Leveraging the Web for Synchronous Versus Asynchronous Distance Learning

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Abstract: This paper reports on the authors' experiences in designing and teaching synchronous distance learning classes in electrical and computer engineering and in designing asynchronous distance learning classes for a graduate program in information technology. These experiences provide insight into the characteristics, benefits, and limitations of these two modes of distance learning. These characteristics imply critical pedagogical and practical issues related to the design, development, and delivery of synchronous and asynchronous distance learning classes. For any form of distance learning to be effective, teaching styles and course design must be altered, at least to some extent, from teaching styles and course design for traditional non-distance learning classroom instruction. Synchronous distance learning classes can be modeled closely after traditional classes, however effectiveness can be substantially increased through use of the World Wide Web and other Internet applications. Asynchronous distance learning classes require a substantially different model with the World Wide Web as the fundamental enabling technology. Our asynchronous course design is built around short "lectures" delivered via streaming audio and graphics. Thus, we are maintaining a lecture-centric approach to learning, but have recognized that the form of the lecture must be significantly redefined.

Keywords: web, IT education, distance education, distance learning, graduate

1. Introduction

Distance learning, in both synchronous and asynchronous modes, is presently the subject of much attention due to both a market "pull" and a technology "push." There is a large and growing population of non-traditional students seeking undergraduate and graduate courses in a variety of fields. There is particularly strong demand for courses in information technology (IT), computer science, computer engineering, and related fields by practicing professionals seeking to keep abreast of new technologies and by others wanting to change to an IT-related career. Rather than simply scaling traditional instructional models to meet this growing demand, which is difficult given relatively flat budgets in higher education and the needs of non-traditional students, universities are utilizing new enabling technologies for distance learning. One- and two-way audio and video can be delivered over satellite systems, asynchronous mode transfer (ATM) networks, and properly configured Internet Protocol (IP) networks for synchronous classes. Asynchronous classes can be delivered over the Internet using the World Wide Web and related applications to provide streaming media and other content. This paper examines these two modes of distance learning, synchronous and asynchronous, and the role that the web can play in enabling delivery and improving effectiveness. The reader should note that the insights, opinions, and findings reported in the paper are based on our personal experiences, not a general and comprehensive survey of many courses and programs. Our efforts have been supported in part by the Southeastern University and College Coalition for Engineering Education (SUCCEED), a National Science Foundation Engineering Education Coalition (Cooperative Agreement 9727411), and a grant from the Center for Innovation in Learning at Virginia Tech.

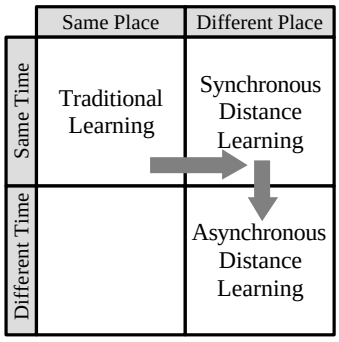
The paper is organized as follows. Section 2 briefly defines synchronous and asynchronous distance learning and summarizes the history of distance learning for electrical and computer engineering and information technology classes at Virginia Polytechnic Institute and State University (Virginia Tech). Sections 3 and 4 discuss our experience with synchronous and asynchronous distance learning. Section 5 discusses course and web site design. Section 6 provides concluding remarks, including speculation on new models for course development and delivery.

2. Traditional learning, synchronous distance learning, and asynchronous distance learning

Most classes, especially in engineering, consist of a number of different instructional components, including, for example, lectures, laboratories, recitations, and out-of-class reading and homework. Thus, it is impossible to assign a complete class to a single category of instructional delivery. For the purposes of this paper, the mode of

instruction is associated with the primary mode of interaction between instructor(s) and students. A commonly used taxonomy, depicted in Figure 1, considers the relation of the instructor and student in both time and place. Traditional courses are characterized as being "same time, same place" since the instructor and his or her students are located in a single classroom at the same time. Synchronous distance learning applies to situations where the instructor and students all meet for class at the same time, but may be in different classrooms. In asynchronous, or "different time, different place," learning, the instructor and students interact at a distance and not in real time.

The evolution of instructional modes for graduate engineering education at Virginia Tech is indicated in Figure 1. The Bradley Department of Electrical and Computer Engineering offers synchronous distance learning courses to multiple sites in Virginia through the Commonwealth Graduate Engineering Program [1] and between the Blacksburg campus in southwest Virginia and Virginia Tech's Northern Virginia Center in the metropolitan Washington, DC area. The department offered its first web-based asynchronous distance learning class, in C++ software design, on a limited basis in 1997. (We were not involved in this course.) The department is also one of five departments offering a joint Masters in Information Technology program [2,3] and will begin teaching asynchronous distance learning courses on a large scale for that program beginning in August 2000.



Distance learning in engineering at Virginia Tech
- Satellite-based synchronous distance learning with one-way audio, two-way video (1983-1998)
- ATM-based synchronous distance learning with two-way audio, two-way video (1998-present)
- Web-based asynchronous distance learning (2000-present)

Fig. 1. Modes of instruction and evolution for graduate engineering classes at Virginia Tech

Table 1 compares the attributes of facilities, students, and instructors – the resources and market – for traditional non-distance learning, synchronous distance learning, and asynchronous distance learning. Different facilities are needed for the three modes of instruction due to the different technologies required for each mode. Facilities for synchronous distance learning tend to augment traditional classrooms with technology to enable remote delivery. Facilities for asynchronous distance learning, however, are significantly different since no physical classroom is used. Different students are attracted by traditional learning, synchronous distance learning, and asynchronous distance learning. Distance learning programs, in general, target non-traditional students who tend to be focused and highly motivated. This self-selection is important, as focus and motivation are necessary for success in a distance learning program. Success in asynchronous distance learning also requires a high degree of independence and skill as a self-learner. This presents a challenge since it is not clear that students are self-selected for these attributes. The composition of instructional staff also differs for the different modes of instruction. The staff for synchronous distance learning typically includes at least administrative and technical assistance at each site. The instructional staff for an asynchronous distance learning class may consist of just the instructor and, possibly, graders.

Table 2 compares the advantages and challenges presented by the instructional modes. If all other factors are equal, most students and faculty prefer live, in-person interaction as offered by traditional courses. However, barriers of time and space prevent many non-traditional students from attending traditional classes to pursue life-long learning objectives. And, due to differences in learning styles, some students may not learn effectively in a traditional classroom setting. Synchronous distance learning removes some of the limitations of space, but students must still go to a properly equipped and connected classroom at a specified time. Removing distance constraints is particularly important to students located remotely from a major university or, as is the case for Virginia Tech, for a university mostly separated from a major urban area. Asynchronous distance learning effectively removes barriers of space and most barriers of time. This allows access to the class by a diverse group of students and, potentially, eliminates state and national borders and time zones as constraints. Effective use of either form of distance learning requires that the instructor create learning communities to allow peer learning and group projects. This is particularly challenging for asynchronous distance learning since the learning community must be strictly "virtual."

Different models for assessing learning and grading are needed for the three different modes of instruction. Individual "take-home" work, i.e. work done outside of class time, can be similar in all three modes of instruction. Mechanisms for submitting work must be in place for collecting material from distance learning students. This

might be by electronic means, e.g., via the web or electronic mail, standard mail, or facsimile. Remote staff can be used to collect assignments for synchronous distance learning. Proctored "in-class" examinations are a challenge for asynchronous distance learning, although commercial testing services do offer to proctor examinations for a reasonable fee. Group projects can be used with all three modes of instruction. Groups can often be formed within sites for synchronous distance learning classes. For asynchronous classes and synchronous classes where multi-site groups are required, e.g., due to too few students at some sites, technology is required to enable group collaboration.

Table 1. Attributes of facilities, students, and instructors for each mode of instruction

	Traditional	Synchronous	Asynchronous
Facilities	• Classrooms • Chalkboard • Overheads • Computer projection • Lab stations • Books	• Classrooms • Electronic whiteboard • Compressed video • Computer screen capture • Internet • Books	• Student at a computer • Streaming media • Course management software • Internet • Books
Students	• Full-time, traditional students • Variety of learning skills	• Part-time, non-traditional • Focused and motivated	• Part-time, non-traditional • Focused and motivated • Independent self-learner
Teachers	• Lecturer • Lab instructors • Graders	• Lecturer • Remote staff • Graders	• Content specialist • Course designer • Facilitator • Graders

Table 2. Advantages and challenges associated with each mode of instruction

	Traditional	Synchronous	Asynchronous
Advantages	• Live, personal interaction among students and between instructor and students	• Breaks down some space barriers • Access to education for full-time professionals	• Breaks down space and time barriers • Access to education for everyone • Allows diverse backgrounds • Internationalization of learning
Challenges	• Adapting to diverse learning styles • Life-long learning	• Scheduling classes • Creating a cohesive distributed learning community	• Creating a cohesive virtual distributed learning community • Better-suited for some subjects than others • Requires significant self-discipline, maturity

3. Experiences with synchronous distance learning

Synchronous distance learning classes at Virginia Tech typically originate from the Blacksburg or northern Virginia campus. Classes make extensive use of videoconferencing equipment. Since 1998, the system has used two-way compressed digital video carried over NET.WORK.VIRGINIA, a state-wide ATM network [4]. The video data rate is 1152, 768, or, rarely, 384 kilobits per second, depending on the capabilities of the originating and remote sites. A multi-point control unit connects multiple sites. The classes are usually structured like a traditional class, supported by specially equipped classrooms, web-based distribution of materials, and additional teaching assistant support. Student participation is encouraged; there is typically one microphone for every two students and when a student activates his or her microphone the camera zooms in on the student. Students are expected to have Internet access to use class and other web sites, discussion groups, electronic mail, etc. An earlier system used one-way analog video and audio over satellite, supplemented by a telephone bridge that allowed students to ask questions. The current two-way system greatly enhances interaction and the general quality of the classroom experience.

Streaming media can eliminate the need for classrooms. Students could attend lectures in real time from home or work. However, this flexibility reduces interaction in class. Also, additional support is needed to create an effective learning community. This latter challenge is also faced when using asynchronous distance learning.

Collectively, we have taught numerous synchronous distance learning classes, including a senior/graduate class in network application design [5], classes in a graduate sequence in computer networking [6,7], and an advanced

graduate class in wireless networks and mobile computing [8]. These courses, like many in engineering, are characterized by a substantial body of knowledge that must be acquired by the student. Students are expected to learn the core of the material through lectures, reading, and homework assignments. Projects are used to develop deeper understanding of specific topics and develop a student's ability to work on open-ended design and research.

These classes employ a traditional lecture-based format. Synchronous lectures are at the core of the course, as in a traditional class. To accommodate part-time students that work, lectures are held one night per week for 2 hours and 45 minutes (150 minutes of lecture and 15 minutes of break). The instructors lecture from the remote site a few times each semester to establish a personal connection with students. The web and other Internet services are critical to distribution and interaction outside of class. Lecture notes, assignments, and other course materials are quickly and conveniently provided to students, typically as either HyperText Markup Language (HTML) or Adobe Portable Document Format (PDF) files. Electronic mail, list servers, and web-based forums are used for interaction between students and the instructor and among students working on group projects. Desktop videoconferencing has been used to a limited extent for interaction outside of class, but proper equipment is not available to many students.

4. Experiences with asynchronous distance learning

Asynchronous distance learning has been around for decades, as traditional correspondence courses and, more recently, prerecorded video classes. Both of these examples rely on materials that are mailed directly to students and are severely limited in the amount and quality of interaction. The popularity of the Internet and increasing bandwidth in access networks have brought new life into asynchronous learning. It seems as if almost every university is teaching or developing web-based courses. Web-based courses have marked advantages over their asynchronous distance learning predecessors. Material is delivered quickly and easily via the web. Communication is improved via e-mail, desktop videoconferencing, web forums, and chat rooms. Students can potentially interact in a meaningful way using web forums and chat rooms. Interactive content, for example implemented as Java applets, can illustrate important concepts. Students have access to a multitude of additional resources using links to other web-sites, posted journal articles, etc. And, there is an opportunity for ongoing self-assessment by students and monitoring by instructors. The success of web-based learning requires taking advantage of the additional opportunities this new medium brings. If a web-based class merely delivers lectures and lecture notes using the web without any of the supporting components, then from a pedagogical point of view it is no different than the correspondence course of the past.

Collectively, we are developing three asynchronous classes for the Masters in Information Technology program. The first of these courses is a foundation course that introduces digital hardware, computer organization, and networking. The other courses are from the graduate networking sequence. A lecture-centric approach is being used where content is presented as graphics accompanied by synchronized streaming audio. However, the "lectures" are organized in a substantially different manner, with each module consisting of only 5 to 10 minutes of audio. Additional content is being developed that will be nearly as importance as the lecture.

5. Course design and web site for synchronous and asynchronous distance learning

Our experience indicates that course design for synchronous versus asynchronous distance learning should differ significantly. Synchronous classes tend to follow the traditional class model of lectures being the "driver" of the course, with lectures based implicitly on learning objectives,. Through lectures, projects, homework, and exams, students learn the subject matter. Asynchronous classes require students to prioritize and learn independently, so the course design must be explicitly controlled by learning objectives. Content, e.g., streaming media, projects, homework, and exams play a more balanced role in student learning.

Effective use of the web is obviously critical to the success of asynchronous distance learning, but it is also important for synchronous distance learning. The design of web sites follows from course design. The high-level design of web sites for synchronous and asynchronous classes is illustrated in Figure 2. A synchronous class can have a relatively linear and compartmentalized web site, for example with index pages for examinations, projects, homework, etc. An effective web site for an asynchronous class needs to be more modular. As is the case for the design of the course itself, the overall site is driven by learning objectives. A final exam and course assessment instrument are also associated with the class. The course is divided into topics, each with its own assignments and exams. Topics are realized by a set of modules consisting of module learning objectives, 5 to 15 minutes of streaming content, links to related resources, and an online self-assessment instrument so a student can ascertain his or her attainment of the learning objectives.

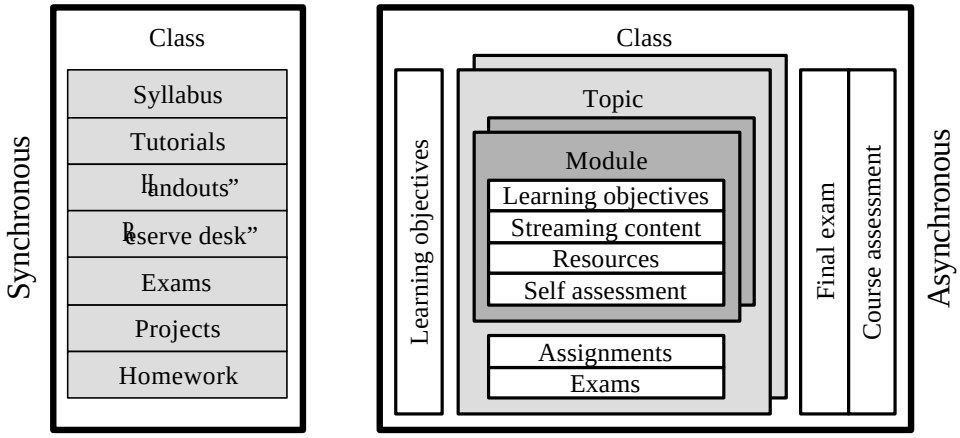


Fig. 2. Web site design for synchronous (left) and asynchronous (right) distance learning

6. Conclusions

Traditional classes and synchronous and asynchronous distance learning classes each have their strengths that allow them to meet the needs of different markets and all three modes are likely to coexist for the foreseeable future. Many traditional and non-traditional students prefer synchronous modes of delivery, but will select an asynchronous course for flexibility. Distance learning will continue to grow due to the ever-increasing need for lifelong learning. Asynchronous distance learning will likely grow at a faster rate than synchronous distance learning due to its inherent flexibility, the growing pervasiveness of the Internet, and the ever increasing bandwidth of Internet connections and capabilities of Internet applications.

The growing importance of and interest in web-based asynchronous distance learning promises great advances in both pedagogy and enabling technologies. Assessment is critical to bringing "science" to the art of teaching by any medium. It is likely that different course developers will experiment with different techniques and effective methods will be determined and adopted largely through informal exchanges among faculty. However, formal assessment of effectiveness, which must be distinguished from efficiency, can provide insight into how students learn and which subjects are the most suitable for which forms of delivery. This information will allow faster, more efficient convergence to effective course design and appropriate technologies for distance learning.

Asynchronous distance learning classes also enable new ways to develop and deliver classes. Since student and teacher can be separated in both time and space, and neither must be physically tied to anything except a computer and the Internet, new roles for the development and delivery of asynchronous distance learning courses can be defined. *Content specialists* provide the intellectual capital of the course and will likely be existing faculty members with a permanent university affiliation. However, it is possible that this function could be performed by a professional content specialist working for a fee. *Course designers* provide the design and technological expertise needed to package and deliver the content. Course design could be performed by university staff, consultants, or a service company. *Facilitators* manage a given offering of the course and answer questions, guide discussions, assign grades, etc. It is likely that a facilitator is not the content designer. It is possible to organize facilitators in a hierarchical manner to provide scalability. Facilitators might be university faculty, or they could be adjunct faculty located literally anywhere in the world. *Teaching assistants* and *graders* play much the same role as they do in traditional or synchronous distance learning classes in that a primary responsibility is to grade assignments. Teaching assistants may also be involved in answering student questions if the student-to-facilitator ratio is high.

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