The Roles of *Scientific WorkPlace* and *Scientific Notebook* as An Instructional Tool in A Mathematics Curriculum.

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Reading This Document On-Screen

The present version of this document was prepared for the Asian Technology Conference in Mathematics that took place in Penang, Malaysia in June 1997 but a special on-screen version of this document is also available for anyone who has a copy of *Scientific Notebook*. Readers of this document are strongly encouraged to read the *Scientific Notebook* version because only that version really conveys the thrust of what this paper is all about. The *Scientific Notebook* version also provides the opportunity to experience first hand some of the activity in which my students are presently engaged. In order to read it, one should proceed as follows:

1. Acquire *Scientific Notebook*. The software may be ordered on a CD or it may be downloaded from the home page of TCI Software Research:

   http://www.thomson.com/tcisoft/default.html

   At this location you will have the opportunity of downloading a full time locked version of *Scientific Notebook* that will work for thirty days or a viewer version that will not be subject to a time limit. There

is no charge for this service. The time locked version can be made permanent at any time by purchasing the software for $60.

2. Once *Scientific Notebook* has been installed, open it, click on File and on Open Location and fill in

   ftp://ftp.mindspring.com/users/lewins/atcm97/ATCM97-for-SN.rap

   After you click on OK you will have the document before you and you can save it locally in your own computer.

1 The Purpose of This Article

The purpose of this article is to describe some of the innovative instructional techniques that have been inspired in the Department of Mathematics at Kennesaw State University by the availability of the software products *Scientific WorkPlace* and *Scientific Notebook,* and to describe some of the pedagogical benefits we have enjoyed from our use of these products.

There are several different ways in which the teaching and study of mathematics can be revolutionized with the help of computer software. The type of application that first comes to mind is the use of the computing features of products such as Maple, Mathematica, Matlab etc. to solve more realistic problems than could be approached by hand and to discover mathematical facts by experimentation. *Scientific WorkPlace* and *Scientific Notebook* are excellently suited to this type of application because they provide simple and natural access to Maple or Mathematica without requiring the user to know any Maple or Mathematica syntax. Much has been written about this type of application. See for example the following Works:

- *Doing Mathematics with Scientific WorkPlace* by Darel Hardy and Carol Walker (provided with *Scientific WorkPlace*)
- *Doing Calculus with Scientific Workplace* by Darel Hardy and Carol Walker, to be published by the Brooks/Cole Publishing Company
- *Doing Linear Algebra with Scientific Workplace* by Manfred Szabo to be published by the Brooks/Cole Publishing Company

- *Innovative Scientific Computation Techniques with Scientific Workplace* by Wei-Chi Yang and Jonathan Lewin, supplied directly by the authors.

- The paper *Encompassing Current Mathematical Software And Technology in Teaching And Research* being presented by Wei-Chi Yang here at ATCM 1997. Among other things, Professor Yang's paper demonstrates some of ways in which the features of *Scientific WorkPlace* and *Scientific Notebook* can be used to study the approximating sums to a Riemann integral.

In this paper, however, my focus is on another application of *Scientific WorkPlace* and *Scientific Notebook.* I shall describe some ways in which they can be used to provide course materials to students, to receive their questions and homework and possibly, even to examine them.

2 *Scientific WorkPlace* And *Scientific Notebook*

2.1 Introducing *Scientific Notebook* and *Scientific WorkPlace*

Scientific WorkPlace and *Scientific Notebook* are the products of TCI Software Research which was known during the decade of the eighties as the developer of the first ever WYSIWYG scientific word processing system; a product known at T^3. I myself used T^3 to produce camera ready copy for the second edition of my book *An Introduction to Mathematical Analysis* which was published by McGraw Hill in 1993. At about that time, TCI Software brought out a new word processing product called *Scientific Word* that ushered in a new era in word processing and this product has been followed by yet two more products called *Scientific WorkPlace* and *Scientific Notebook.*

For a description of these interesting products and a comparison between them, go to the same location

http://www.thomson.com/tcisoft/default.html

that was mentioned earlier.

I should mention here that *Scientific WorkPlace* is TCI Software's flagship product. It contains some sophisticated features for producing professional quality printed documents. *Scientific Notebook* still produces some excellent printed documents but without the level of sophistication of *Scientific WorkPlace*. However, since the present version (Version 3.0) of *Scientific Notebook* is newer than the present version (Version 2.5) of *Scientific WorkPlace*, there are also some features in *Scientific Notebook* today that *Scientific WorkPlace* does not yet have. Another consequence of the fact that *Scientific Notebook* is of a newer vintage is that it requires Windows 95 or Windows NT 4.0. At present, *Scientific WorkPlace* can still run on Windows 3.1.

2.2 *Scientific WorkPlace* at Kennesaw State University

Kennesaw State University has a campus-wide site license for Scientific Workplace 2.5 which is installed in computer labs to which students have access and is also installed on a large number of faculty office machines, particularly in the Department of Mathematics. Many instructors use Scientific Workplace as a computing tool for their classes, making use of its friendly and natural computing environment.

Both the computers in the labs and those in faculty offices are connected to a Novell network that a contains a drive P: which can be accessed with both reading and writing privileges on the faculty machines but is read-only on the machines used by students. Thus, for example, my own students know that they can find material I have placed on this drive for them by opening the Math folder and scrolling down until they come the folder Lewin. Inside this folder they can find a folder whose name is the number of the course they are taking. Students who wish to modify the documents that have been provided for them or who wish to create new documents are required to do so on a diskette that they bring with them into the lab.

A steadily increasing number of students have their own desktop computers. Most of my students who run Windows 95 are taking advantage of the opportunity to download a free copy of *Scientific Notebook* that will run on their computers for 30 days while some of the students who run Windows 3.1 are buying the student edition of Scientific Workplace. These students often come to lab to copy documents that have been placed there for them and then take these with them to use on their home machines. Such students

have to be taught to use the document manager that is supplied with Scientific Workplace to perform the copy operation instead of using the Windows file manager. As will be explained shortly, my own students can also access their course material from my FTP site.

Since none of the computers in the computer labs runs Windows 95, we are unable, at present, to provide the students with *Scientific Notebook* in the labs. I expect to make *Scientific Notebook* available in the computer labs in September 1997. For the most part, we do not experience any compatibility problems caused by students who transfer documents between their own *Scientific Notebook* installations and the *Scientific WorkPlace* installation that presently exists in the labs. However, as the documents being written become more sophisticated there will be some areas in which care has to be taken during such transfers.

3 My Use of *Scientific WorkPlace* in The Classroom

3.1 My Classroom Technique

I no longer use a blackboard. I keep all of my lecture material in the form of *Scientific WorkPlace* documents in my laptop computer with copies on the P: drive of Kennesaw State's Novell Network and on my FTP site. When I enter the classroom to give a lecture, I hook my laptop computer to an LCD display that has been placed in the room for me. As I teach, I type the contents of the lecture on the screen in front of the students. All of this material goes into a single document in which each day's lecture begins with a chapter heading that shows its date. After giving each lecture I update the document in the computer lab and in my FTP site so that students can read the material on-screen at their leisure and print it.

In the following paragraphs I discuss some issues of lecturing technique that have arisen from this new way of giving my classes:

3.1.1 Preparation of Lectures

I find it necessary to be a little more carefully prepared than I used to be when I taught at a blackboard. Sometimes, I walk in with a portion of my lecture material already typed but I believe that this has to be done sparingly.

It is necessary to balance the desire for spontaneity with a desire not to have to type too much. The act of typing in front of a group of people is not as easy as it looks but one gets used to it. When I do use material that I have typed previously, I keep it in a separate source document that I open simultaneously with the main lecture notes document. When I want to pick up some pretyped material I switch to the source document and I carry only small amounts at a time, via the clipboard, to the lecture notes document.

3.1.2 Drawing Figures

One particular problem that has to be overcome is what to do about figures. My normal lecturing technique is to draw a large number of figures. For example, if I refer to an interval $[a, b]$ then I am inclined to show a piece of number line with a and b marked on it. Simple sketches of this type can be produced directly in *Scientific WorkPlace* as follows

$$a\_\_\_\_\_b$$

but more complicated figures must be drawn using a graphics utility. I use Designer 4.1 by Micrografx to draw such figures and I can switch to Designer, draw and save my figure, export it as a wmf file, switch back to *Scientific WorkPlace* and import my picture quickly and effortlessly. I must admit, though, that I had to practice this process for quite some time before I dared use it in the classroom. If I think that a particular figure may be too hard to draw quickly in front of the students I draw it ahead of time and paste it into my lecture notes document when it is needed.

3.1.3 What Should The Students Write Down?

When I taught at the blackboard my lecturing technique was to write down the entire contents of my lecture exactly as I wanted students to have it in their lecture notes. The students knew exactly what to write and they knew that they were responsible for knowing something if and only if it was in those notes. Now, I find that I am necessarily producing material much more rapidly than I did before. I am also saying much more, saying it more carefully and providing more working steps. For example, if I want to evaluate the integral

$$\int_{\pi/6}^{\pi/2} \frac{\sin 2x}{\sqrt{1+\sin^2 x}} dx$$

then, working at the blackboard I would rewrite this integral as

$$\int_{\pi/6}^{\pi/2} \frac{2\sin x\cos x}{\sqrt{1+\sin^2 x}}dx$$

and then make the substitution $u = 1+\sin^2 x$. However, now that I have this expression before me in a *Scientific WorkPlace* document I am tempted to highlight the numerator, drag it next to the dx and then fill the empty space with 1 yielding

$$\int_{\pi/6}^{\pi/2} \frac{1}{\sqrt{1+\sin^2 x}}2\sin x\cos x dx.$$

This action takes me about three nanoseconds to accomplish and it helps to motivate the substitution $u = 1+\sin^2 x$. I would not expect my students to write this extra step down during the lecture.

I therefore find it necessary to instruct my students about what they should actually write down during the lecture and to make sure that they understand that the complete lecture notes are the ones in the *Scientific WorkPlace* document; not what they wrote down in the classroom.

Some of my students take few notes if any during the lecture. I have mixed feelings about this practice. One may argue that a student who is freed from the need to write notes can devote all his/her energy to what is being taught. But, on the other hand, the process of taking notes may help a student to stay awake.

3.2 Pros And Cons of My Lecture Technique

In this section I shall try to give an objective account of what I think are the advantages and disadvantages of teaching at the computer keyboard instead of the blackboard. I have listed the cons first.

3.2.1 Development of Teaching Skills

I found it necessary to train myself with several dry runs before I dared to type on the computer screen in front of the students. Even though I am a moderately good typist I have found that the process of teaching at the computer keyboard to be a little daunting. The first couple of weeks were the worst.

Even now, I sometimes make typing errors. At times, I am not looking at the screen while I am typing and I discover that something has gone wrong when the students burst out laughing.

3.2.2 Discomfort While Teaching

In order to optimize the quality of the LCD display I find it necessary to configure my laptop computer in such a way that the computer's own display screen is blank. This means that I have to look at the big screen while I type and I have to wear my distance glasses for to see that screen. Because I am wearing those glasses in a darkened room, I have difficulty seeing the keyboard and this sometimes causes me to make typing errors.

My attempts to face my students and also see the material on the screen sometimes leaves me with an aching neck.

3.2.3 The Cost

Although Kennesaw State has LCD displays available for classroom use and has the facilities for installation of *Scientific WorkPlace* over the Novell network, it could not buy me a laptop computer. The laptop is my own and I shall be paying for it for a long time to come.

I hope, eventually to obtain a grant that will enable my department to buy several more laptop computers and also set up a new computer lab in order to make this new method of teaching available to my colleagues.

3.2.4 Murphy's Law

Every time I connect my laptop to an LCD I hold my breath until I see the image come up correctly on the screen. Sometimes I have found that a few choice words muttered under my breath will help the connection to work. Some people have suggested the power of prayer for this purpose but, so far, I have found prayer to be ineffective.

I also discovered that LCD displays have a bulb that tends to burn out at the worst possible moment. It took me two weeks and much lost lecture time to discover that these machines have a second bulb that can be engaged by turning a little lever.

3.2.5 Limited Display Area

The computer method does not allow me to display as much material at any one time as I can display on a blackboard. I can alleviate this to some extent by switching between screen views but this can be disconcerting to the students. I have found it necessary to adjust my lecturing technique to accommodate this problem.

I should mention, however, that, although it is possible to show more material at a time on a blackboard, the material on a blackboard must eventually be erased. Once it has been erased, blackboard material is gone for ever but my computer material can be recalled at any time. Students sometimes come to me during the break or after class to discuss something I have written and I can work in that portion of the document. I can even improve it allowing all of the students will see the improved document when they go to the computer lab or download from my FTP site.

Scientific WorkPlace also allows me to open the same document several times and I can keep the cursor in several different places. I can switch very rapidly from one window to another and this helps the students see what they want to see at any one time.

3.2.6 Quality of The Notes

My students are grateful for the opportunity to have clear, complete and reliable lecture notes. They are also grateful for the opportunity of picking up the notes that were given in a lecture that they missed.

On the other hand I have to make a very forceful case in order to persuade students to attend every lecture.

3.2.7 Provision of Extra Material

After giving a lecture I can revise the notes that I typed. I can clean them up, if necessary, correct errors and include homework exercises. I can also answer questions that I have received from students. Sometimes I answer questions in the main lecture notes document and sometimes I do so in a separate "ask" document. In either event I am able to provide all of my students with the answer to a question that any one student has asked me.

Many students are grateful, not only for the answers to such questions, but for the knowledge of what questions other students are asking me.

4 The Role of The teacher

A question that may come to mind is whether the teacher is still needed in a course of the type I am describing here. Is it still necessary for students to come to class? For most students I believe that the answer is a categorical *yes.*

4.1 The Need to Come to Class

Certainly, the process of typing the lecture into a computer makes it a little easier for a student who is forced to miss a lecture. I have had instances of students who are hundreds of miles away connecting to the internet, downloading the lecture notes given that day, pasting some of these into a new document with questions for me about what I was doing and then enclosing this material as an attachment in an e-mail letter to me. I usually reply within an hour or two to such e-mail. Thus, a missed lecture is not quite the same disaster that it used to be.

Nevertheless, there is an enormous distinction between the act of looking at lecture notes, no matter how good these are, and the process of hearing and participating in a well run lecture. I teach very forcefully with a great deal of passion. No computer could replace me.

4.2 The Need for A Text Book

In some courses I have found that a conventional text is no longer needed in my courses. In some of my courses I have found that my lecture notes serve as a text book for the course. In this event, however, I have to make sure that I have placed a rich enough variety of exercises into the document I am making.

I have found that students in a calculus course ought to have a copy of the text, if the text is worth having. I strongly encourage my students of calculus to acquire a copy of James Stewart's Calculus, 3rd Ed. I do not believe that anything I could write in front of the students in the class room can replace the material that is contained in Stewart. Perhaps the text book can be seen as a source for exercises and for supplementary reading.

5 Examples of Lecture Note Material

This section contains some small excerpts from actual lectures that I typed on the computer screen as I presented it to the students. Those who download the *Scientific Notebook* version of this paper will have the opportunity of reading these lecture notes in their entirety.

5.1 Excerpt from The Fundamental Theorem

5.1.1 Review of Part 1 of The Fundamental Theorem

Suppose that f is continuous on an interval $[a,b]$ and suppose that for each $x \in [a,b]$ we have defined

$$F(x) = \int_a^x f = \int_a^x f(t)\,dt.$$

Then for each $x \in [a,b]$ we have $F'(x) = f(x)$.

5.1.2 Part 2

Suppose that f is continuous on an interval $[a,b]$ and suppose that we happen to have found an antiderivative h of f. Then we can use this function h to evaluate the integral $\int_a^b f$. Here is the method:

First we make a definition: we define

$$F(x) = \int_a^x f(t)\,dt$$

for each $x \in [a,b]$. By part 1 we know that F is also an antiderivative of f. In other words we know that for each $x \in [a,b]$,

$$h'(x) = f(x) = F'(x)$$

and so $(F-h)'(x) = 0$. Therefore the function $F-h$ must be constant. Call this constant k. So we have

$$F(x) - h(x) = k$$

for each $x \in [a,b]$. So $F(x) = h(x) + k$ for each x. Now the punch line:

$$\int_a^b f \quad = \quad F(b)$$

$$\begin{aligned} &= F(b) - F(a) \\ &= (h(b) + k) - (h(a) + k) \\ &= h(b) - h(a) \end{aligned}$$

5.1.3 Example

Since sin is an antiderivative of cos we know that

$$\int_0^{\pi/2} \cos x dx = \sin \pi/2 - \sin 0 = 1.$$

5.2 Excerpt from A Lecture on Partitions

5.2.1 Regular Partitions of An Interval

If $\mathcal{P} = (x_0, x_1, \cdots, x_n)$ is a partition of $[a, b]$ then we do not require the intervals

$$[x_0, x_1], [x_1, x_2], [x_2, x_3], \cdots, [x_{n-1}, x_n]$$

all to have the same length. If all of these intervals do have the same length, in other word, if

$$x_1 - x_0 = x_2 - x_1 = x_3 - x_2 = \cdots = x_n - x_{n-1}$$

then we say that the partition $\mathcal{P}$ is a **regular partition** of the interval $[a, b]$.

If $\mathcal{P} = (x_0, x_1, \cdots, x_n)$ is a regular partition of a the interval $[a, b]$ then we must have

$$x_1 - x_0 = x_2 - x_1 = x_3 - x_2 = \cdots = x_n - x_{n-1} = \frac{b-a}{n}.$$

In other words, for each $j = 1, 2, \ldots, n$, we have

$$x_j - x_{j-1} = \frac{b-a}{n}.$$

We see also that

$$\begin{aligned} x_0 &= a \\ x_1 &= a + \frac{b-a}{n} \\ x_2 &= x_1 + \frac{b-a}{n} = a + \frac{2(b-a)}{n} \\ x_3 &= x_2 + \frac{b-a}{n} = a + \frac{3(b-a)}{n} \end{aligned}$$

and, in general,

$$x_j = a + \frac{j\,(b-a)}{n}.$$

Notice that, according to this formula,

$$x_n = a + \frac{n\,(b-a)}{n} = b$$

as we expect. We sometimes call this partition the **regular n-partition** of the interval $[a, b]$.

6 The Documents in My FTP Site

This section demonstrates the process by which students who have their own *Scientific Notebook* and an internet connection can access material that I have provided for them.

As I have indicated earlier in this paper, documents in my FTP can be opened directly using *Scientific Notebook* by means of the Open Location option. One may also open a location that ends with the name of a folder, for example

ftp://ftp.mindspring.com/users/lewins.

In this event, Netscape will open and show a list of documents in that folder. One may either return to Open Location filling in the name of one of these documents or one may click on the document name on the Netscape screen because then Netscape will call upon *Scientific Notebook* to open the document.

My FTP site also contains some zip files. Thee must be downloaded and unzipped locally before they can be read.