Online Learning in Engineering Graphics Courses: Research, Tools, and Best Practices

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Abstract – This paper discusses some of the tools available that can be used to deliver instruction synchronously and asynchronously, summarizes research and experiences from engineering and other disciplines related to online instruction, describes some of the issues related to delivering engineering instruction online, and provides some solutions to issues related to online learning.

Keywords: Online instruction, distance education, engineering graphics, community colleges

INTRODUCTION

For years we have had the ability to offer courses at a distance through online instruction. Many instructors have taken advantage of online tools to supplement their classroom instruction, but few have embraced the full potential of online learning technologies. Some of these tools include course web pages, course management and development tools, and online tutorials. Reasons for not embracing online learning technologies include inadequate training in the necessary tools to develop an online course [1], perceived lack of interactivity or dialogue between the students and instructor and between students in online courses, lack of technology support at one’s institution, or insufficient time to develop online materials [2]. In some cases online courses are not developed because face-to-face courses are sufficient to meet student demand. Engineering graphics instructors face additional challenges with issues such as finding appropriate ways to demonstrate CAD software, preparing materials that are graphics intensive, and determining adequate methods to evaluate student work. More recently, synchronous communication tools for learning have been developed that allow instructors to communicate with students in real-time. These technologies have increased the level of community within an online course by integrating audio, video, and other means for student to interact [3].

As these learning technologies have increased and become easier to use, faculty have found creative ways to offer their engineering courses. We now regularly see courses offered using Course Management Systems (CMS). These systems allow the instructor to take advantage of asynchronous technologies [4, 5], synchronous technologies [6], and videoconferencing technologies [7, 8]. Whether these courses are offered for students at a distance or for on-campus students, these tools are giving faculty more options for delivering instruction. The CMS are available to meet the needs of all experience levels of faculty. Whether the instructor is just trying to add a small amount of course material online or has a desire to offer a course at a distance, systems exist at all price ranges. Examples of CMS include Angel™, Breeze™, Convene™, Blackboard™, Desire2Learn™, Embanet™, eCollege.com™, Elluminate™, Gradepoint™, Horizon LiveWimba™, IntraLearn™, Centra Symposium™, and WebCT™. These systems typically include both asynchronous and synchronous learning tools. Asynchronous tools can be used to deliver online instruction with some time delay between an instructor’s action and when the learner accesses the instruction and responds. With synchronous online tools, participants are engaged in real time activities such as text chat, audio, and/or video.

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Asynchronous Tools

Asynchronous tools involve instruction through a “different time-different place” mode. Examples of asynchronous tools are discussion boards, blogs, email, online quizzes, streaming audio and video, narrated slideshows, learning objects, and website links. The main advantage of these tools is that participants can access the instruction at their own convenience [9]. Figure 1 illustrates an example of an online test that was used to check students’ understandings of material related to geometric dimensioning and tolerancing. Students were given a window of time within which they must have completed the quiz.

2. Unit 2 - question 2
(10 points)
Select the item that corresponds with the following instructions: Make the top surface in the plan view perpendicular within .005 to datum A. Also identify this surface as datum feature B.

![Figure 1. Example of an Online Test within WebCT Vista.](image)

Synchronous Tools

Synchronous tools involve instruction through a “same time-different place” mode. These tools allow the instructor and students to engage in activities in real-time. Examples of synchronous tools are application sharing, audio conferencing, text chat, web conferencing, white boarding, and video conferencing [10]. Figure 2 illustrates an application sharing example of a web browser. Application sharing allows the instructor to present material, demonstrate software, or turn control of the software over to participants.
EXPERIENCES TEACHING AT A DISTANCE IN ENGINEERING COURSES

Teaching at a distance in engineering courses, especially engineering graphics topics, creates some unique challenges for instructors. Since most of the instruction involves using static 2D graphics, static or dynamic 3D models, or animations, significant time must be spent to prepare the graphics and to also consider the quality with which they will be viewed.

Howell describes an experience modifying an introductory engineering graphics course at Lawrence Technological University to accommodate a student studying overseas. One of his students had the opportunity to study at a university in Stuttgart, Germany during the fall 2003 semester. This created a problem because she had to take his engineering graphics course during the same semester. His solution involved using Blackboard for asynchronous activities for the entire class (posting assignments and giving exams) and using Gradepoint for synchronous instruction for the student in Germany (CAD demonstrations and real-time discussions). He concluded that engineering graphics courses do not lend themselves easily to an online format since they require CAD software demonstrations with graphics intensive programs. They also require some interaction with a knowledgeable instructor to answer questions and provide accurate feedback. The distance education format requires that the student and the instructor be motivated to learn new technologies. The course can be as successful as a face-to-face format, however, instructors may become overwhelmed with a large class because of the time required to respond to students online [11].

Using synchronous video for instruction can also offer some challenges for instructors. In another example where a great distance separated the instructor and the students, faculty at the University of California, Berkeley and at Hanyang University, Seoul, Korea taught an engineering course simultaneously using the Internet. The instructors at each institution took turns delivering lectures to both schools. Two screens were set up in each classroom. One projected the instructor’s computer presentation and the other projected live video of the other classroom. The instructors concluded that PowerPoint presentations worked better to communicate information than videos of overhead slides. It was also critical that the instructor at a particular site needed to be able to see students at the other site while lecturing to adequately pace instruction. They recommended the use of a high quality web camera for best results [12].
EXPERIENCES USING CMS IN NON-ENGINEERING COURSES

In addition to teaching undergraduate engineering graphics courses, the lead author also teaches instructional design graduate courses at a distance for technology education students and community college instructors in the STEM areas (science, technology, engineering, and mathematics) [13]. In the instructional design course, a combination of WebCT Vista and Centra Symposium is used. Students are required to complete readings and respond to discussion postings asynchronously. In addition, synchronous sessions are held once or twice each week in Centra Symposium to present material, hold real-time discussions (as a group or in break-out rooms), conduct student presentations, and demonstrate web design tools. Figure 3 illustrates an example of using the whiteboard to conduct brainstorming activities. With the whiteboard tool, all participants can add information to the screen simultaneously while interacting via live audio.

![Image](image_url)

Figure 3. Brainstorming Activity Using the Whiteboard in Centra Symposium.

As part of a National Science Foundation project to study the effects of an online graduate certificate program for community college teachers, data have been collected at the end of each Centra session for both the community college educators and for traditional technology education graduate students. Figures 4-7 present data regarding where and how students connected to the session and the effectiveness of Centra to deliver the instruction. Figure 4 illustrates that the community college instructors either connected from home or work, while the technology education graduate students were equally divided between home, work, and school. Most students used high bandwidth connections (Figure 5). Their opinions about using Centra in the future were similar, however, some of the technology education graduate students did not care for the online environment (Figures 6 and 7).
In addition to the online evaluations, data are being gathered for the community college instructors through self-assessments of their technology skills, phone interviews with an external evaluator, assessing samples of work, and summative surveys after each course. The following are comments made by the first cohort of students after completing the Instructional Design in Technical and Technology Education course during the 2005 summer session.

What things did you like best about the Centra Symposium sessions?
- It allowed us to connect in real time. It was a great way to share and discuss our projects.
- The "group feel"... it was nice to "meet" my cohort.
- The ability to talk while projecting PP or some other file.
- Being able to ask a question and get an answer right away.
- I liked the instructor going over the chapters and keeping us informed of expectations for the assignments. The text was very good, too.

What things did you like least about the Centra Symposium sessions?
- Nothing really, it would have been nice if the instructor didn't have to teach everyone how to use it every time, but this is a problem with the students, not Centra or the instructor.
- I could never get the app share to work as well as the others.
- I did not have enough experience with the software to use the tools effectively.
• I don’t like having to stay on the computer over 1 hour and 15 minutes. That did not happen often. So, I appreciate that. On the computer over an hour is not the same as face-to-face. However, we were very active on the computer – break out sessions, or writing on the white board, and that helps the class to go by quicker.

**How has participating in an online format influenced the course experience?**

• [The instructor] made such an effort to keep us connected via weekly Centra sessions that other than seeing each other, it was almost like a seated course. I guess the major influence is that it has forced us to gain more experience with computer applications and e-mail.
• Becoming part of the larger piece helps address the doubts and fears of online teaching.
• Online is always better for me, because I need to be able to work late at night and early in the morning.
• We have to communicate with our classmates more. We can actually email anyone and get feedback. I think we have a stronger relationship because of the online format.

**ENGINEERING GRAPHICS COURSES AT NC STATE UNIVERSITY**

In North Carolina State University’s Graphic Communications program in the department of Mathematics, Science and Technology Education, several types of systems are being used to deliver engineering graphics instruction to students. In addition to regular web pages (see Figure 8), WebCT Vista is being used to supplement face-to-face instruction in three courses. In the introductory engineering graphics course, several instructors are using the CMS to provide basic course information (syllabus, calendar, assignments, etc.), present content, and provide links to other resources (see Figure 9). In the second and third level computer-aided design courses, the software is being used for online testing. Students are required to complete readings and workbook activities and then take short quizzes to test their knowledge before coming to class. This has been quite successful in the upper level CAD course. In the spring 2004 semester, students were required to read the assigned material, view voiced-over slides streamed over the Internet [14], and then take the midterm and final exams that were based on the material. During the spring 2005 semester, the instructor also required that the students take an online quiz for each reading assignment. Figure 10 shows exam scores before and after using the online quizzes.

![Figure 8. Delivering Information, Content and CAD Tutorials Through Web Pages.](image-url)
CONCLUSIONS AND RECOMMENDATIONS

Based on data collected from the community college educators in online courses and data gathered from engineering graphics courses where only portions of the courses are online, course management systems have been an effective way to deliver instruction. The community college educators have been incorporating the techniques they have learned into their own classroom practices. The group also reported that there is a need to feel better “connected” with their classmates. Since they do not meet face-to-face in a classroom, some participants missed the community building that typically occurs in many face-to-face classes. Course management systems have also allowed engineering graphics faculty to deliver course content and assess student learning in an efficient manner.

Moving some parts of a course or an entire course to an online format can be a daunting task for some faculty. Course management systems offer a wide range of asynchronous and synchronous tools that allow instructors to explore alternative ways of delivering instruction. Implemented properly, the online tools can be just as effective as
face-to-face courses in most situations. For those who are skeptical about these tools or not totally confident about
delving into these technologies, several recommendations are offered.

1. Talk to someone at your institution who is currently using these tools or systems and get their advice. They may
be willing to provide you with template files to get you started with creating web documents.
2. Find out if you have support staff at your institution who can provide training in the various distance learning
tools.
3. Start out small. Moving an entire course to an online format can be overwhelming if you have never taught using
CMS tools.
4. Visit an online session. If you know faculty who are using tools like Centra Symposium, ask them if you can
virtually “sit-in” on a session. It will give you a good feel for the types of things you can do in that environment.

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