

# Synchronous Distance Education in a Mechanical Engineering Technology Course

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## Abstract:

Instruction using the internet is not new and is being used more and more frequently. Some types of classes lend themselves very well to this mode of delivery; technical courses are more of a challenge. The need to use graphics and equations in the instruction and assessment increase the challenges of this type of instruction. Methods of delivery must be modified from face-to-face delivery, along with the methods of assessment.

There are many facets to the education of an engineer or engineering technician. Some of the objectives of the engineer's and engineering technician's education involve the following:

- Development of problem solving skills
- Understanding of the theory of physical science.
- Application of physical science theory through the solution of homework problems.
- Application of physical science theory through laboratory experiments.
- Application of physical science theory through the design of devices, processes, and systems.
- Communication of the results of the above through sketches, equations, numerical solutions, drawings, written reports, and oral reports.
- Solution of problems through teamwork.
- Management of time and other resources

The pedagogy of engineering and technology has been developed over the years through "stand and deliver" methods to meet the objectives above. Overhead projectors, written and copied material, chalkboards and whiteboards for sketches and equations, hand written assignments and tests, and physical laboratory experiments, etc. are all easy to use to accomplish the objectives for educating the engineer or technician. With online training, however, different methods must be used to accomplish the educational objectives; some of which have not even been imagined. In this paper, online instruction for technology and engineering courses will be examined. In particular, the experiences of teaching a first synchronous distance education course will be delivered, including the good, the bad, and the ugly. Some good and bad practices will be given, along with techniques for working example problems, and grading of homework.

## Background:

In the Purdue University College of Technology, there are different opportunities for students to earn a degree in Mechanical Engineering Technology: one of those is at the West Lafayette Campus; another is by attending one of the various Statewide Technology (SWT) Sites. One of those SWT sites is on the Ball State University campus in Muncie, Indiana. Here a student may earn an Associate Degree in Mechanical Engineering Technology. Class sizes are small compared to West Lafayette and sometimes too small for a class to be offered. Consequently, a student may have to wait to take a needed course. In the spring of 2007 this was the case for two SWT sites. The enrollment for this course was below the minimum at

both the Muncie and the Richmond SWT sites. There were three possibilities: have the students wait until there were enough enrolled, have two professors teach this class as arranged, or teach the class as a distance class. The third of these possibilities seemed to be the best for all involved.

The course the students needed was MET 214 Machine Elements. This is the first course in machine design, and is a non-laboratory course that is typically taken in the second year of the curriculum. Since I had taught this course for many years and had been experimenting with different methods of distance delivery, I volunteered to teach students at both sites. Because of various factors, including administrative issues, the decision to proceed was not made in time to fully prepare the course for this mode before the start of the semester. Therefore we had to learn as we proceeded with the course.

I had been experimenting with different modes of instruction for a few years and had some idea how this course should proceed. For example, various videos of screen captures had been prepared for other courses that were applicable to this course. In addition, methods of learning assessment had been tried, including online exams, as well as methods of assigning and grading homework. The following paragraphs will go into detail how this course was taught and what lessons were learned. This is meant as a beginning forum for this mode of delivery for technology courses so that we can learn from each other.

## **Lectures:**

Students in engineering and technology courses, most of the time, require lectures from a learned person to explain difficult topics. In the past, this has been done by standing at a blackboard, or whiteboard, making sketches, writing equations, solving example problems, etc. Using the internet for course delivery requires a different mode of performing these tasks.

The first problem was how are the lectures to be accomplished? There are different methods that can be used to deliver synchronous lectures online; namely, internet conferencing software, video conferencing, screen captures with voiceover, and MediaSite to name a few. The method that we started with was an internet conferencing software program called Macromedia Breeze, and now called Adobe Connect. This program was available through two sources for us: through IHETS and Purdue's Itap. With this program, web cam images and voice as well as PowerPoint and other images are transmitted over the internet. Anywhere a student has a high speed internet connection, there they can watch and participate in the class. The students don't even need a camera or microphone, even though these are recommended.

The second problem was how is the material to be presented? PowerPoint is a powerful program for presenting many kinds of material. This was what was used, since most of the class was already prepared as PowerPoint slides. Images from the text were scanned into PowerPoint and comments along with equations were put into the slides. A second associated problem was how are these slides to be presented to the students? There are at least three methods for presenting PowerPoint presentations using Adobe Connect. The first is to upload the presentation into Adobe Connect and then use the whiteboard capability of Connect for annotation on the slides. The second is to create an Adobe Acrobat pdf file and use the advanced commenting capabilities of Acrobat to do the annotations on the pdf file. The third is to use a second monitor and share the computer screen with everyone, and simply show the PowerPoint presentation in the normal fashion. In this class,

I used all three of these; but, found the Acrobat pdf method the best. I found that the whiteboard capabilities of Connect were difficult to use; but using the Acrobat pdf file and a pen tablet, it was easy to mark up the pdf images.

The third problem was, how can graphics be presented, equations be shown and manipulated, and example problems worked? In the conventional classroom, an instructor has the whiteboard or blackboard, and in many cases either an overhead projector or a document camera to capture images written on paper and then projected on a screen. In either of these scenarios, the instructor is writing where they are looking and they are using an instrument (pencil or chalk) that they are familiar with. When the class is taught using the internet and the computer, the images that you normally put on a board, or write on paper under a document camera have to be accomplished in a different manner. Some systems like Media Site use a document camera, which is not too different from the conventional classroom. Some experimentation was done with a digital camera operating as a web cam, but the resolution was not good enough for the students to understand what was being written. Like the lectures, it was found that annotation on pdf files was the best method of presenting graphics and equations. A second associated problem was how can hand drawn images be captured by the computer and transmitted over the internet? Today there are tablet PCs that do this job nicely and emulate the blackboard or paper; but, if you are like me and don't have one, you can use a pen tablet, or if you are very good, just the mouse itself. The pen tablet, however, has a drawback; you do not write where you are looking. You are writing on a tablet on your desk and looking at the screen where the image is going. This takes some practice, but is not impossible. The nice thing about computer graphics is that you can change colors and line styles easily and quickly.

A fourth problem was how would the course be managed? How will the students be communicated with, how will assignments be given and collected and grades recorded for the students to view at their leisure? Fortunately, Ball State University has Blackboard for course management. This system allows for announcements, assignments, a grade book, email to the students, and a nice feature called the digital dropbox. In addition, external links to the recordings were such that the students had to only click on the hyperlink for the recording.

Some of the students were familiar with Blackboard; but, most had not used it before. It was found that students unfamiliar with Blackboard had difficulty learning how to use it. One lecture was dedicated to the use of Blackboard and Adobe Connect. A PowerPoint presentation was given to all students in person, along with a short laboratory session on the use Blackboard and Adobe Connect. This one lecture did not prove to be adequate. Unfortunately, at mid-semester, some students still didn't know how to see their grades in Blackboard.

In the future, the first few lectures will be done in person. Another department at Purdue that is using Adobe Connect for lectures even has a "boot camp" for learning how to get the most out of the class. This would have been beneficial for this class. However, it requires someone to travel which defeats the purpose of distance learning.

Ball State University has been involved in online classes for some time and has looked at many technologies. As already stated, Adobe Connect was chosen as the mechanism for presenting this class, because of the capability for student participation. Another technology was available and was tried; but was limited in the requirement for the students to ask questions in "real time". Ball State University has multiple rooms with Media

Site installed. This technology allows the students a better view of the instructor during lectures and has a document camera for the graphics part of the lecture. Questions, however, can only be asked through email, text messaging, or telephone. Recording of the lectures are available for easy recording and student viewing. Recording of the student's questions is not available, only the instructor's answers. To get around the issue of student's questions, Adobe Connect for VOIP audio and Media Site for the video and document camera were tried together. Band width problems at the student's computers became such a problem that the students would lose the lecture entirely. This was abandoned after two lectures.

### **Other Lecture Methods:**

As discussed above, I have recorded entire lectures and short explanations using a program called HyperCam and another program called CamTasia Studio. These two programs allow video recording of the computer screen and audio recording of voice. I have recorded lectures on shear and bending moment diagrams, statically indeterminate beams, and other subjects, as well as worked example problems. When lecture time is limited, recordings, such as these, help with review of previous topics, explanation of difficult material, and solving example problems.

The main problem with recordings is that the students cannot ask questions in "real time". They either have to remember to ask the question during class time, or email or call the instructor.

### **Graphics:**

As has been said, graphics is a critical part of engineering and technology education. Tablet PCs are quite common today and provide this capability easily. I do not have a tablet PC and had to find another way to accomplish this objective. Wacom makes a pen tablet that will allow graphic input using a pen stylus. These come in various sizes and capabilities. The one I purchased cost about \$250. It has the capability to map to the screen, so that you can tell on the tablet approximately where you are on the screen. With a little practice it is possible to print and write on the tablet by just looking at the screen as you write. Also, it is possible to make sketches that are legible. The problem with any graphics is the amount of memory required to store the images. In addition, when these are recorded, there is a tremendous amount of disk space taken up. In one of the lectures, I worked an example entirely with the advanced commenting in Adobe Acrobat and recorded the example. The example never got recorded either because of the amount of graphics being recorded, or some other reason. Therefore, example problems were worked out on paper, scanned into Word and printed to Adobe Acrobat pdf and explained by marking some on the scanned image using the advanced commenting feature of Adobe Acrobat.

### **Assessing Understanding:**

This is one of the most difficult problems to solve in synchronous distance delivery of technology courses. The problem is to determine how much the students have understood and if they can apply what they have learned. Exams have been the mainstay in assessing the understanding and application of material for a long time. The problem is how, can this be done in a distance environment. One way is to use internet based testing programs like a program called InQsit. InQsit is a software package that is available here at BSU. It is useful for assessing understanding where questions can be used such as: multiple choice, true and false, or even some essay type questions where a range of answers can be established. If on the other hand it is necessary to also assess the student's understanding of the method of

arriving at that answer, it doesn't work very well. Engineering and technology assessment is as much about method as it is about the answer. In the case of this course, I chose paper exams that were presented in person. Proctored exams would also have been a possibility, but I chose delivery of the exam in person.

Homework is another mode of assessing understanding of the material. Sometimes, however, it is difficult to tell whose work you are assessing. Students are encouraged to work together and most will not plagiarize, but some do and homework is not trusted to be a good indicator of understanding. However, if the students do the homework and want feedback, how can this be done in a distance environment? What was found to work the best was to have the student do the homework in a normal fashion, scan the completed paper documents into MSWord and create a pdf of the Word document, or send the Word document as is. Blackboard has a digital dropbox feature in which students can electronically deposit their work. When this is utilized, the instructor's email is not overloaded, plus a time stamp is placed on the document to tell when it was "handed in".

Another method for submitting and grading homework is of course postal mail. This has been used in the past with success; however, it's not called snail mail for nothing.

Two methods were utilized to grade and comment on the homework: in the cases where a pdf file was created, the advanced commenting of Adobe Acrobat was used; in the cases where the doc file was submitted, either a pdf file was created and commented on, or a Microsoft Document Imaging file was printed directly from Word and commented on. In either case the students got feedback very similar to a hand graded paper.

There were two examinations given during the semester: a mid-term and a final. As already stated, these were both paper exams that were given and graded in the conventional manner. For the exams, an Excel spreadsheet was used to determine the understanding of the students and what objectives for the exam and course were met. For future courses, automated methods for assessment are being researched. Table 1 shows the grading sheet that was used for the mid-term exam. The names have been replaced to protect the student's privacy. As can be seen the right most column gives some indication of how well the class understood the particular topic.

**Table 1. Grading for Exams**

Objectives	Value	1	2	3	4	5	6	7	8	9	Percent
<b>Problem 1</b>											
Overall Free-body	10.0	9.5	10	9.5	9.5	9.5	9.5	9.5	9.5	9.5	95.6%
Determine Reactions	10.0	10	8	10	10	10	10	10	2	10	88.9%
Shear Diagram	10.0	10	10	8	8	10	10	5	5	10	84.4%
Moment Diagram	10.0	10	8	8	8	10	10	5	5	10	82.2%
Torque Diagram	10.0	10	0	5	10	10	10	0	0	10	61.1%
Diameter of Shaft for Strength	20.0	15	20	0	0	5	18	10	10	19	53.9%
Check Windup	10.0	0	0	10	0	10	10	0	0	0	33.3%
Bearing Selection	20.0	20	18	15	0	20	20	5	10	15	68.3%
<b>Total Problem 1</b>	100.0	84.5	74.0	65.5	45.5	84.5	97.5	44.5	41.5	83.5	
<b>Problem 2</b>											
Stress Element	10.0	10	10	10	8	10	10	10	10	10	97.8%
Mohr's Circle	20.0	10	15	15	15	20	20	15	20	20	83.3%
Maximum Shear Stress	10.0	10	5	5	0	10	10	8	10	10	75.6%
Principal Normals	10.0	5	5	0	5	10	10	8	10	10	70.0%
<b>Total Problem 2</b>	50.0	35.0	35.0	30.0	28.0	50.0	50.0	41.0	50.0	50.0	
<b>Problem 3</b>											
Endurance Limit Definition	20.0	20.0	10.0	0.0	20.0	20.0	20.0	20.0	0.0	20.0	72.2%
<b>Problem 4</b>											
Compute Angular Deflection	30.0	30	25	30	0	30	29	30	30	30	86.7%
<b>Total Problem 3</b>	30.0	30.0	25.0	30.0	0.0	30.0	29.0	30.0	30.0	30.0	
<b>Totals</b>	200.0	169.5	144.0	125.5	93.5	184.5	196.5	135.5	121.5	183.5	75.2%

**Record or not:**

Each of the lectures was recorded so that if a student couldn't make it to the live lecture they could watch it after the fact. Also, this provided a good way for the students to review material, in particular, the example problems that were worked. The recordings proved helpful to many of the students. My policy has been to take attendance in all of the "stand and deliver" classes that I teach; but, with the distance class, I told the students that attendance was not necessary. One student in particular #9 in Table 1, attended less than half of the lectures because of a work conflict. As can be seen, the lack of attendance does not show in this student's grade.

**Time required to Prepare for a Distance Delivery Class:**

I did not keep time records of the preparation time for this class; however, it was approximately a 10:1 ratio. As I have already said, I have taught this class before and had many of the PP slides created. If the class was taught for the first time and nothing was prepared, that figure could easily be doubled. With a distance class, not only do you need to prepare the lecture materials, but you need to prepare any example problems ahead of time, especially if you are going to comment on an Adobe Acrobat pdf file.

Some other things that may or may not be obvious, is that you need to be early for the class. You need to be online waiting for the students so that they can be given camera and voice rights for participation.

**Equipment Needed:**

The only requirements for students to participate in a class of this nature are a computer and a high speed internet connection. A microphone is not necessary, but is desirable if the student wants to be heard. The students can use the chat capability of Adobe Connect; but, this requires the instructor to keep monitoring the chat pod.

A web cam is also not necessary even though we used them. The band width that is taken up by the video makes it desirable to pause the camera or freeze it in one position to conserve band width.

For homework, the students should have access to a scanner. These devices are fairly inexpensive and usually available. In our case, these were available for all of the students.

**Problems encountered:**

The biggest problems encountered were with bandwidth. We chose to hold this class at 11:00 AM to 11:50 AM Tuesday, Thursday and Friday. This is about the time that a lot of people eat their lunch. Our bandwidth suffered because of this, because people were looking at their email and were on the internet. This problem may not be easily solved, but consideration of the time of day for a class that depends on good bandwidth is important.

Another problem also associated with bandwidth was that some students were connected to the internet over a wireless connection. This caused problems, especially with the voice transmission. Students and instructor should be on the fastest connection possible.

A third problem was with some of the recordings. At least one of the recordings was lost as has already been stated. Another problem is that the instructor must remember to start the recording. This is not automatic. Most of the time this was not a problem, but it is something else that the instructor must do.

**Student Questions Outside of Class:**

Most instructors want to be available for student's questions. With a distance class this becomes another problem. With this class, I provided "online office hours". On Monday and Wednesday evenings from 6:00 to 8:00 PM, I was in the meeting room available for any student that signed in. This is no different than conventional office hours, just a different mode. In addition, I provided the students with phone numbers where I could be reached, even my cell phone number. Email was also available for the students. I found that students used email and some phone calls for their questions and almost no one used the "online office" hours.

**Design Projects:**

An online class provides a state of the art experience for students. In today's engineering environment, many projects involve some distance collaboration. MET 214 has always had a design project for the students and this class was no different. There were nine students in the class and they were divided into three teams. At first, the students were assigned to teams that required them to meet at distance. I set up individual team meeting rooms in Adobe Connect for the students. I purposely assigned students to teams where they would have to collaborate at distance. This was changed early on in the semester because of complaints from some of the students. However, one of the teams was forced to use the meeting rooms to meet online with the company they were designing their device for. Because of the effort of the leader of this team and the cooperation of the client company, this was the most successful design project.

The presentation of the projects is normally done in a conference room setting; but,

this time the presentations were all done online with Adobe Connect. A recording of those presentations is available upon request.

### **Assessment of the Class:**

There were two modes used for assessment: the first was the normal course and instructor evaluations, the second was a survey that the students completed via a link emailed to them. The internet survey primarily focused on the internet delivery of the course, while the conventional evaluation included both the course and the instructor. These evaluations will not be presented here because of space requirements. However, the course assessment document will be presented upon request.

### **Conclusion:**

Any online class must be prepared well in advance of the semester it is taught. With synchronous delivery, students should be given thorough instruction in the use of the software and hardware utilized before instruction begins. Ideally this instruction should be like a boot camp where they meet in a laboratory environment and know how to use the equipment before the first lecture. One program at Purdue has the students come to campus for a week before the semester begins to instruct the students and to gain a community atmosphere. This has been successful for them; but for most students this would be impractical, if not impossible. Whatever method is used, students need help in the early stages of a course such as this.

Assignments should be given through a single document for each lecture. This document should include the objectives for the module, what the student should be expected to learn from the module, homework assignment, and a quiz to test the student's comprehension. Homework should be required to be handed in on time and should be handed back in a timely manner.

Any projects or group assignments should be given to force the students to use the internet for collaboration.