

# Using a Computer Screen as a Whiteboard while Recording the Lecture as a Sound Movie

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## Abstract

The purpose of this presentation is to demonstrate the process of using a laptop computer screen as a whiteboard, while, at the same time, recording all screen activity, and everything that is being said, as a sound movie. The result is a clear, complete, and reliable set of lecture notes that the students can pick up from the instructor's web site, and also a complete movie recording of the actual proceedings of the classroom.

When viewing a movie, students have the option to pause it at any time while they collect their thoughts; or they can pull the cursor back and forth to view the specific parts of the movie that are most important to them. The movie recording of each lecture, and other course materials, are made available on a CD which is duplicated in a CD copier, and is ready to be picked up by the students very soon after the lecture ends.

Lecture material is written with *Scientific Workplace* or *Scientific Notebook* which combine the advantage of a dynamically produced clear and complete set of lecture notes with instant access to a computer algebra system. The movie is created, either with the recording utility in *Camtasia Studio* by TechSmith, or by *ScreenCorder 4* by Matchware. Then the CD is mastered by the MenuMaker utility in Camtasia Studio and, within minutes, a complete, friendly self-contained CD has been mastered and can be carried to the instructor's CD copy machine.

The presentation will demonstrate how these software products can be used to produce the results that have been described here, and will discuss the advantages of giving students the option of duplicating the actual lecture room experience rather than merely reading a set of lecture notes.

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# 1 Introduction: Technology for Communication

The use of technological tools in the teaching of mathematics has come to be identified, largely, with the use of computing tools such as computer algebra systems and hand-held calculators. Accordingly, the programme of a typical technology conference bristles with presentations on the use of various computer algebra systems and on the use of hand-held calculators to enhance the teaching and learning of mathematics.

The author of this paper recognizes that such technological tools can have enormous value of under certain conditions, but feels that the mathematical community has taken too narrow a view of technology and has plunged headlong into an orgy of computer algebra and calculator use that is out of proportion to its true value. I am concerned that some mathematics courses are losing their frame of reference and abdicating their responsibility to teach the understanding of mathematical ideas and principles as they continue to look for new ways to embellish the material with the use of computer algebra systems. I am also concerned that some mathematics curricula and technology conferences may be subsidized by those whose computing products would be featured in them and who therefore have a financial interest in the content being presented. There is a danger that the academic integrity of such curricula or conferences may, in some cases, be tainted.

This paper presents suggestions for a different role of technology, a role of *communication*. I discovered some years ago that it is possible to train oneself to write with an efficient scientific word processor much more rapidly and effectively than anyone can write on a chalkboard. I started producing my lectures by typing into a laptop computer and projecting my image onto a screen, and I found that I could generate a set of lecture notes that was vastly more readable, complete, and precise than anything that could be written on a board, while still having the benefit of being the actual notes that were created during the teaching process in the classroom. In this way, I could free my students from the responsibility of compiling the notes while they are also trying to absorb what I am saying to them, and I could guarantee that the notes on which they based their studies were complete and reliable. Furthermore, since the notes thus created could be read both as hard copy and on the computer screen, where use of a computer algebra system happens to be appropriate, I can make my notes interactive with the help of the computer algebra systems that are bundled into the mathematical word processor that I use.

Then, about three years ago, I took the next logical step and started recording the entire process as I teach in the classroom. I use a recording utility that can record any chosen region of my computer screen and, in this way, I produce a sound movie reproduction of my lectures, exactly as they take place in the classroom. Thus, students who are having trouble working through their lecture notes have the option of a virtual re-entry to the classroom to receive any chosen item of the material again in a lecture environment. Within a few minutes of the end of each of my lectures, I have mastered a CD that contains the complete set of lecture notes given, to date, in the course, and contains the

movie recording of the latest lecture. The master CD is carried to my office where I have a CD copy machine and, a few minutes later, I am placing CDs on a table for the students to pick up. Each student receives a CD for each time that the class meets.

## 2 Software Issues

### 2.1 Using The Computer Screen as a Whiteboard

My solution to the problem of using a computer screen as a whiteboard is to type into a *Scientific Notebook* or *Scientific WorkPlace*<sup>1</sup> document. In order for such typing to be done efficiently, some considerable training is required. It would, of course, be easier to write directly onto an electronic whiteboard or onto a conventional board while someone is holding a camcorder. But, for those who take the trouble to acquire the skills for efficient typing, the advantages are manifest. The document screen allows rapid and continuous scrolling so that nothing has to be erased as the lecture progresses. The notes being produced have a truly professional textbook look. I build in several different colored highlighting options to make it easy for the student to distinguish between different items in the notes. The notes are easy to publish on a website and, in order to read and print the notes, a student is not required to purchase any software.

Typing aids such as "drag and drop" make it possible to produce notes at a vastly greater rate than anyone can realize while writing on a blackboard, and I am able to show many more working steps. During the lecture, I can return at any time to a position in the document and insert additional working steps in response to student questions. The dragging process also provides a visual effect, allowing the students to see where something comes from.

I often begin a lecture by opening the notes of the preceding lecture, saving it under a new name, and then working through homework problems that were placed in that document. This saves me the time and effort of rewriting those homework problems.

Finally, while teaching, I can often make my typing even more rapid by using the built in computer algebra system to perform operations on my algebraic or calculus expressions, or to draw a wide variety of graphs. Moreover, I can insert interactive ingredients into my notes that allow the student to use the computer algebra system to explore the mathematics as the notes are being read.

### 2.2 An Excerpt from a Set of Lecture Notes

The following excerpt from an a set of lecture notes generated in the classroom gives an idea of how the notes can appear. Of course, the color highlighting

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<sup>1</sup>*Scientific Notebook* and *Scientific WorkPlace* are trademarks of MacKichan Software Inc. ([www.mackichan.com](http://www.mackichan.com))

and other special effects cannot be shown here. The notes the students see look more attractive.

## The Series $\sum \frac{\sin nx}{n}$

We assume that  $x$  is any given number and we are going to show that  $\sum \frac{\sin nx}{n}$  must always be convergent.

### Case 1

In the event that  $\sin \frac{x}{2} = 0$  the number  $\frac{x}{2}$  must be an integer times  $\pi$ . If we have

$$\frac{x}{2} = k\pi$$

then

$$x = 2k\pi$$

and, for each  $n$  we would have

$$nx = n2k\pi$$

and the series

$$\sum \frac{\sin nx}{n}$$

is just  $\sum 0$

### Case 2

We now assume that  $\sin \frac{x}{2} \neq 0$ .

Since

$$\sum \frac{\sin nx}{n} = \sum \left( \frac{1}{n} \right) (\sin nx),$$

and since we know that  $\frac{1}{n}$  decreases to 0 as  $n \rightarrow \infty$ , all we need to see, in order to be able to use Dirichlet's test to show that

$$\sum \frac{\sin nx}{n}$$

is convergent is that, for some constant  $q$  we have

$$|\sin x + \sin 2x + \sin 3x + \cdots + \sin nx| \leq q$$

for all  $n$ .

Now, for each  $n$  we have

$$= \left| \frac{\sin x + \sin 2x + \sin 3x + \cdots + \sin nx}{2 \sin \frac{x}{2}} \right|$$

We are now going to use the trig identity that says that, if  $\alpha$  and  $\beta$  are any given numbers then

$$\begin{aligned}\cos(\alpha - \beta) - \cos(\alpha + \beta) &= (\cos \alpha \cos \beta + \sin \alpha \sin \beta) - (\cos \alpha \cos \beta - \sin \alpha \sin \beta) \\ &= 2 \sin \alpha \sin \beta\end{aligned}$$

In other words,

$$\cos(\alpha - \beta) - \cos(\alpha + \beta) = 2 \sin \alpha \sin \beta$$

Using this identity we see that

$$\begin{aligned}& |\sin x + \sin 2x + \sin 3x + \cdots + \sin nx| \\ &= \left| \frac{2 \sin x \sin \frac{x}{2} + 2 \sin 2x \sin \frac{x}{2} + 2 \sin 3x \sin \frac{x}{2} + \cdots + 2 \sin nx \sin \frac{x}{2}}{2 \sin \frac{x}{2}} \right| \\ &= \left| \frac{\cos \frac{x}{2} - \cos \frac{3x}{2} + \cos \frac{3x}{2} - \cos \frac{5x}{2} + \cdots + \cos \frac{(2n-1)x}{2} - \cos \frac{(2n+1)x}{2}}{2 \sin \frac{x}{2}} \right| \\ &= \left| \frac{\cos \frac{x}{2} - \cos \frac{(2n+1)x}{2}}{2 \sin \frac{x}{2}} \right| \leq \frac{1 + 1}{|2 \sin \frac{x}{2}|} = \frac{1}{|\sin \frac{x}{2}|}\end{aligned}$$

and so, for any given choice of  $x$ , we have the inequality

$$|\sin x + \sin 2x + \sin 3x + \cdots + \sin nx| \leq \frac{1}{|\sin \frac{x}{2}|}$$

and so the convergence of the series  $\sum \frac{\sin nx}{n}$  follows from Dirichlet's test.

## 2.3 Producing Graphics

When I am using my computer screen as a whiteboard as I write into a *Scientific Notebook* document, I can produce all of the mathematical graphs directly, but there is also a need to make drawings of the type that one would draw freehand on a blackboard. Again the process requires some training but the effort is well worth while. Once in a while, I need the freedom that comes with raster style graphics and, for this purpose, I work in a raster layer in *Paint Shop Pro*<sup>2</sup>. However, my principal graphics work horse is *SmartDraw*<sup>3</sup>. While teaching, I can Alt+Tab to *SmartDraw*, draw a figure, copy it to the clipboard, Alt+Tab back to *Scientific Notebook* and paste in less time than I could draw the figure on a blackboard. The Copy As Picture feature of *Scientific Notebook* also allows me to paste mathematical symbolism into my *SmartDraw* figure.

When I need more complicated figures, I can “cheat” by making them in advance of the lecture. The analogue in conventional teaching would be to walk in with the figure and project it with an overhead projector, but my method actually imports the figure into the notes that the students will have in their own computers or in their hard copy prints.

<sup>2</sup>Paint Shop Pro is a trademark of Jasc Software Inc. ([www.jasc.com](http://www.jasc.com))

<sup>3</sup>SmartDraw is a trademark of SmartDraw.com.

## 2.4 Recording in the Classroom

There are two software products that may be used for creating recordings of computer activity. These are *Camtasia Studio*<sup>4</sup> and *ScreenCorder 4*<sup>5</sup>. Each has its own role to play.

*Camtasia Studio* includes a recording utility called *Camtasia Recorder* that is able to record any rectangular region of the screen, together with all sound, and to export the recording as a high quality AVI file. I use this recording utility in the classroom. It has the advantage of being very fast and totally reliable. I have never experienced a crash with *Camtasia Recorder*. Once the AVI file has been made, I use the *MenuMaker* feature in *Camtasia Studio* to master a CD. Within a few minutes, I have a CD mastered with a nice friendly welcome menu that shows links to all of my lecture notes and to the latest movie. The *Camtasia Player* is also bundled into the CD and is used automatically to play the movie. In that way, I am assured that all students will see exactly the same thing and that there won't be any technical difficulties. *Camtasia Studio* also provides a *Pack and Show* method of supplying movies. This method is suitable for shorter movies (not much more than 30 minutes of full screen playing) and supplies the movies as EXE files that can be the targets of hypertext links in any good on-screen word processor, or in an HTML file.

One may also choose from a variety of other file types. For example, one may choose to export the movie as a WMV file that will play in the Windows Media Player. The quality is not quite as good but it is still good enough if the settings are chosen carefully. Note that movies viewed with Media Player *must* be played full screen. It is necessary to teach students to switch their settings to full screen (Alt + Enter) as the movie begins playing. The greatest weakness of the Windows Media Player is the crude facilities it offers for fast-forward and rewind. Another disadvantage of this method is that the instructor must devote additional wait time for conversion of the movie, and this wait time can be considerable, especially with a slower computer. A striking advantage of this method is that the WMV file sizes are considerable smaller than the AVI file sizes. And finally, the WMV files are suitable for streaming and can be made available on a website.

## 2.5 Recording Outside of the Classroom

Recordings made in the classroom are “warts and all” recordings of the actual proceedings of a lecture. But there is also a need for recordings of a much more polished nature that would be made in the privacy of an office. Such recordings could be companions to textbooks or supplied in their own right. For the recording of such movies, I recommend *ScreenCorder 4*. Although *ScreenCorder 4* exports its video more slowly than *Camtasia Recorder*, and although *ScreenCorder 4* may not match the stability of *Camtasia Recorder*, there are features

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<sup>4</sup>*Camtasia Studio* is a trademark of the TechSmith Corporation. ([www.techsmith.com](http://www.techsmith.com))

<sup>5</sup>*ScreenCorder 4* is a trademark of Matchware. ([www.matchware.net](http://www.matchware.net))

in *ScreenCorder 4* that make it a *sine qua non* for quality recordings done in the office.

A principal and unique feature of *ScreenCorder 4* is its ability to supply some editing functions while the actual recording is taking place. At any moment, the movie may be paused and the cursor dragged back to any chosen point to allow playing of the movie made from that point. Then, if what has been made is not what is wanted, the cursor can be placed before the unwanted material and the recording process started again. All of the movie from that point onward will be overwritten by the new attempt. *ScreenCorder 4* also allows the project to be saved at any time. The saving is instantaneous. So one can re-enter the movie at any time and make changes by overwriting all of the movie that comes after any chosen point.

By using *ScreenCorder 4*, one may make movies that are vastly more polished than movies that have to be made in a single recording session. Then, after the movie has been made, one may import it into *Camtasia Studio* and use the editing features in *Camtasia Studio* to delete unwanted portions of the movie, insert missing material, splice movies together etc. Finally, the movie can be presented with either the *Camtasia Pack and Show* feature, or its *MenuMaker* feature.

For even higher quality CDs (such as those that might be created for sale), I would use a professional quality CD mastering utility to make my welcome screen and then place a link there to a *Camtasia MenuMaker* screen.

## 2.6 Copy Protecting CDs

This is a very hard problem. So far, I have not seen any cheap solutions. Be prepared to jump through hoops and pay big bucks. Hopefully I'll have better news in the future.

# 3 Hardware Issues

## 3.1 Recording Sound

In order to record sound, one needs to have a microphone. I do not advocate use of a microphone that may be built into a laptop computer. Instead, a microphone can be mounted on the instructor's head. For good quality sound, the microphone should be plugged into a small tube preamplifier that, in turn, is plugged into the line-in jack of the computer. You can expect to pay about \$200 for this sound equipment. For sound equipment needed to make movies, I recommend that one visit a good music store, rather than a computer store.

Note that some of the more recent laptop computers from Dell are no longer supplied with line-in jacks, but I have been instructed by Dell to use the microphone jack and have had no problems.

### 3.2 The Need for a Good Graphics Card

A computer to be used for the making of movies should have a reasonably fast CPU. I don't know how fast is enough but I have evidence that 1.2 GHz seems to be insufficient and that 3.0 GHz is sufficient. Above all, the computer should have a good graphics card. I ordered my present Dell 5150 laptop with an upgraded graphics card and this computer works well during the recording process.

If a computer lacks sufficient computing power to make the movies efficiently, it is necessary to go into the screen display settings and, in the Advanced menu, to disable the graphics acceleration before recording a movie. Failure to disable graphics acceleration in a slow computer could cause the computer to choke while the movie is being made. Both *ScreenCorder 4* and *Camtasia Recorder* offer an option for automatic disabling of graphics acceleration, but I prefer to do it manually. The disabling of graphics acceleration can cause a variety of undesirable effects and so it is vastly more preferable to have a sufficiently powerful computer and not to disable graphics acceleration. One may also reduce the load on the computer by reducing the color depth but, in my opinion, reduction of the color depth is very undesirable.

### 3.3 Mouse and Keyboard

In my opinion, under no circumstances should one try to use the built in screen mouse and keyboard of a laptop computer. For fast, efficient, and reliable typing, carry a conventional mouse and a high quality ergonomic keyboard. Never use a standard flat keyboard. Use the same keyboard at every computer at which you work. Never type on someone else's keyboard.

### 3.4 Burning CDs

CD copy machines have become much more common over the past couple of years, and the price has dropped sharply. You can expect to find a nice free standing copy machine for about \$2000. The simplest machines would cost less, but a really nice fast machine that would work together with your desktop computer could cost as much as \$8000. The CDs themselves have become very cheap. By looking for specials and by bargaining on the basis of the large number of CDs that I buy, I have been able to reduce the cost of CDs to a minimum. I don't bother with labels. I write the course number and date on the front of each CD with a Sharpie pen. I don't bother with sleeves or jewel cases but some of my students have their own. Others treat my CDs more harshly, but they play well in spite of such treatment.

My department finds it necessary to require students to pay for the CD blanks that are used for my courses and this comes to between \$5 and \$7 per semester. I have made it clear to my students that, if anyone comes to me and tells me that he or she is unable to pay the fee, then I shall willingly do so on



his or her behalf out of my own pocket. To date, I have not had anyone take me up on that offer.

## 4 Conclusion

The process of using a computer as a whiteboard requires some hard work and intensive training, and it also requires the spending of some money on software and hardware. But, for those to take the plunge, it is possible to elevate the quality of mathematics teaching to a new level. The response I have had from students is enthusiastic and they show great appreciation for the service that I provide to them. Time and time again, I have heard students complain that they felt that they understood the material when they were sitting in the lecture but then they couldn't make sense of it later when they were reading the notes. My movies allow them to go back to the actual lecture whenever they like and to sit through any part of it that they need.

And yes, I have noticed a lower drop rate and higher course grades.