Emulating F2F for a Distance Learning Environment

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Abstract

The potential pedagogical benefits of online learning are being recognized widely. This is reflected in the widespread development of remote labs and online academic courseware. Academic online courses today are characterized by static media elements with occasional applet animations or video clips that are often of low resolution, and which do not lend themselves to easy navigation by the online learners.
This paper presents our experience of developing a multimedia-rich, learner-friendly online courseware to emulate a face-to-face (F2F) learning environment for distance learning. The major emulation tools in our course material are graphical animations, pop-up multimedia elements for reminders and alerts, intra-module and end-of-module interactive quizzes that help to create an enjoyable and engaging learning environment. Our pilot course for the emulation experiment is a Data Structures course that has now been offered for six semesters. Results of assessing our emulation environment are very encouraging, showing effective emulation.

Keywords
F2F, Emulation, Online, Data Structures

Introduction

The most interesting development in the use of technology for education is the employment of the WWW for the delivery of course material and student-tutor interaction, and there are countless examples of such initiatives worldwide (Smeaton, 1997; MIT, 2005a; NSF 2005; CISCO, 2005; MIT, 2005b). The (World Lecture Hall, 1996) is an online repository or listing of such courses. At the time of writing, there were 82 different categories by subject area with Computer Science having 86 different online courses on offer from various universities. Most of these courses deliver teaching material that is organized in the form of an electronic textbook or electronic course notes that the student can ``read" at his/her own pace. Some also provide multiple routes of navigation through the material, search facilities, integration of text, images, video, user-interaction, and question-answer tests. We note that only one of the four courses on data structures in this repository provides links to some applet animations in addition to the course syllabus and static course slides.

The above observation is true for many other online courses offered elsewhere (Unitar, 2005; MVU, 2005; Learndirect, 2005). We believe that a well-designed course that is rich in multimedia is necessary for the creation of an effective online learning environment.

This is the objective that the work reported here has set to achieve. As we discussed in the following sections and elsewhere (Junaidu, 2004a), this effort has resulted in a successful emulation, online, of a typical F2F learning environment.

Our online course is a computer science Data Structures course. This course is the last of a series of three basic courses (corresponding to the introductory courses of (Chang, 2001)) offered by our department. The students taking the course have good computer and Internet skills, with 98% of them owning PCs. We note that this is the only course the students are required to take online; they take other courses in the traditional F2F paradigm. This makes our work both interesting and challenging.

Considerations for a Distance Learning Environment

Discussions with many faculty members and higher education administrators led to the belief that distance learning is lower in quality than traditional F2F higher education. This feeling was attributed to the following:

a) F2F students have the chance to listen and see instructor's presentation. Instructors have the chance to illustrate the topics in an easy and interesting manner that may include chalk or PowerPoint illustrations, modulations in voice intensity, the underlining and stressing of more important points, eye contact, etc.
b) F2F students have the course broken down for them in little, manageable chunks called lectures or classes.
c) F2F students have the ability to interact with the instructor in class and during office hours.

We believe that online learning provides the following advantages:

a) Ability to educate students according to their own personal assimilation capabilities.
b) Combining educational activities: students can combine covering course content, which is done through class attendance in the F2F format, with studying the course material, and communicating with the instructor and other students regarding the course.
c) More dynamic: Basic course content is implemented in a soft format. Delivery is through the web and without the effort of instructors. The instructor's efforts can therefore be directed towards the continuous improvement of the course material.
d) More uniform: in the F2F paradigm, the same lecture is repeated many times by different instructors with varying instructional expertise. In contrast, good online courses are developed by a team of experts thereby emulating highest quality instructional expertise.
e) Quicker in implementing changes: Any update or improvement in course content is immediately available to all online students.
f) Customizable: Not only can course content be customized to meet student discipline and needs, the whole curricula can be customized to create different related disciplines.
g) Better utilization of technological tools. Recent advances in technology can be employed to enhance learning. The capabilities of these tools include:

1. Better visualization of educational content,
2. Better access to simulations of experiments.
3. Better students interaction with course material; students can influence the sequence and depth of course coverage.

h) Better observation of standards: Observation of standards of quality in F2F education depends to a large extent on the instructor. In contrast, the ability to have stricter standards across the entire spectrum is much higher for online learning.

i) Less redundant: the same course/lesson/lecture does not have to be repeated hundreds of times by different instructors.

j) More scalable: In F2F education, every instructor has to be a subject mater expert (SME) in order to be able to deliver course content. Students in an effective online learning program will have access to mentors who shall work under the guidance of an SME. Thus, online learning requires fewer SME's than F2F for larger numbers of students. Moreover, online learning facilities require less building space, fewer support and administrative employees.

k) Better support for several modern forms of communication like collaborative work, group design, as well as one-to-one communication when needed.

By emulating F2F in our online development we can provide the distance learner with the advantages of both F2F education and online learning, and realize the vision of allowing students everywhere to take the best courses as taught by the greatest teachers. The following are points we considered, and tools we implemented, to emulate the F2F class function in online learning:

a) PowerPoint-like format: Most lectures in our university are delivered using PowerPoint presentations. Our Authorware-generated slides are very similar and with added interactivity value.

b) Use of voice: There is voice explanation associated with each bulleted point. The instructor explains each point in a fashion similar to his role in the classroom. The difference being that what is said is not spontaneous, but well selected and reviewed.

c) Use of illustrative tools: When a code segment, a diagram, or a figure is illustrated, a few tools were used:
   1. A pink rectangle that blinks three times and remains near the part that is being explained by voice.
   2. A bright green arrow of suitable size is directed towards the part being explained.

   Both tools are flexible. You can move them around freely as the explanation proceeds. In a F2F setting, you normally erase chalk and markings during the explanation; this sometimes becomes ugly and may obscure the presentations.

d) Use of animations. Animations were used when useful in making concepts clearer. Good animations are not easy to develop. As an example, a single animation took a course developer 3 days to create and only lasts 10 minutes of online lecture time. Explaining the same concept in a F2F format usually takes an entire class period.

e) Providing good navigation support: We have provided the online learner with navigational capabilities at different levels:

1. Slide level: The student can repeat a slide or skip a slide at any point. The student can disable the voice, enabling quicker navigation.
2. Topic level: Each lecture was broken into topics and subtopics. The student can go to any topic or subtopic from the first slide of the lecture. The student can go to the first slide of the lecture, or to a topic, from any point during the presentation.
3. Lecture level: The student can go to any lecture of the course from the course web page.

With such an implementation we have created an effective online course material that enhances the ability of students to learn. Because of our careful and team-based collaborative development effort, we were able to cover 25% more material than in the F2F course without overwhelming students.

Contents Development

The success of this course is, to a large extent, attributable to the organized and systematic way in which the course content was developed. Each unit was developed through a preparation-presentation-feedback-preparation cycle before acceptance.

A few lectures were discussed each time during our team's weekly meeting. Each presenter received detailed comments on various aspects of his presentation, including content, choice of examples, content organization and the nature of animations proposed. The overall flow of the presentations is also checked to ensure smooth transition among the lectures. We also tried to ensure that subsequent lectures build on examples presented in earlier lectures.

One of the important requirements of an online course is the need to engage the learner in an active way. To achieve this, our lecture units contain an average of two pop-up interactive quizzes that test the user's comprehension of the material. The quizzes were developed using Authorware's *knowledge objects* tool. Various kinds of questions were created to increase learner's interaction with the content.

Review exercises at the end of each lecture material are designed and tailored to reinforce the student's understanding of the relevant material. The laboratory material is developed hand-in-hand with the lecture material and is intended to complement the latter. As the laboratory session is the most important component of the course with respect to the building of skills, homework questions are designed to enable students to build on the laboratory coverage. This provides the potential for cementing students' skills and building his confidence for independent self-study.

It is clear from the foregoing discussion that the investment of time during content development is high. Content development, voice transcript writing and the transfer of content to the presentation template amount to about 40% of the total online course development time. We believe that this investment is worthwhile in order to produce duplication-free, tightly coupled lectures, labs and homework content.

Animations, Recording and Synchronization

One of the most important aspects of an online course is that it should be illustrative. This point cannot be overemphasized. An online course should use multimedia elements (animations, sound, graphics, color etc.) in a measured way to illustrate and explain important concepts. As mentioned earlier, animation decisions (what to animate and the nature of the animations) are best done at content preparation time.

Multimedia components allow the accommodation of a variety of learning style preferences. Learners can choose to study course contents in a way that suits their preferences, with the added opportunity of controlling the pace of study. With judicious use of multimedia, an online course author may appeal to a learner's intuition and can potentially be more effective than the traditional F2F method of instruction.

Using Authorware's animation capabilities we effectively animated algorithms on trees, graphs, hashing and data compression. It is instructive to note that algorithms that are cumbersome to teach effectively in a single traditional lecture session have been successfully animated and typically learnt within ten minutes. Students' performances in examinations reveal an effective mastery of such animated algorithms (Junaidu, 2004a).

Creating animations can be extremely time consuming. We note that examples like AVL tree rotation, Dijsktra's shortest-path computation, and Huffman coding can each take at least a day to animate well. Although animations could be incorporated into Authorware presentations from external sources, it may not be possible to obtain animation elements with fine granularity, especially if these elements need to be synchronized with voice elements. In our development experience, animations account for about 30% of the total production time (involving the six team members working in parallel).

If an online course is to include voice, then issues of recording software, recording format, recording environment and synchronization have to be carefully considered. After trying various voice-editing software packages we settled for Sound Forge, from Sonic Foundry, as our recording software. The choice of a recording format is a trade-off between sound quality and space requirements. We found that a 16-bit, mono .wav file at 98 kHz, saved in PCM format, produces sounds of acceptable quality. Recording should be conducted in an environment in which background noise has no effect on sound quality. We recommended the established of a multimedia development lab for this (Junaidu, 2004c).

Synchronizing multimedia components must be done carefully. Animation and sound require a certain length of time to play-time that can vary from computer to computer (Macromedia, 2001). We must ensure that these components start and stop at the right time when they are played together. Otherwise the presentation will not be smooth. Authorware provides two functions, `SyncPoint()` and `SyncWait()`, to synchronize sounds with display text and graphics. Synchronization using these functions usually requires repeated testing to determine how long each component takes to play, where noticeable pauses occur when a component is loaded into memory, and the start and stop points for each component.

We devised a better alternative to the above functions: divide the sound files into smaller units as dictated by the corresponding text and/or graphics that the sound segments explain. The associated text/graphics and sound segment are then played concurrently or sequentially as desired. This provides additional low-level synchronization control and makes the presentation more amenable to future enhancements.

Recording, synchronization and packaging our course material for delivery onto the Web accounts for about 25% of the total course development time.

Presentation Template Design

Before discussing issues of packaging and delivery to the Web, we highlight the issue of designing a presentation template. There are two major issues here: (1) the presentation template itself: its size, color, font styles and size, and (2) the navigation options to be implemented.

When designing a presentation template, the developer should consider carefully the kind of computers that their clients will be using in order to arrive at an acceptable template size. A template size of 640 x 480 pixels is likely to cater for most computer screens in use today, and we use it as a good common denominator.

We implemented standard navigation options found in typical GUI-based systems. Each subtitle in the front page of a lecture is a link to the first page on which discussion of that topic begins. At the bottom of the presentation template are navigational buttons and sound/presentation control buttons. Each button has a tooltips text message indicating its purpose.

Our experience with the course reveals that students demand more control over navigation through the online material. We are considering adding inter-lecture links and a slider to give additional navigational control. A sample page of our presentation template is shown in the appendix.

Uploading onto WebCT

At this point all the technical issues of course development have been completed. We are now ready to compile and upload the material onto the Web.

Before uploading to the Web the .wav files produced during the recording process should be compressed for increased uploading efficiency while viewing the course material. Compression and conversion formats may depend on the authoring tool used. Working with Authorware, we converted our .wav files to Shockwave format. *Shockwave Audio* makes sound files smaller and plays them faster from disk or over the Internet. It can compress sounds up to a ratio of 176 to 1. It also makes sound files streamable-meaning that they can begin playing before they're completely loaded into the computer’s memory.

The streaming technology of Authorware enables a presentation to be packaged especially for the Web, so that it can be efficiently downloaded over the Internet from a compatible browser. Streaming consists of a packager and a player. The packager prepares the piece and breaks it into segments for faster transmission over the network.

The packager also creates a map file that tells the web player what to download, when to download it, and where to put the downloaded segments. The web player manages the downloading according to the map file and runs the presentation independently of the Authorware application.

After packaging the course, we upload it to WebCT. WebCT contains a rich set of tools for managing communication, student tracking, assessment, and tools for conducting and analyzing surveys. We use these tools heavily in this course to good effect.

Course Delivery

As mentioned earlier, our online course is different from most existing online courses in the sense that it provides a good blend of graphical animations, user-friendly interface and appropriately-spaced interactive quizzes. Although the course could be taken completely online with no F2F lectures, it is currently offered as a blend of F2F and online instruction methods. A single tutorial session accounts for the F2F component and replaces the traditional three-hour weekly teaching times. The laboratory component (it is a four-credit course) also remains F2F. We hope to make the course completely online in the near future.

The tutorial sessions aim to increase personal contacts between the students and the instructors. They provide an opportunity for students to discuss the course material and ask questions F2F. A quiz is also conducted in alternate weeks during the tutorial hour. This helps students keep to the course schedule and avoids procrastination.

The laboratory F2F meeting is one of the most important components of the course because this is where the students demonstrate and reinforce their understanding of the course material. The laboratory exercises are carefully designed to reinforce and complement the course material. The laboratory sessions are often started with short quizzes on the material for the current laboratory. This greatly assists the students in assimilating and learning the course material, as results of our surveys show (Junaidu, 2004b).

Clear benefits of online lectures, as in our emulation, are that students take control of their own learning, and do so at their own rate, albeit moderated by the facilitator in charge of the course. The passive transfer of information in the form of conventional lectures can now be replaced by personalized delivery, with the student determining when, what, how fast, how much and how often the course material is covered.

The content of our course is organized into forty lectures as would typically be presented in the traditional F2F lecture method. Chunking the material in this way helps in easy mapping between the F2F and the online coverage. Each lecture takes, on average, 35 minutes to complete when viewed with the full audio explanations and animations.

As a supplement, the students are also provided with paper copies of the screen dumps of the Authorware presentation for off-line study. The students make use of the hard copy to write additional notes that they transcribe from the online presentation. The course material that is uploaded onto WebCT is password protected, and each student is provided with an account with which to access the online course material. A CD is also

provided containing the compiled course material as posted on WebCT. For online study of the material in the college laboratories, students are provided with walkman-style headphones so as to reduce disruption in the laboratories caused by audio over speakers.

Students Feedback

Following (Smeaton, 1997), we evaluate our course according the following three criteria:

- Students' performance
- Online course system usability
- Scale of investment needed to create and maintain the online course.

The performance of students is a measure of how well they have learned from the online versus the traditional mode of lecture delivery. Comparative analysis of students' performances in examinations, over five semester pairs, between the F2F and the online offering of the course revealed encouraging results in favor of the online offerings (Junaidu, 2004a). Furthermore, online students demonstrated a much deeper understanding of the course material. This is due partly to the relatively more active role that students played during online learning.

We analyze the usability of our online course system using the 5 criteria established by (Nielsen 1993):

1. Learnability. This refers to the user's ability to quickly learn how to use a system. We base the analysis of our system's learnability on the two questionnaires given within each semester. In each of these questionnaires, about 80% of the students say they find the system easy to use. However, there have been continuous requests for additional control on navigation (Junaidu, 2004b). We responded by enhancing the course presentations enabling the learners to:
    - disable audio in the presentation for faster navigation
    - pause and resume at any point within the presentation
    - navigate using hyperlinks attached to lecture topics and sub-topics

    With these enhancements, our online course rating increased by 30% in subsequent questionnaires. We are planning to add more control to the learner by adding sliders and hierarchical trees controls.
2. Efficiency of use in our online course is assessed in terms of the effectiveness of our animations. Our teaching experience with the F2F method is that it is difficult to effectively teach topics such as AVL rotation and Dijkstra's shortest path algorithms using reasonable examples within a lecture session. With our carefully designed animations, however, we are able to demonstrate these algorithms in about ten minutes each. Furthermore, a student can replay these animations to improve comprehension, unlike the F2F method where the instructor erases such illustrations. This is one point where the online delivery method has a clear edge over the F2F method.
3. Memorability is a measure of a student's ability to grasp material quickly. Statistics from our questionnaires indicate that most students grasp the algorithms being illustrated after following our presentation slides the first

time. They normally revisit the presentations to refresh their memories about additional concepts that are explained in the audio parts of the presentations.

4. Errors refer to the number of minor corrections (typos, etc.) and major problems (system downtime, system failures). Admittedly, typographical errors and minor formatting errors are some the main things we had to face during our first revision of the course material. We maintain a log file of errors we find as well as those received from user feedback.
5. Subjective satisfaction with the online lectures will be measured using post-course questionnaires. There are currently ten students who took the online course and are now providing feedback and working part-time on developing other online courses. These students are also sourcing valuable feedback from other students currently taking the course. Critical feedback is acted upon immediately, while the remainder is left for the next revision period.

Overall, the results of our student surveys are encouraging. Surveys were typically conducted at the start, in the middle and at the end of a semester. The results indicate increased student satisfaction through the semester. Generally, about 60% of the students indicated that they were worried early in the semester, and about 30% said they opposed the methodology. In the last set of questionnaires, however, about 60% of the students indicated they were extremely satisfied, 30% moderately satisfied, and about 5% said they were not satisfied at all.

The final aspect of the evaluation of our work concerns the scale of investment needed to create and maintain online lectures. As mentioned earlier, the course material is hosted on WebCT, for which there was an existing administrator before our online course commenced. The WebCT administrator is responsible for creating student accounts and troubleshooting the system.

The big investment in creating the online lectures has been the time required. Six instructors worked almost round-the-clock for about three months to produce the first online course. The same instructors worked part-time for three months in the first review period of the course. Other costs include the cost of the Authoring tool, headphones for students and backup hardware. Although each of the course instructors meets the students once a week, the instructors put significant amounts of effort into the delivery of the online course. In addition to frequent quizzes and homeworks, the instructors have to respond to students' questions online or through WebCT's chatting tool, as well as conduct and analyze questionnaires.

In spite of the above costs, online courses have a number of potential benefits. First, they provide opportunities for training students to be more independent learners, better time managers, and ultimately more able researchers. Online courses also lead to significant reduction in classroom space usage since the F2F meeting time can be reduced significantly. Furthermore, online courses provide more scalability at relatively low cost. Another important factor is recognition - the authors' university is becoming a pace-setter in this important area of online education. Many other universities in the Kingdom, and the region at large, are showing interest in learning from this experience.

Summary and Future Directions

We have presented the design and implementation of a unique, media-rich, and flexible online data structures course. The primary objective of the course implementation was to emulate F2F classroom education into online course delivery. The result was not only preserving the same quality level of the course but also substantially enhancing it. It also provides the flexibility needed for offering for distance learning. The implemented course goes beyond traditional online courses that typically consist mainly of still-text presentations. Our online course also supports learner interactivity to cater appropriately for the needs of fast and slow learners; the user can pause, disable voice explanations, repeat a certain point and jump within a lecture at will.

We have also discussed the important role that animations play in an online course. We described how we created effective, reusable animations that are fundamental in illustrating important concepts. Each lecture unit typically consists of two short pop-up quizzes that play the double role of making the learner participate actively in the learning process, as well as testing the learner's comprehension of the content.

As with every online course development effort, we plan to put in place a continuous review regime aimed at improving the course content. Before the next offering of the course we plan to rearrange the placement of some material, and incorporate additional solved examples and drill questions. We also plan to add a navigational slider and a keywords search facility as additional forms of user navigation and control.

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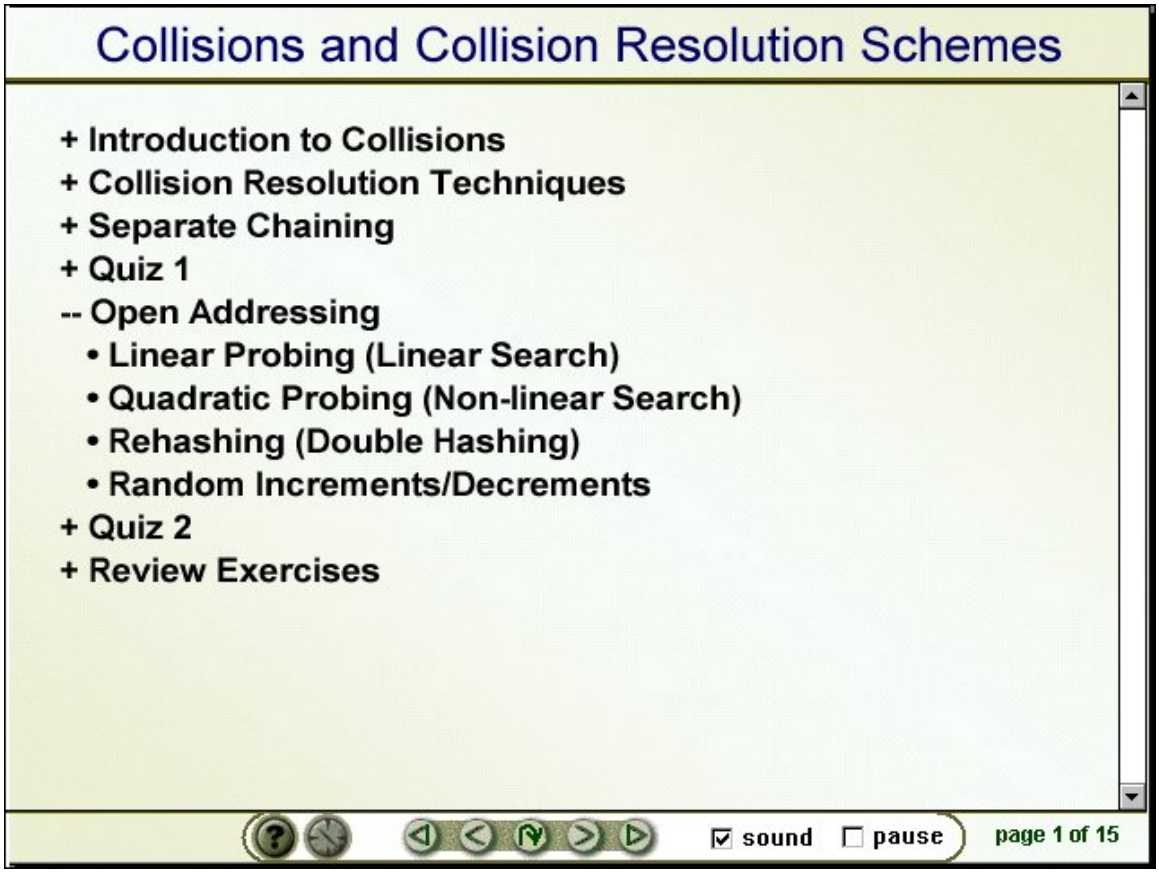
2. Appendix



Sample Presentation Template Page