

## **AC 2008-238: DEVELOPMENT OF AN EET LECTURE COURSE IN IPOD© FORMAT**

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# Development of an EET Lecture Course in iPod® Format

## Abstract

The method used to convert a conventional Old Dominion University Electrical Engineering Technology lecture course to Apple iPod® format is shown. Included are course pedagogy development; methods of creating PowerPoint slides, including graphics, animation, and text; file format conversion; file editing; and final production of iPod-compatible material. Additional information is included regarding the selection and testing of various types of commercially-available file capture, file conversion, and media editing software.

## Introduction

As part of Old Dominion University's (ODU) distance education program, the Electrical Engineering Technology program offers lecture courses in several formats including live televised courses, internet streamed courses, and CD-ROM-based courses. However, with the introduction and subsequent popularity of the Apple iPod®, it seemed a natural step to migrate course instruction into that particular method of course delivery. This paper encompasses the process of producing a 3-semester-hour lecture course in a format that can be effectively viewed by students on an Apple iPod®, or watched on any computer using Apple QuickTime® media player.

With the growth of the distance education program at ODU, several logistical problems began to appear, including shortages of satellite broadcast channels, broadcast studio classrooms, and classrooms at ODU's receiving locations, and an increase in the number of distance education students who are not located near a ODU receive site (termed "siteless" students). These siteless students include those located outside the of Virginia, those located overseas, and those in the military, especially aboard ships.<sup>1</sup> Several years ago, this prompted an increase in courses designed to be delivered via CD-ROM or internet streaming delivery. However, both of these delivery methods require the student to be sitting at a computer, and the latter requires a high speed internet connection (either DSL or cable). For many students, one or both of these requirements is impossible.

Since most students own an iPod®, or as an alternative have a computer with QuickTime installed, it was determined that iPod® delivery of lecture courses would merit investigation. Since the course material would be engineering by nature, audio-only Podcasting was immediately ruled out. Video would be necessary in order to display schematics, equations, mechanical diagrams, photographs, and when necessary, animations.

As a goal, the course was to be delivered entirely in iPod® format with no supporting documents (other than the course textbook), and it should fit entirely in a standard 30 Gb iPod®. This would allow deploying military students to load the entire course on their iPod® prior to departure.

The ultimate goal of this paper is to include information on the development of this course, what works and what does not, all required development software, production techniques, limitations

of using an iPod<sup>®</sup> as a course delivery medium, and results of the project. For any instructor considering iPod<sup>®</sup> course delivery format, this is fundamentally a "how to" paper.

## **Course Description**

The course to be converted to iPod format is EET350 Fundamentals of Electrical Technology. It is a 3-credit course for non-electrical majors offered by the Electrical Engineering Technology program and taught by EET faculty. It is intended to provide the student with fundamentals of electrical circuit analysis, semiconductor electronics, digital circuits and an introduction to electrical machines.

The course provides non-EET majors with the underpinning to complete the electrical engineering technology minor at ODU, and as a leveling course for EET majors entering the program with a military electronics school background.

## **Course Delivery and Pedagogy**

At the outset, several delivery methods were considered, including web, CD-ROM, DVD, and iPod. Because of the anticipated file sizes, web delivery was immediately disqualified. CD-ROM and DVD were good candidates, but lacked portability, a feature that could be well utilized by the military component of our student body. Because iPod-based courses could be viewed either on an Apple iPod or on a desktop or laptop computer via QuickTime, it was decided that iPod delivery would be the best choice.

By nature, engineering courses are visually intensive. It is difficult, if not impossible, to deliver any course material to students without the use of equations, graphs, charts, diagrams, mechanical drawings, photographs, and schematics. For this reason, the target iPod for this project were chosen to be the 30 Gb and 80 Gb video iPods. These devices contain an integrated 320 x 240-pixel color LCD display.<sup>2</sup>

In addition to the display, another important issue was whether the iPod contains enough hard drive space to be able to store an entire course. The file size for each lecture would be a function of the type of video used. Movie-based lectures in which the instructor delivers lectures using frontal and overhead cameras (a traditional distance education broadcast classroom environment) would require extremely large file sizes, and was eventually deemed to be impractical. Generally speaking, the size of iPod video files (.m4v format) are determined by the amount of motion contained in the video. If, instead of using a "talking head" format, a slideshow-with-narration format is used, file sizes can be kept to a minimum.

Experiments were conducted with small 10- to 15-minute lectures and the resulting file sizes were extrapolated to estimate the space required for an entire course. From the results of these initial experiments it was determined that by using the narrated slide show format for the lecture modules, the entire course could easily be contained in less than 5 Gb of hard drive space. The conclusion therefore, was that an entire course could be preloaded into a 30 Gb or 80 Gb iPod, thereby making the course completely portable. Additionally, by keeping the total size of the course files below 5 Gb, the course can be delivered to the student via data DVD. This also

allows the student to drag all of the course files from the DVD into iTunes and sync them into the iPod, or to simply watch the lectures on the computer using QuickTime.

### **Required File Formats**

At the outset, creating and assembling the lectures seemed to be a rather daunting task. An obvious choice is that lectures with narration would be developed in Microsoft PowerPoint. However, from this point many other types of supporting application software would be required in order to generate equations, schematics, sketches, and photographs, and then to translate the resulting composite PowerPoint slideshow into the .m4v file format needed by the iPod.

**Equations** were created in MathType<sup>®</sup>. This was a simple decision because MathType integrates seamlessly into Microsoft PowerPoint. Additionally, the author used MathType for many years prior to this project, so there was no learning curve.

**Graphs** were created in Microsoft Excel or MatLab<sup>®</sup> and imported into PowerPoint using Windows clipboard or TechSmith's Snag-It<sup>®</sup>.

**Schematics** and **mechanical drawings** were created in Microsoft Visio<sup>®</sup>, clipboarded, and pasted into PowerPoint.

**Photographs** were taken in digital .gif format using a digital camera, and imported directly into PowerPoint.

**Animations** were done in PowerPoint using its animation feature. This had somewhat of a slow learning curve, but after some practice it was determined that the extent of animation that can be done in PowerPoint is only limited by the ingenuity of the user.

After assembling each set of PowerPoint lectures slides, voice narration was added and re-saved in PowerPoint thereby creating a complete self-pacing presentation in which the slide transitions are controlled by the length of the accompanying narration. It was then necessary to convert each of the .ppt files into .m4v iPod format.

### **File Conversion Software and Capabilities**

At first, it appeared that Camtasia<sup>®</sup> (TechSmith) would be capable of performing the necessary conversion of .ppt files into .m4v format. TechSmith advertises Camtasia as having the capability to import PowerPoint slideshows and then output them in iPod .m4v format. After purchasing and installing the software, it was found that the conversion is not a true file conversion, but instead is done by performing a screen and audio capture of the slideshow in real time as the presentation actually runs on the computer. This creates drawbacks.

First, the maximum screen resolution available is only as good as the screen resolution setting for the computer at the time the capture is performed. Since the target device (iPod) only has a 320 x 240 pixel screen resolution, this may not seem to be a problem. However, it was found that if the computer is not set to a high screen resolution when the capture is performed, the quality of

the final 320 x 240 video is degraded (softened), and artifacts can be detected in the video. This may be due to pixel dithering and averaging that is done in the resolution conversion process.

Second, if the slideshow contains smooth animations and slide transitions, the animations and slide transitions in the resulting .m4v file will be "jerky". The reason for this is that when Camtasia is performing a screen and audio capture, the additional resource loading on the computer's processor is such that frames of video are skipped, resulting in "jerky" animations and slide transitions when the file is viewed on the iPod. The author attempted to alleviate this by killing unnecessary processes that were running on the computer such as the virus checker, LAN drivers, and other resource loads. However, these did little to alleviate the problem. Next, assuming that there may be a bottleneck in the computer's video processor, the author installed a video accelerator board in the computer and shut-down the on-board video processor. This too did little to solve the problem.

After many hours of trials with little improvement, it was determined that the jerky video problem could best be solved by finding a program that could convert the PowerPoint .ppt file to a Camtasia-compatible format without using a real-time capture process; in other words, actually perform a true file conversion. It was deemed desirable for the lectures to pass through Camtasia because it has extremely good video and audio editing capabilities including video zoom and pan capability, and audio leveling and noise reduction.

After many hours of research into available software, it was determined that the best choice to perform this conversion is Presentersoft's PowerVideoMaker Professional<sup>®</sup>. PowerVideoMaker (PVM) can convert a .ppt file directly to .wmv, .mpeg, and .avi formats, any of which can be imported into Camtasia. It has the capability for the user to select video resolution up to 800 x 600 and the audio sample rate and resolution. Additionally, since it performs a true file conversion (not a screen capture), the process can run in the background without skipping video frames, even when the computer is concurrently performing other tasks. The author chose to use .wmv file format for this conversion because it provided the best combination of both video and audio quality. The result was smooth artifact-free video that could be directly imported into Camtasia.

Once the .wmv file was imported into Camtasia, an audio edit was performed to remove background noise. Also, since the iPod screen has low resolution, fine details of the graphics that would not be viewable on the iPod screen were zoomed and panned in Camtasia. After the lecture module was completely edited, reviewed, and ready for final production, the file was output from Camtasia in .m4v format.

It should be noted that the conversion from .avi or .mpeg to .m4v format could also be done with WinXMedia Software's WinXMedia AVI/MPEG to iPod Converter<sup>®</sup>. However, although the program was purchased and evaluated, it was not used in this project because it lacked the audio and video post-production features that are contained in Camtasia.

## **Course Development**

It should be noted that the actual development of course lectures did not begin at the time the software was received and installed. Prior to beginning course development, several months of preparatory work was required including the selection of software tools, testing of best audio and video formats, development of PowerPoint animation skills, and the honing of post-production editing skills in Camtasia. During this time, dozens of short trial lectures were developed, synced to the iPod, and then viewed and critiqued by the author and colleagues.

The course material was divided into small lecture modules, typically 2 to 6 modules per textbook chapter. In the end, 49 lecture modules were developed, each being 10 to 35 minutes in length. Although this totals less than the time included in a conventional 3-credit classroom-based course, consider that the lecture modules do not contain time-sinks that normally occur in the conventional classroom that detract from actual lecture time. These include student-instructor interactions, interruptions for questions and answers, taking of the roll, taking up and distributing papers, and going over homework problems, tests, and exams. This is not to say these actions do not exist in an iPod-based course, but instead they exist outside of the recorded iPod lectures thereby significantly reducing the total recorded lecture times.

One additional initial concern that impacted the course development process is the time that the iPod would operate on a single battery charge. With a course that requires video material to be constantly viewed, the iPod screen backlight is on constantly, which significantly shortens battery life. If battery life is very short, it would be necessary to break the lecture modules into smaller segments. Apple specifies that the iPod will play video up to 5 hours on one charge. This was tested experimentally, and found that run times in excess of 3 hours were the norm. This was determined to be sufficient to allow the student to view 6 to 12 lecture modules between battery charges, and deemed acceptable.

## **PowerPoint Development**

Since the iPod is foremost an audio reproduction machine, ensuring high audio quality for the project was a relatively simple matter. However, because of the small 320 x 240 pixel screen size, optimizing the video portion of the project was time-consuming. Many weeks of initial experimentation were undertaken prior to recording the course lectures in order to choose screen colors, type font, font sizes, graphics management, and animations to determine both the limitations of the low-resolution iPod screen and the optimal way to present material on the screen for best readability.

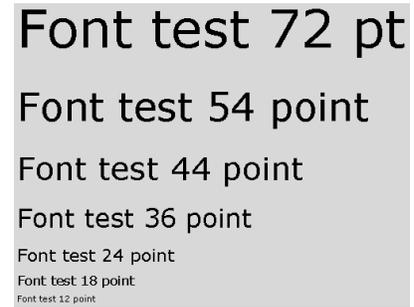
### **Slide Color Selection**

The ODU graphics designers were consulted regarding the selection of slide colors (background and font color). It was pointed out that the best readability of a slide can be achieved by having a high contrast between the background and font colors. Obviously, white background and black letters would be the best selections, but would also result in very boring slides, not to mention wasting the exceptional color rendering capability of the iPod screen. After some experimentation, light blue background (RGB values 185, 220, 255) and black lettering and

graphics (RGB values 0, 0, 0) produced an esthetically pleasing screen, while maintaining readability. These two colors were used throughout the lecture series with two exceptions: 1) The university logo appearing on the first slide of each lecture module used the university colors; and 2) other brighter colors (red, orange, bright green) were used to highlight important items on the screen.

## Font and Font Size

The ODU graphics designers also specified that for best readability, the optimal font is Verdana, mainly because it is simple and contains no serifs. To determine the range of optimal font sizes, a test screen containing Verdana script in various point sizes with blue background and black letters, shown in Figure 1, was developed in PowerPoint, processed into iPod .m4v format, and loaded into an iPod. The experimental result indicated that any text smaller than Verdana 24 points in PowerPoint would not be readable when viewed on the iPod. (Note that Figure 1 has been sized so that if this document is printed, it will be the actual size as viewed on the iPod.) Therefore, the font and font size chosen for this lecture series was Verdana, 24 point minimum.



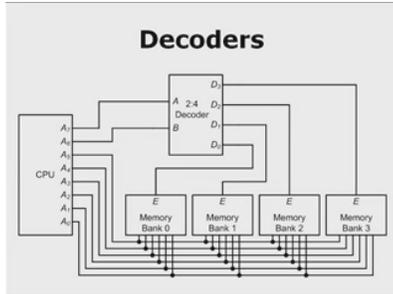
**Figure 1 - Font Test Screen**

## Graphics

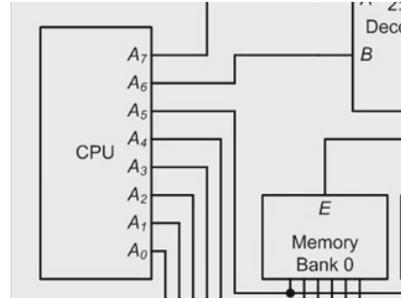
By nature, engineering graphics are intricate and sometimes large, making them especially problematic to display on an iPod screen.<sup>2</sup> Placing an entire electrical schematic diagram on an iPod screen would shrink every component in the diagram and render the entire schematic unreadable. Initially, it was decided to break the diagrams into parts and show each part on separate PowerPoint slides. However, after some practice with Camtasia, it was determined that its zoom and pan features would be ideal in solving this problem.

Figure 2 illustrates how the zoom feature in Camtasia was utilized to make portions of electrical schematic drawings more readable. In this figure, which illustrates how digital decoders are used to construct a simple computer memory, it is difficult-to-impossible to read the text contained in each of the component boxes. Therefore, for this part of the lecture, the slide in Figure 2 is initially introduced as a typical memory layout consisting of a CPU on the left, decoder on the top, and four memory chips on the bottom. Then, when the narration turns specifically to the CPU itself, the picture is simultaneously zoomed and panned to the left so that the CPU block fills the screen, as shown in Figure 3. Notice in Figure 3 that all text lettering is now readable, while this was not the case in Figure 2.

Once the CPU discussion is completed, Camtasia is again used to zoom back to the full schematic, and then zoom and pan to the next component to be discussed. By illustrating intricate graphics using smooth zooms and pans, the student always maintains a perspective of where in the diagram a particular zoomed component is located and its relationship to other components.



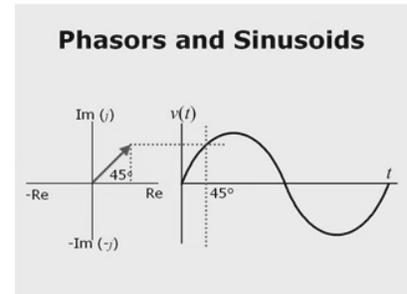
**Figure 2 - Graphic Example**



**Figure 3 - Zoomed Graphic**

## Animations

In engineering lecture material, animations add attention to lecture slides, illustrate how things work, and add realism to electromechanical illustrations. Animations can enhance the lecturer's ability to impart difficult concepts to the student and show how mathematical equations and graphical data relate to actual working devices. Figure 4 shows an illustration that relates a phasor (vector) in a Cartesian coordinate system on the left to a waveform on a time-domain graph on the right. In this illustration, the phasor on the left was rotated counterclockwise and projected onto the graph at the right to trace a sinusoid, thus allowing the student to immediately see the relationship between rotating phasors and sinusoidal waveforms.



**Figure 4 - Phasor Animation**

Although Camtasia contains some animation features, these are limited to highlights, markups, and scrolling title slides. It is incapable of performing animations on pre-embedded graphics. Therefore, all animations were added in PowerPoint. Although there is a somewhat slow learning curve on PowerPoint's animation features, after some practice, it was found to be capable of some relatively impressive animations. In the end product, animations were used to fade in/out equations, show how to connect measurement equipment to circuits, illustrate current flow and voltage polarities, draw XY graphs in real time, and illustrate rotating motors and generators.

## Slide Narration

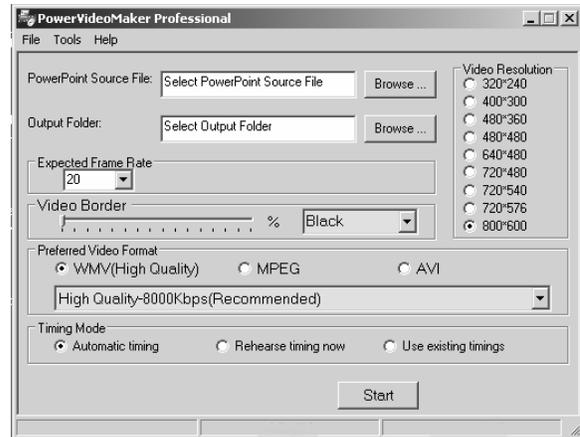
Slide narration was added using PowerPoint's "record narration" feature. For this portion of the project, it was found that a headset microphone performed best because it maintained a constant distance from the narrator (thereby maintaining a constant and repeatable volume level), it minimized ambient room noise, and by careful adjustment of its position, it also minimized pop and breathing noises. PowerPoint imbeds the recorded narration within the PowerPoint .ppt file, but also tracks the narration for each slide individually. The result is a single PowerPoint file containing all slides and narration while still retaining the capability to re-record the narration for any individual slide.

## File Production

Before processing the narrated PowerPoint presentation into other file formats, it is extremely important to watch the entire lecture and fix errors in either the graphics or narration. The author found that since errors are not so obvious to the one who made them, it was also very helpful to have a colleague review each presentation. Because the post production is a two-step process each requiring 30 to 120 minutes, it is very important that the initial PowerPoint presentation be as error-free as possible. After post-production, it is very time-consuming to fix errors.

### WMV File Production - PowerVideoMaker

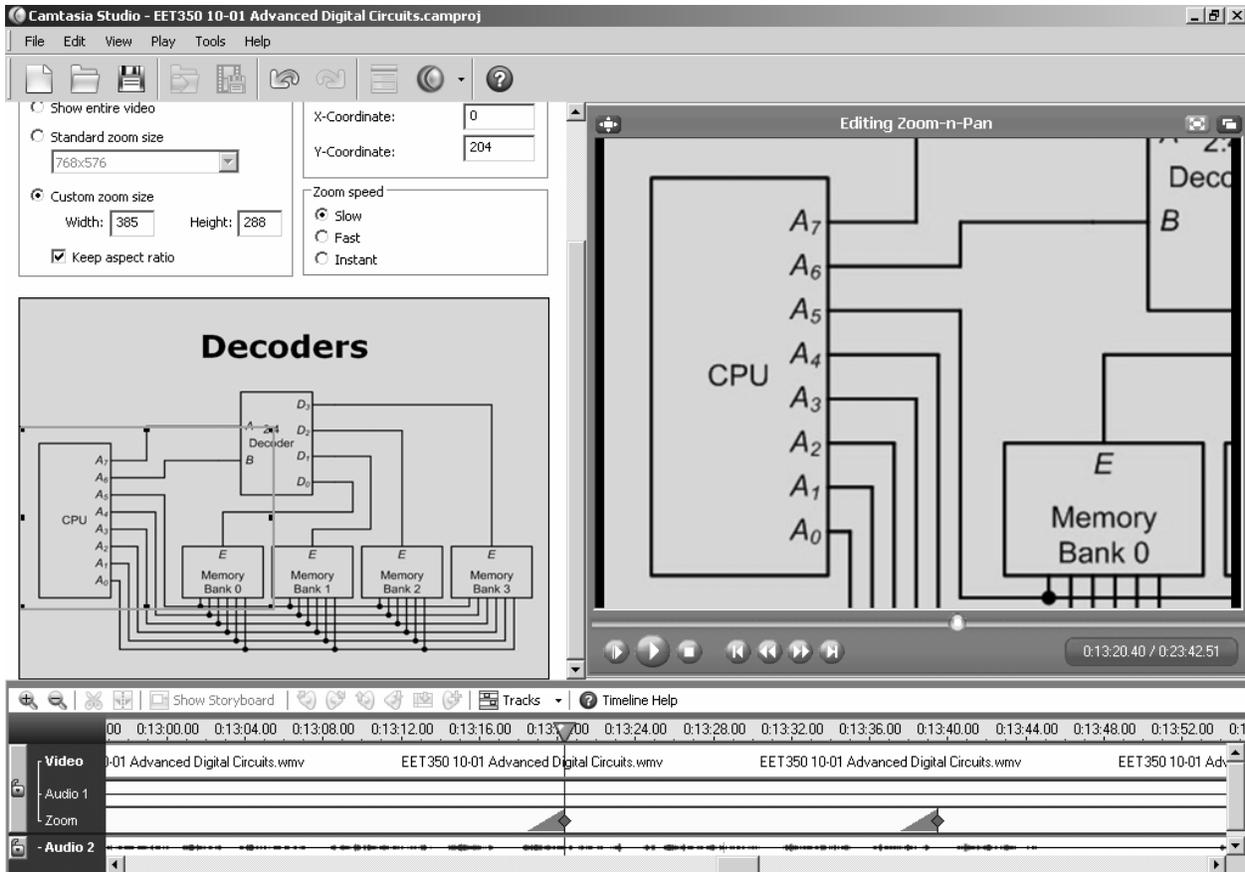
PresenterSoft's PowerVideoMaker was used to convert the .ppt file to .wmv format. PVM is also capable of converting to .mpeg and .avi formats, but after some experimentation, it was decided that .wmv format resulted in the best video and audio quality. Experimentation also showed that by setting PVM for the best possible audio and video qualities, some improvement in the final iPod audio and video was achieved. Therefore, as shown in Figure 5, PVM was set for a video resolution of 800x600, a frame rate of 20 fps, and audio quality of 8000 Kbps. Additionally, by checking the "automatic timing" radio button, PVM does an initial pass of the .ppt file to first determine slide timing. Unlike Camtasia, PVM does not have a batch mode, so .ppt files must be converted one-at-a-time.



**Figure 5 - PVM Setup**

### WMV File Editing - Camtasia

The next step is to load the .wmv file produced by PVM into Camtasia, add video zooms and pans, and process the audio for noise reduction. Zooming and panning is done using a timeline edit feature in which they are positioned as desired on the timeline and the speed of the zoom and pan is adjusted.



**Figure 6 - Camtasia Zoom and Pan Feature**

Figure 6 shows Camtasia's zoom and pan feature in use. The current zoom/pan is shown on the timeline at the bottom of the window. Notice that when the cursor is placed on the zoom (the wedge shape on the timeline), the play window at the upper right shows the screen view at that instant in time. Above the timeline on the left is the window used to define the area of the screen to be zoomed. Notice in the left of this window is a selection box that can be sized and dragged to fit the desired target area. Once a zoom or pan is initiated, it remains in effect until it is modified by another zoom or pan.

Background audio hiss and low-level ambient room noise in the audio can be eliminated by switching on Camtasia's "Remove Noise" feature. This feature is extremely effective and adds little distortion to voice narration.

### MP4 File Production - Camtasia

Once all video and audio edits are complete, the file is saved to a Camtasia project file (extension .camproj), and then the project is converted to .m4v iPod format. This is done by running the production wizard, selecting "Produce Video as..." in the menu, and following the on-screen directions.

Camtasia has a batch production feature. If several Camtasia projects are ready for final .m4v conversion, they can be placed in a cue and processed as a batch. For the EET350 project, as many as 10 projects were batch-processed overnight, thereby freeing the computer during the day for lecture development.

### Relative File Sizes and Backups

For planning purposes, it is important to be able to estimate expected file sizes in order to insure that sufficient hard drive space is available both on the computer and in the iPod.<sup>3</sup> File sizes vary according to length of the lecture and animated content. The amount of voice narration has a small effect on file size, but compared to the space needed for video storage, it can be considered to be insignificant. Typical file sizes for a 30-minute lecture are listed below.

.ppt Powerpoint with narration	21 Mb
.wmv file (output from PowerVideoMaker)	166 Mb
.camproj Camtasia project file	55 kB
.m4v iPod file	73 Mb

Using the production methods outline in this paper, a typical 3-credit lecture course will require 10 to 20 Gb of hard drive storage space for all ancillary files. Because of the extreme investment in time and effort required to produce an iPod-based course, it is imperative to backup all files on a regular schedule. For this purpose, a large external USB or networked hard drive works well. As a general rule, the author backed up working files at the end of each work session at a minimum.

### Results

At the time of this writing, the EET350 course production is completed, and a spring 2008 semester EET350 course has begun with 13 students registered. These students understand that this offering of the course uses a new delivery method and have agreed to contribute to the improvement of the course by reporting errors and suggesting improvements. Initial email feedback from the students is positive, with comments mainly stating that the use of effective animations makes the lecture material easier to understand.

At week 7 in the 14-week semester, a survey of the registered students was conducted consisting of five statements relating to the quality and video clarity of the lecture material. Students were asked to respond using the scale 1=strongly disagree, 2=disagree, 3=neutral, 4=agree, 5=strongly agree. The statements and responses are shown in Table 1, with 9 of the 13 students responding. In addition to the data shown in the table, it should be noted that for statements 1 through 4, all respondents gave responses of 3, 4, or 5, thereby indicating a general agreement that the lecture material being offered in this format is acceptable to their needs.

Interestingly, the class was neutral on statement 5, "Given a choice, I would rather take this course in this format than in a conventional classroom format (i.e., a class that meets in a classroom on a regular schedule)." This could be interpreted as meaning that overall the

comprehension of course lecture material in Podcast lecture format is equivalent to that of live lectures in a classroom format.

Statement	Mean	S. Dev.
1. I feel that I am adequately learning the required material in this course.	4.11	0.609
2. Compared to conventional classroom lectures, the recorded lecture material is relatively easy to understand.	3.89	0.609
3. The course material is organized so that lectures build one upon another.	4.63	0.518
4. The video quality in the lectures is adequate for the material being presented.	4.44	0.527
5. Given a choice, I would rather take this course in this format than in a conventional classroom format (i.e., a class that meets in a classroom on a regular schedule).	3	1

**Table 1 – Student Survey Results, n=9,  
Scale: 1=strongly disagree, 2=disagree, 3=neutral, 4=agree, 5=strongly agree**

As part of the survey, students were also given the opportunity to add written comments. They are all listed (unedited) below.

“I would rather have this type of class in a conventional classroom setting, but having this format available is a great alternative for students with busy class and work schedules, such as myself. Though it is good to have this available when the conventional class is not offered, I wouldn't try to replace the conventional class with this type of format.”

“I find the material well presented. The ability to replay areas that I don't grasp immediately is invaluable. Also the ability to work in convenient time blocks is a plus. The only drawback is purely my own. As a returning student of *many* years I miss the feedback of the classroom at this time.”

“If I had the ability to attend a conventional class I would. I believe that attending class aids in understanding the material; this is particularly true when you can ask questions as they arise during the lecture. For a person who is motivated and does not have the ability to attend a traditional course (due to scheduling / distance) I believe that this course is a great avenue for learning.”

“If the material was harder...I would recommend a classroom...”

“I love the way this class is offered because of my family's structure. My husband is in the Navy, and I am a fulltime student with two young children. This class is exactly what Distance Learning should be like. The teacher is still available for assistance, but the lectures provided are great and easy to follow. I LOVE this class!”

“The main problem that I encountered was that when I would get stuck on a problem or a concept, I would tell myself that I would ask the instructor about it, but I never get around to doing it. This is why I think that it would be very beneficial for the student to be required to perhaps meet with the instructor once a week so the student would be more likely to take care of the original problem before the new lectures build upon the previous ones.”

## Conclusions

Conversion of an engineering technology lecture course to a format that can be played on an Apple iPod is a challenging, but very achievable goal. Assuming that the instructor has access to standard office and technical software (PowerPoint, drafting, and math equation editing), the remaining file conversion software is relatively inexpensive (Camtasia \$169, and PresenterSoft PowerVideoMaker \$150). However, learning to effectively utilize the software to produce a quality product is a time-consuming trial-and-error process. The instructor should plan to spend 1-2 months becoming familiar with the software and developing and producing trial lectures prior to beginning the actual course lectures.

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