lectures were planned with audio only. While the audio is automatically synced to the slides, you cannot annotate or physically interact with the slides in a spontaneous manner as in the Eluminate or vClass systems. However, with PowerPoint, you can broadcast live or place the presentation on file for later viewing. Because of the uncertainties and vagaries

of a live Internet broadcast, it was decided to pre-record the PowerPoint lectures with audio and play them for the students who would assemble in a common place.

It was envisioned that after the pre recorded PowerPoint with audio only lecture was played, a short live NetMeeting video/audio session would be held to answer any questions, conduct course housekeeping, and for the instructor to ask questions pertaining to the presentation. Because of budgetary constraints, NetMeeting was selected since it is much better at short "face to face" meetings, and if communications were lost, no great harm would be done.

Blackboard, which has all of the course management tools, live chat, bulletin board, and grade posting capabilities, was selected as the way to communicate with the students outside the lecture. It was also helpful that the University uses Blackboard extensively.

The GATE website would be used to supply course details such as syllabi, procedures, lab setups, etc.

The net effect is a ***blended*** approach to distance learning. The students assembled once a week, for about an hour, to commune and get a chance to interact live with the instructor. The rest of the time for this four credit course, the students will be free to complete and submit their work at their own pace, as long as stringent submission schedules are met.

Phase 2 – The Implementation Phase

The course objectives were formulated as follows: Upon completion of this course, the student will be able to:

1. Recognize and understand basic cartography such as different projections, datums and coordinate systems.
2. Understand the basic principles of Vector and Raster GIS processes.
3. Learn how to use the GIS Software.
4. Perform a GIS analysis on a problem provided by the instructor in which data has to be obtained and processed before applying GIS processes to solve the problem.

The process of developing a course syllabus was initiated which involved the selection of a course text, and laboratory workbook. The greatest effort in this phase was directed to the development of the lecture material, laboratory exercises, and the expansion of the GATE web site. The lectures presented material generally covered in the text and lab text, but supplemented with other information.

A new second edition of the text previous used was chosen - "An Introduction to Geographical Information Systems, 2nd Ed." by Heywood, Cornelius, and Carver. This text covered the basic fundamentals of GIS without getting into the details of individual GIS software. It also had the advantage that some other GIS text did not of having discussion questions at the end of each chapter. Lecture material was based on and generally followed the text content but was liberally enriched from other sources.

Since the lectures were prerecorded using PowerPoint, there was little room for adlibbing or going off the path since they add time to the presentation and time means larger files. Also, speaking extemporaneously in a venue where the presenter is not in front of a live audience leaves the presentation slow and uninteresting in places. Because of this, and to add coherence to the presentation, it was decided to script the lectures – writing the script in a conversational/presentation style. The completed lectures were copied to a CD to be played at the predetermined time. In this way, the Internet was not involved in the presentation. However, the lecture files were placed on the GATE site for subsequent viewing by the students – preferably with a high speed Internet connection. Forming the PowerPoint slides, scripting and recording the presentation took an unexpectedly large amount of time (almost 200 hours for the five lectures), but in the end, the presentations were nearly flawless.

To keep at least a modicum of interest, about halfway through the lecture, a "Little Grey Cells" quiz was interjected. The three question quiz could be answered by yes or no, true or false, or a short answer. The quiz took no more than 45 seconds, and in the NetMeeting live session following the lecture, students were called on at random to give their answers. This created a clear and present need to stay awake during at least the first half of the lecture. According to the Homework Syllabus, students answered the homework questions from the text, and forwarded them for grading as a WORD attachment to an e-mail.

- Laboratory Text/Exercises

A totally new lab text (compared to the Fall 2002 course) was necessitated by a completely new and extensively revised version of the GIS software – ArcView - produced by Environmental Systems Research Institute – ESRI. The software was awarded to the University of Hartford as part of an ESRI grant program. It was fortuitous that the new lab text (to go along with the new software from the grant) came out when it did. The lab text "Getting to Know ArcGIS Desktop", by Ormsby et.al, and published by ESRI, included of two CD's – one containing the lab exercises, and the other containing a full blown version of the software ArcView which would last 180 days after it was installed. It should be noted that the ArcView software retails for $2500 but came free (at least for 180 days) with the $49 lab text. ***The importance of this should not go unnoticed. It meant that if a student had the proper computer configuration (which was not at all advanced), the student could replicate the GIS system set up in GIS Lab and not have to come to the University to execute the lab exercises or the term project.*** Those students, who, for some reason did not have the ability to complete the lab exercises at home, could perform the labs in the computer laboratory. Unfortunately, the text did not have assessment questions at the end of each exercise, so that review questions had to be formulated. These questions were posted on the GATE site and had to be answered and forwarded for grading as a WORD attachment to an e-mail.

- Modification of the GATE web site.

Following the format for previous courses, a web site for "Introduction to Geographic Information Systems – eLearning Version" had to be developed essentially from scratch.

Phase 1 and 2 summaries:

At the end of the research phase, the system specifications chosen were to produce a ***blended*** approach to distance learning:

- Lectures: Pre-recorded PowerPoint (with audio) - shown at a specified meeting time and place (classroom).
- Question and Answer Session: Live NetMeeting "Chat" Broadcast to/from the classroom after the lecture.
- Homework, Labs, Course Syllabus, Grading Policy, etc.: Posted on GATE web site.
- Communication (outside NetMeeting sessions): e-mail, Blackboard.

At the end of the implementation phase, the course infrastructure was in place and included:

- The lectures had been pre-recorded using PowerPoint (w/audio)
- Programming for the addition to GATE of "Introduction to Geographic Information Systems – eLearning Version" was completed, including homework assignments, laboratory procedures, and details of the Term Project.
- Materials for Blackboard were uploaded and ready.
- The course was ready for presentation.

Phase 3 - The Course Delivery Phase (see Results)

Results

The lecture portion of the course was held in a computer aided instruction class room. The students were present for about an hour to listen to the pre-recorded lecture and take part in the short live NetMeeting session following the lecture. For the rest of their time, students were required to complete their homework and laboratories on their own time and place as long as the requirements for the time and date of submission were met. It is estimated that the homework and labs required 5 to 8 hours per week of outside work. One of the major components of the course (30% of the grade) was the term project. The students had to construct and complete a project on their own, with no real detailed guidance as is given by the extraordinarily well written ESRI labs.

By allocating grades from the appropriate homework and laboratory assignments to specific course objectives, attainment of these objectives can be assessed. Data for the objectives, including objective 4 which involves the term project, can be seen in Figure 1. The data reflect the averages of the 16 mostly second year students that participated. The results are acceptable, except for Goal 4 – the term project. There were discernable problems associated with the term project:

- Computer technical and accessibility problems.
- Inability to draw a cartographic model (program plan).
- Calculation errors.
- Problems with the software that could not be replicated using e-mail.
- Poor report writing techniques.

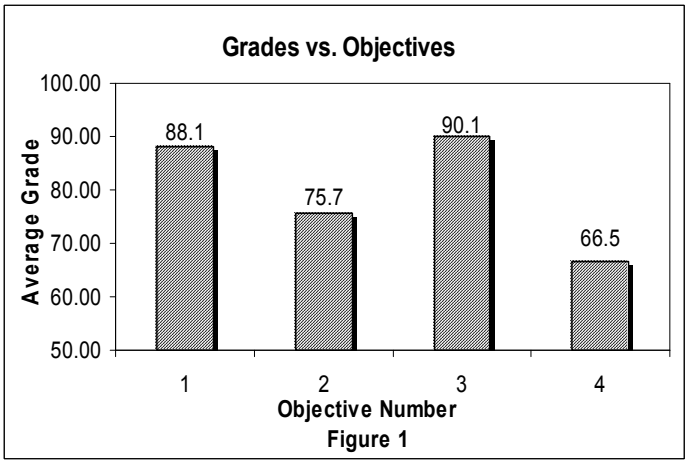

Figure 1

Course Objectives

1. Recognize and understand basic cartography such as different projections, datums and coordinate systems.
2. Understand the basic principles of Vector and Raster GIS processes.
3. Learn how to use the GIS Software.
4. Perform a GIS analysis on a problem provided by the instructor in which data has to be obtained and processed before applying GIS processes to solve the problem.

Since the final grade for the GIS portion of the course was calculated as 70% of the average of the homework and laboratory grades, plus 30% of the Tem Project grade, the relatively poor performance in the term project was somewhat ameliorated. The final GIS grades are shown in Figure 2.

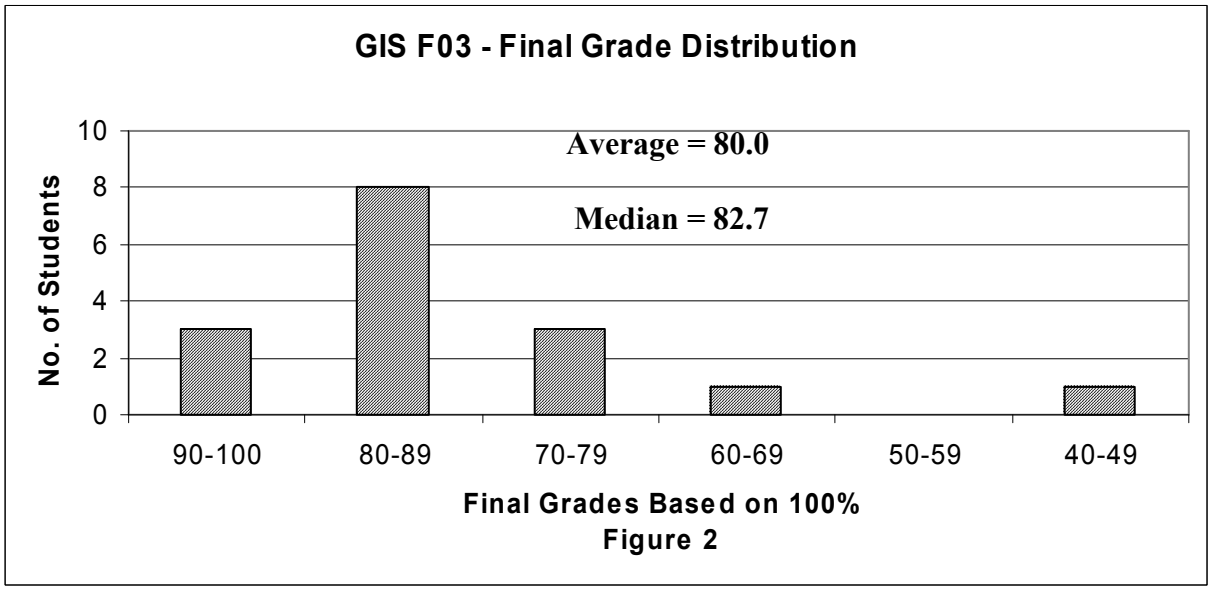

Figure 2

Comparing results with the traditional course taught in Fall 2002 in Table 1, it can be seen that although the averages are similar. the term project average is 11.5 points lower. In 2002, all the technical work on the term project was done in the GIS lab under the tutelage of the instructor. The reports were written up outside the lab. This hands-on-support and personal assistance needs to be replicated in the distance learning version.

Semester	No. of Students	Term Proj.	Homework and Labs	Average Grade
F 02	**10**	**83.2**	**81.4**	**81.7**
F 03	**16**	**71.7**	**83.7**	**80.0**

Table 1
Grade Comparison Between Traditional and Distance Learning Courses

Student assessment of the course

An assessment questionnaire was prepared and managed by Professor Susan Coleman from the Barney School of Business. Because of the experimental nature of the course, it was longer than conventional surveys (35 questions). The questions (with accompanying average scores) can be broken down into the following categories:

1) Evaluation of the Instructor **4.29**
2) Evaluation of the delivery system **3.21**
3) Assessment of course materials **4.22**
4) Assessment of attainment of course goals **4.12**
5) Assessment of course mechanics **3.65**

The answers to the questions were evaluated with the following scale:

1	2	3	4	5
Strongly Disagree	Disagree Somewhat	Neither Agree nor Disagree	Agree Somewhat	Strongly Agree

Any score of 4 or greater is considered acceptable.

Conclusions

- The ***blended*** approach to distance learning is an effective way to teach the fundamentals of Geographic Information systems.
- The goals of the course were met.
- The students were generally receptive to the course.
- Changes in the way lectures are presented, namely a change to a live narrative version (category 2), and more preparation for the term project (category 5), need to be instituted.
- Laboratory write-ups and homework assignments were completed and submitted by the students, assessed and returned, with little difficulty.
- Homework and Laboratory report grades were similar to those for the conventionally taught Fall 2002 GIS course.
- Blackboard is a highly effective way to communicate with students.
- University technical resources are needed to assist distance learning instructors. The resources may range from making sure the transmission hardware and software are

operating properly at the time of delivery, to assistance with student communications, including web site development. Students may also need assistance with their computers.

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