

Using a Computer Screen as a Whiteboard for the Creation of Lecture Notes and Screen Capture Videos

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Introduction: Technology for Communication

In the mathematics teaching community, the use of modern technological tools has come to be identified, largely, with the use of computing utilities such as computer algebra systems and hand-held calculators. While I recognize that such utilities, properly used, have the potential to enhance the teaching and learning of mathematics, I feel that the mathematical community has taken too narrow a view of technology and has plunged headlong into an orgy of computer algebra and calculator activity that is out of proportion to its true value. I am concerned that some mathematics courses may be losing their frame of reference and may be abdicating their responsibility to convey understanding of mathematical ideas and principles as they attempt to embellish the material with the use of computer algebra systems. I am also concerned that some mathematics curricula and technology conferences may be tainted by the financial support that they receive from those whose hardware and software products are 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 and conferences may, in some cases, be compromised.

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, several 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 everything that appears on 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 uploaded to my office where I have a CD/DVD duplicator machine and, a few minutes later, CDs are ready for the students to pick up. Each student receives a CD for each time that the class meets.

Using The Computer Screen as a Whiteboard

Finding the Right Mathematical Word Processor

The process of using a computer screen as a whiteboard hinges on the instructor's ability to type quality documents that support mathematical notation and it depends on the ability to produce such documents rapidly and effortlessly. I achieved this ability using the **MacKichan Software** product *Scientific WorkPlace* (or *Scientific Notebook*). There is nothing else like it in the marketplace. Not only is it possible to learn to type quickly and effortlessly, but all mathematical content is understood by its built-in computer algebra system. 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 board and, using these products, I am able to show many more working steps than would otherwise be possible. During the lecture, I can return at any time to any 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.

No matter what method is used to type the documents, some considerable training is required before one can type mathematical material rapidly in front of an audience. It would, of course, be easier to write directly, albeit more slowly, 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 with *Scientific WorkPlace*, 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.

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. While teaching, I can sometimes 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.

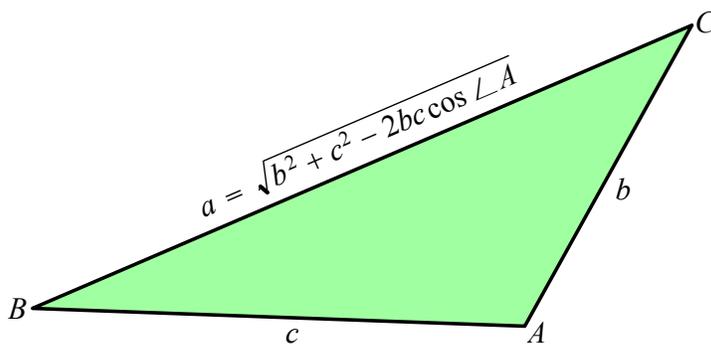
Inserting Drawings into a Document

Broadly speaking, there are two kinds of drawings, vector graphics drawings and raster graphics drawings. Vector graphics have true printer quality. Raster graphics products provide only screen quality but are less restrictive.

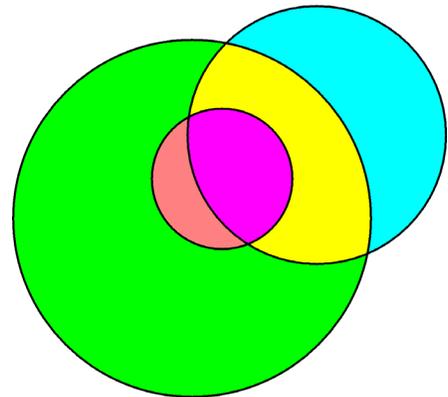
For the creation of vector graphics drawings, I use either Corel Designer (www.corel.com), Version 10 or earlier, or SmartDraw (www.smartdraw.com), version 7 or earlier. Combining these drawing products with the Copy Picture feature in Scientific Notebook, one can easily make drawings like the one on the left below and the whole process takes under a minute. I must emphasize, however, that there is an incompatibility between the Copy Picture feature of Scientific Workplace 5.5 and the latest versions of both SmartDraw and Designer. It is possible to order SmartDraw Version 7 over the phone even though it is not offered on the Smartdraw.com website.

When we need the extra freedom that raster graphics allows, we can use any one of a number of products. The two products I use most often are Corel PaintShop Pro and SmartDraw FotoFinish. The figure on the right below shows an example raster graphics drawing that makes use of the

flood fill tool  that can be provided only in a raster graphics environment.



Vector Graphics



Raster Graphics

I should add that Paintshop Pro makes it possible for a drawing to contain both vector and raster layers.

An Excerpt from an Actual Set of Lecture Notes: Work Done by a Force

The following excerpt from an actual set of lecture notes generated in the classroom in front of the students shows how the notes can be expected to look.

We have a particle sitting at rest with mass m at a point a on the the axis. The particle is acted on by a force F and it arrives at a point b on the number line with velocity V . We want to know how much work was done.

Einstein (1916) gave a formula for mass at speed v to be

$$\frac{m}{\sqrt{1 - \frac{v^2}{c^2}}}$$

where c stands for the speed of light.

The work done is

$$\begin{aligned} \int_a^b F dx &= \int_a^b \frac{d}{dt} \left(\frac{mv}{\sqrt{1 - \frac{v^2}{c^2}}} \right) dx \\ &= \int_a^b \left(\frac{d}{dv} \left(\frac{mv}{\sqrt{1 - \frac{v^2}{c^2}}} \right) \right) \frac{dv}{dt} dx \\ &= \int_a^b \left(\frac{d}{dv} \left(\frac{mv}{\sqrt{1 - \frac{v^2}{c^2}}} \right) \right) \frac{dv}{dx} \frac{dx}{dt} dx \\ &= \int_a^b \left(\frac{d}{dv} \left(\frac{mv}{\sqrt{1 - \frac{v^2}{c^2}}} \right) \right) v \frac{dv}{dx} dx \end{aligned}$$

When we change from x to v we get

$$\int_a^b F dx = \int_0^V \left(\frac{d}{dv} \left(\frac{mv}{\sqrt{1 - \frac{v^2}{c^2}}} \right) \right) (v) dv$$

and, when we integrate by parts, we see that

$$\begin{aligned} \int_a^b F dx &= \left[\left(\frac{mv}{\sqrt{1 - \frac{v^2}{c^2}}} \right) (v) \right]_0^V - \int_0^V \left(\frac{mv}{\sqrt{1 - \frac{v^2}{c^2}}} \right) \left(\frac{d}{dv} v \right) dv \\ &= \frac{mV^2}{\sqrt{1 - \frac{V^2}{c^2}}} - 0 - \int_0^V \frac{mv}{\sqrt{1 - \frac{v^2}{c^2}}} dv \end{aligned}$$

Now let's talk about

$$\int_0^V \frac{mv}{\sqrt{1 - \frac{v^2}{c^2}}} dv$$

We write

$$u = 1 - \frac{v^2}{c^2}$$

then

$$du = -\frac{2v}{c^2} dv$$

which gives us

$$\begin{aligned}v dv &= -\frac{c^2}{2} du \\ \int_0^V \frac{mv}{\sqrt{1 - \frac{v^2}{c^2}}} dv &= -\frac{mc^2}{2} \int_1^{1 - \frac{V^2}{c^2}} \frac{1}{\sqrt{u}} du \\ &= -\frac{mc^2}{2} \left[2\sqrt{u} \right]_1^{1 - \frac{V^2}{c^2}} \\ &= -mc^2 \sqrt{1 - \frac{V^2}{c^2}} + mc^2\end{aligned}$$

So, going back, we see that the expression

$$\frac{mV^2}{\sqrt{1 - \frac{V^2}{c^2}}} - 0 - \int_0^V \frac{mv}{\sqrt{1 - \frac{v^2}{c^2}}} dv$$

is equal to

$$\begin{aligned}&\frac{mV^2}{\sqrt{1 - \frac{V^2}{c^2}}} + mc^2 \sqrt{1 - \frac{V^2}{c^2}} - mc^2 \\ &= \frac{mV^2 + mc^2 \left(1 - \frac{V^2}{c^2}\right)}{\sqrt{1 - \frac{V^2}{c^2}}} - mc^2 \\ &= \frac{mc^2}{\sqrt{1 - \frac{V^2}{c^2}}} - mc^2\end{aligned}$$

This comes out as

$$\left(\frac{m}{\sqrt{1 - \frac{V^2}{c^2}}} - m \right) c^2$$

and this amount of work is c^2 times the amount by which the mass of the particle increased when the particle changed from being at rest to moving at speed V .

Recording Computer Activity

An instructor who is sufficiently fluent with the process of using a computer screen as a whiteboard can move to the next level and record the entire process as a sound movie. There are two principal software products that may be used for creating such recordings of computer activity. These are Camtasia Studio 5 (www.techsmith.com) and ScreenCorder 5 (www.matchware.net). Each has its own role to play.

Recording in the Classroom

For recordings of lectures given in the classroom in front of the students, speed and reliability are the main considerations. My choice for this purpose is Camtasia Studio. It 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 very rapidly as a high quality AVI file. Once the AVI file has been made, I use Camtasia Studio to master a CD. Within a few minutes, I have a CD mastered with a friendly welcome menu that shows links to all of the lecture notes to date and to the recording of that day's lecture. The students line up to collect their CDs to take home.

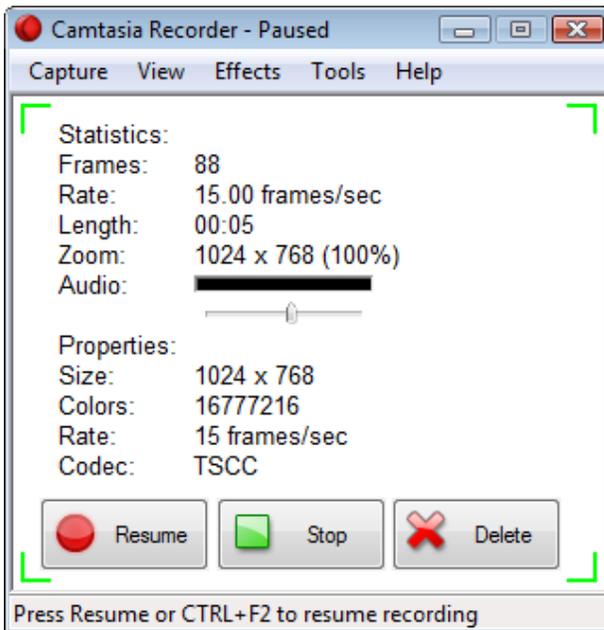
A question that I have been asked frequently is why I bother with CDs. An obvious alternative would be to convert the recordings into a streamable format like Flash or WMV and provide it on my website. I have several answers to this question:

1. Even my fastest 2.6GHz quad core desktop takes many hours to render the 4.5 hours of lectures that I give on a typical Monday or Wednesday at Kennesaw State University. The earliest I could provide the material on a website would be the next day.
2. There is nothing like the quality of the original AVI file compressed with the lossless TSCC codec. Furthermore, the Camtasia Player that is bundled by Camtasia Studio into my CDs is ideal for my recordings.
3. My students have told me that they prefer my stuff on CDs.

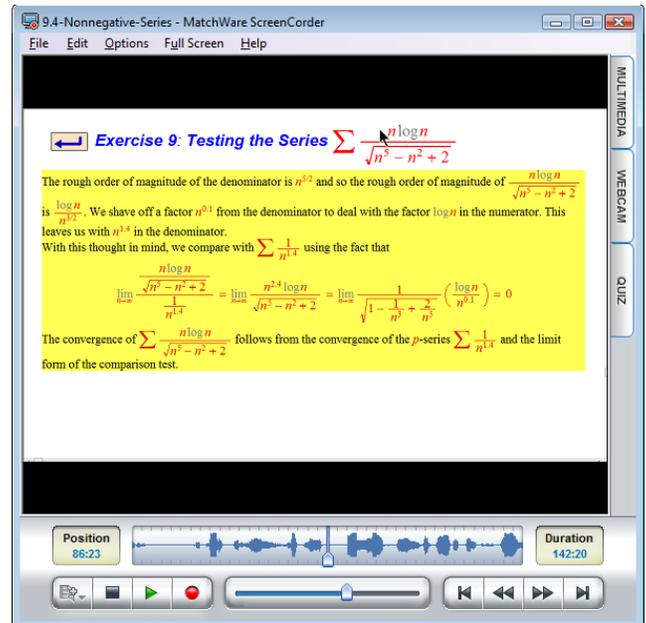
Recording in a Studio

In contrast to recordings that are made in the classroom where speed of production and stability of the software is the top priority, there is also a need for recordings of a much more polished nature that would be made in a studio. For such recordings, I believe that the recording utility of choice is ScreenCorder because it has the unique feature of allowing editing during the recording session.

When a recording session is paused, Camtasia Recorder, shown on the left below, offers only the options to resume or to stop and export the video. In contrast, ScreenCorder provides an actual timeline.



Camtasia Recorder



ScreenCorder 5

In this way, ScreenCorder 5 provides actual editing features. One can play any part of what has already been recorded in a session. One can choose to overwrite from any point onwards or one may insert video and audio, or insert audio with video frozen or overwrite the audio track. ScreenCorder 5 also allows the project to be saved at any time. One may therefore come back at any time, even after the computer has been turned off, and resume the recording process.

After the movie has been made by ScreenCorder and exported as an AVI file, the next step is to import it into a Camtasia Studio 5 project and to use the sophisticated Camtasia editing and movie production features to produce the movie in its final form. I believe that both Camtasia Studio, and ScreenCorder are indispensable tools in the hands of anyone who wishes to produce quality instructional material in video form.

Recording the Audio

For recordings made in the classroom, I use a simple Logitech USB microphone that I plug into my laptop. However, for the more polished movies that I make at home, I cannot emphasize too strongly the need for good sound equipment. I use a top quality condenser microphone that I plug into a preamplifier that can supply the phantom power that a condenser microphone needs. From the preamplifier, the signal goes into a compressor that helps to eliminate pops, overloads, and background noise. From the compressor, the signal goes into a USB mixer that, among other things, will give control to treble and bass. It is most important to be able to boost treble and reduce bass for voice recordings. Then, finally, the signal goes into a USB port of a computer. The computer must not be located anywhere near the microphone. If the computer is a desktop, it should not even be in the same room and there needs to be an effective sound reducing screen between the computer and the microphone. My recommendation is to buy all the necessary sound equipment in a music or audio store rather than in a computer store.

The Author's Own Video Products

Using the techniques described in this article, the author has produced two products, a precalculus level product called *Virtual Math Tutor* and a calculus level product called *Virtual Calculus Tutor*. Each of these products is presented as a combination of an on-screen textbook and a set of sound videos that simulate an actual classroom experience. When a student has identified an item that requires more than the mere reading of a document, a couple of mouse clicks take him/her to the video version of that item. For a more detailed description and some demo videos that describe these products, please go to www.math-movies.com.

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.