

Designing Computer Graphics Courses for Distance Learning

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1 Introduction

Distance Learning is not a new concept to higher education. Adult correspondence courses using print media dates back to the 1800's. London University offered an External Degree program to overseas students beginning in 1858. As communication technology advanced, different forms of distance learning emerged. Courses by radio were offered in the 1930's. Television gave rise to the "Telecourse" which began with Chicago-based *Sunrise Semester*, broadcasting a teacher lecturing in a classroom, in 1959. Universities that were totally based on distance learning began appearing in the United States in the early 1970's. A timeline of major events in early distance learning can be found at [Camplese 1999].

The advent of the internet brought a whole new dimension to distance learning by providing the capability for two-way interaction between instructor and student, a rich environment for multi-media, instant on-demand access to thousands of courses in all disciplines, and a unique technology medium capable of interactive demonstrations of concepts. The proliferation of broadband access has furthered increased both the capability and demand for online education. While the initial intent of distance learning was to reach remote and disadvantaged students, the increased capabilities of web-based distance learning has resulted in an explosion of internet course offerings from both purely online institutions as well as a large number of traditional academic institutions. According to US News, over 90% of public colleges will offer online courses in 2005 [Bossler 2004].

There are several terms that have evolved for distance learning approaches including computer-based training, technology-based training, web-based learning, e-Learning, online learning, distributed learning, etc. Several definitions have also been proposed over the years. For purposes of this discussion, distance learning refers to *learning primarily via the internet by students at remote locations*.

A common experience for anyone developing a course for distance learning is that it is very different than developing a traditional academic course. While the end-goal course objectives and student outcomes may be the same, the approaches for achieving them are, by necessity, different. Not only is the technology and delivery mechanism vastly different, but many issues also arise about how to effectively incorporate student-teacher interaction and feedback, how to organize individual and group projects, how to accurately assess student knowledge, and how to leverage the capabilities of the technology. Fortunately, the proliferation of distance learning has also led to the creation of several organizations, publications, and research initiatives dedicated to the issues and experiences of effective distance learning. As a result of this proliferation, there exists several guidelines, guiding principles, shared experiences, and helpful hints for the design of distance learning courses.

The purpose of this paper is to look at the application of a few of these distance learning principles to the design of online offerings of computer science courses in computer graphics. It is the author's contention that computer graphics courses are well-suited to a distance learning environment and that application of general design principles can result in effective online courses in computer graphics.

2 Suitability of Computer Graphics

One of the first questions that should be asked when developing a course for distance learning is whether the course material is suitable for an online environment. Examples of instructional content that is *not* suitable would be the requirement for:

- physical manipulation of objects
- access to specialized laboratory equipment
- face-to-face interaction
- oral presentation

In general, most computer science courses may involve some aspects of the above, but do not rely primarily on them for instruction. Unless computer graphic courses are being taught on specialized workstations, they also do not fall in the above categories.

Another concern regarding computer science courses, and specifically graphic courses, are that they are often project-driven to illustrate concepts. While administering effective online student projects, including programming exercises, requires careful planning, there are several examples of successful distance learning courses in computer science that rely on student exercises to demonstrate and reinforce ideas. A discussion of the some of the issues in a programming course can be found in [Boone 1999]. Care must be taken when developing such projects to ensure that:

- Students have sufficient access to the necessary software tools to complete the projects
- Synchronous or asynchronous assistance is available to answer questions
- Tools and procedures are available, if appropriate, for student collaboration on projects
- Appropriate assessment and feedback mechanisms are in place

Computer graphic courses are not only suitable for distance learning, they are in fact prime candidates! They have the characteristics of being motivating to students, visual, and well-suited to interactive demonstrations. These characteristics are furthered explored below.

3 Guidelines for Designing Distance Learning Courses

As previously stated, a number of organizations and institutions have proposed guidelines to distance learning course developers, some examples are [Chikering and Ehrman 1996; Pennsylvania State University; American Federation of Teachers; Indiana Higher Education]. These cover a myriad of topics such as:

- Course planning
- Learning objectives
- Choosing technologies and delivery methods
- Planning interactivity
- Teacher-student and student-student communication
- Student collaboration
- Administering student projects and exercises
- Student assessment
- Working with students with disabilities
- Copyright and ownership issues
- Reusability of learning modules
- Course management
- Course evaluations

While there is a great deal of overlap and common themes in the various guidelines available, there is no single approach or guiding principles that are universally accepted. Rather than go through an exhaustive list of different approaches, and how they might apply to computer science and computer graphics, this discussion focuses on three general guidelines that are specifically applicable to teaching computer graphics. For maximum effectiveness, a course developer needs to apply good-practice techniques to all aspects of developing an online computer graphics course, many of which are common to courses in any subject.

The following general guidelines to distance learning are specifically applicable to computer graphic course design:

Guideline 1: Keep the student motivated

Student motivation is key to success in any learning environment. Motivation may be intrinsic such as seeing the value of the material, or having a strong personal interest in the topic. Or the motivation may be extrinsic such as the desire for a good grade, or the need to complete a requirement. Traditional ways of motivating students include showing the relevance of material, incorporating ways of making the concepts entertaining or interesting, and allowing the student greater participation in setting their own learning objectives or means of achieving the objectives.

Motivation becomes even more important in an online environment in which courses are typically self-paced and not directly overseen by an instructor. In addition, remote students may have other distractions to deal with such as a noisy environment that detracts from the student's focus. Traditional motivating approaches can be incorporated into the online offering in the way the material is presented, or the course is structured. Additionally, using the internet as the delivery mechanism allows for a unique "hands-on" opportunity that are not typically available in a classroom setting. Examples of these are discussed further below.

In general, computer graphics courses are at a distinct advantage in that students are often self-motivated and find the topics of high personal interest. It is easy to show relevance of topics to areas of student interest such as games, topics in the entertainment industry, and applications in other fields. Students are also motivated by the opportunity to create images and animations that are personally satisfying and can impress their friends. For example, it has a much broader appeal to show off a realistic ray-traced image than the successful implementation of a hash sorting algorithm.

One way of reinforcing these in an online course is to provide links to motivational examples along with the material that can allow the student to further explore the topic on other web sites. For example, topics on scientific visualization can point to numerous engaging examples on the NASA and NCSA sites. Topics in animation have several options for movie trailers and "how it was done" sites in the making of movies and special effects. A small amount of investigation can result in many links to extra material that are student-controlled links and not mandatory to the course. This allows students to spend as much or little time as desired in areas of interest.

Another suggestion for designing motivation into a computer graphics course is to provide ample opportunities for the student to produce their own creative imagery. Even before they understand the underlying principles and algorithms, they can be using predefined library calls and online tools to have some level of creative control over the final image. For example, a lesson on shading can allow the student to arbitrarily place or move objects in a scene, specify shading parameters, and re-render the scene. This not only reinforces the material by demonstrating a cause and effect relationship, but also allows the student to experience a small sense of ownership in that it was an image that they created. Such an interactive shading applet along with several other excellent demonstrations can be found in the Brown Exploratories [Brown University].

Guideline 2: Design the course to be visually engaging

This guideline is not only important for online courses in general, but is critical to courses dealing with computer-generated imagery. Text-heavy web pages are an ineffective way to transfer large amounts of factual information and can de-motivate the student toward the material. Different distance learning guidelines suggest maximum amounts of text per page of online instruction. Fortunately, because computer graphics is so visually-based, it is not difficult to determine appropriate images or diagrams to explain a concept. In other words, it is not necessary to include a gratuitous piece of clip-art simply to dress up a page. Several locations on the web, such as [ACM SIGGRAPH Education Repository], maintain a repository of educational images demonstrating different concepts in computer graphics.

In addition to static images, many computer graphic and computer animation concepts can be best illustrated with short video clips. Including these in the online content not only reinforces the concept, it also results in a visually dynamic experience for the student and enhances the presentation variety of the material. While animation clips demonstrating specific concepts are not as easy to locate as still images, there are resources and specific examples available online including an archive of SIGGRAPH videos [Internet Archive] and clips from the annual conference

Computer Animation Festival [ACM SIGGRAPH Video Reviews]. Care must always be taken when designing with multi-media to ensure the appropriate bandwidth and software support (e.g., plug-ins) are available to the student. Incorporating video that takes a long time to download or does not immediately play can have a negative impact on the student's experience.

Another major concern with the inclusion of any imagery or multi-media in a distance learning course is the issue of copyright. Educators have traditionally used the Fair Use clause of copyright law to give liberal access to a broad variety of protected material for classroom use. Use of the internet and online posting of course material makes copying and accessing protected material even easier, while muddying the waters of ownership rights and Fair Use. Every producer of distance learning material should become familiar with copyright laws as applied to distance learning. A good overview can be found at [University of Texas].

Guideline 3: Keep the student actively involved

This is a self-evident principle for online as well as in-classroom instruction. The difference in online approaches is *how* to keep the student involved. In a classroom setting, involvement can be achieved through teacher-student or student-student dialog, proverbial "board work", and classroom exercises. The online equivalent to a long boring lecture is page after page of text to read with little or no interaction. Student involvement can be achieved through online discussions (either asynchronous threaded discussions or real-time chat), integrated student exercises, quizzes with feedback, simulations, and interactive demonstrations.

Interactive demonstrations are an extremely effective way to involve the student in the presented material. They enhance student understanding of concepts as well as motivating the student to "play" with and see the cause-effect of changing parameters. Many computer graphic concepts lend themselves to interactive demonstrations such as 2 and 3D transformations, drawing algorithms, color models, rendering and shading, and visualization. For example, teaching color spaces is much more effective when the student can interactively manipulate parameters in different color spaces and see the results. An example of this can be seen at Nan Schaller's demonstration [Schaller].

There is a wealth of such interactive demonstrations already created and available for online instruction [Brown University; Min]. These demonstrations are written in Flash or as Java Applets, so they can be easily incorporated into a web-based course. Allowing a student to read about a concept followed by a hands-on interactive demonstration not only reinforces the concept, but also keeps the student engaged in the material and focused on the subject. In addition to pre-existing demonstrations, the Brown material includes building blocks of code to allow the course developer to quickly build their own visualization applet of different concepts [Brown University]. In this way, demonstrations can be tailored to the specific course and concepts being taught.

4 Conclusion

Distance learning courses in computer science and all disciplines will continue to increase as more and more universities are investing resources and research into online course development.

Major universities already have online offerings for various courses in computer graphics. The value of such courses depend on how well the course developers have adhered to established principles of effective online course design.

Courses in computer graphics are natural candidates for effective online offering in that they are easy to motivate students, they are visual by nature, and they lend themselves to interactive demonstrations. By taking advantage of these characteristics and existing resources, developers can design computer graphic courses that are highly successful in a distance learning environment.

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