Using Technology to Enhance the Classroom Environment in State of the Art Classrooms

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Abstract: This paper summarizes a workshop that was given at the 15th Annual ICTCM conference. The purpose of the workshop was to assist participants in dealing with one of the key challenges facing education today, namely, how to utilize computers and other technology as part of the learning environment both inside and outside the classroom. A number of approaches taken by the author to use technology to enhance the teaching and learning of mathematics were introduced and discussed. These included the creation of a comprehensive web site that provides students with a wide variety of resources relating to courses, the use of Scientific Notebook and its Maple kernel both within and outside the classroom, teaching in a classroom where students have use of laptops that are connected to the Internet, the creation of mathematical slide shows that use stream technology to present the solution to typical mathematical problems, and the integration of computer software, the Internet and animations during lectures. Below is a summary of what was presented.

Introductory Remarks

At the beginning of the workshop it was pointed out that the author is convinced that the "traditional" lecture/teaching model is still of great value. Indeed, it is this author's belief that nothing can replace a "live" teacher in the classroom. A good instructor can relate to and inspire students in ways that no technological method, no matter how sophisticated or advanced, can match. Thus teachers need not fear that the use of technology will "put them out of business." However, the use of technology where appropriate can add new and exciting dimensions to the teaching/learning experience both inside and outside of the classroom. It can be used to create an environment of dynamic interactive learning. Despite this one must keep in mind that technology should only be used when and where appropriate so that it does not appear to be "forced" into the teaching/learning environment.

Course Web Sites

Students will make use of and benefit from a good web site that contains important information about a course they are taking. Such a site should be easy to navigate and provide as much relevant information about the course as possible. This includes instructor office hours, class schedules, the course syllabus, exam dates and other appropriate dates, homework assignments, course lecture notes, exams given in previous years and solutions to these exams, links to supplemental material, projects, grades, etc. In a course with a good web site there is no need to write homework assignments on the board, distribute handouts, etc.

While students find all of this information of value, the anonymous posting of grades as the course progresses is of particular importance to them. In addition to allowing students to track their progress, it also gives students the opportunity to point out discrepancies between recorded grades and actual grades. Indeed, when grades are posted it becomes the responsibility of the student to make sure that they are correct. It also fosters an attitude of openness and fairness when students know that all students with the exact some total points will get the same grade.

Some words of caution are called for here. One simply cannot create the type of web site described above in a few hours. The author has created an extensive web site that incorporates the features described above, but it has taken years for the site to develop into it present format. (Go to http://attila.stevens-

tech.edu/~llevine/) In addition, an instructor must be prepared to spend a few hours each week updating and maintaining such a site.

The Big Question

Perhaps the biggest question facing faculty today can be summarized as, "**My course will meet in a high tech facility, now what do I do with all of this equipment?**" The answer to this question depends to some extent on the technology that a given classroom has and also on the nature of the material being taught. Here are some suggestions.

- **Lecture Notes:** The simplest thing that teaching in a classroom that has a computer with an Internet connection and a projection system allows one to do is to present notes that the instructor has prepared. The lecture notes should also be made available to the students either as handouts or downloads from the instructor's web site. One can do this with slides and an overhead projector, but for some reason it seems to be easier when done with a computer. The experience of this writer has been that this approach is most effective when dealing with a topic that requires the presentation of a large number of formulas.
- **Software Demonstrations:** If one is using particular software in a course, then a computer projection set-up allows one to show the students how to do various things with the software. In a classroom set-up where the students have laptops one can also have them practice the concepts being presented right in class. There is no substitute for this sort of on the spot reinforcement.
- **Demonstrations and Simulations:** Having a computer connected to the Internet and a projection system allows one to do demonstrations and present simulations that can make a topic "come alive." Finding such demonstrations and simulations often involves a web search. This writer has found the search engine at www.google.com to be particularly helpful.

Classroom Set-ups

There are a variety of technological resources that a classroom can have. Some are:

- **Basic set-up**: The most basic classroom set-up that allows an instructor to use technology as part of his/her teaching is one in which there is a computer, a network connection (either wired or wireless), and a projection system. This allows one to do demonstrations, present material, illustrate how to use software, show web sites, etc.
- **Better set-up**: A better set-up is one in which an instructor can bring his/her laptop to the classroom and connect to the network and a projection system. This has the advantage that everything that the instructor wants to do with the laptop can be prepared in advance.
- **Even Better set-up**: In both of the set-ups described above, there is little student participation aside from viewing what is projected. In order to have real participation and interaction, the students need to have computers with network and power connections that they can use in the classroom. At one time this meant a "lab" with PCs. Today the most desirable configuration is one in which the students have laptops that they bring to class and use there. As wireless technology improves, it is becoming increasingly clear that such Internet connections are the most cost effective and allow for the most flexibility.

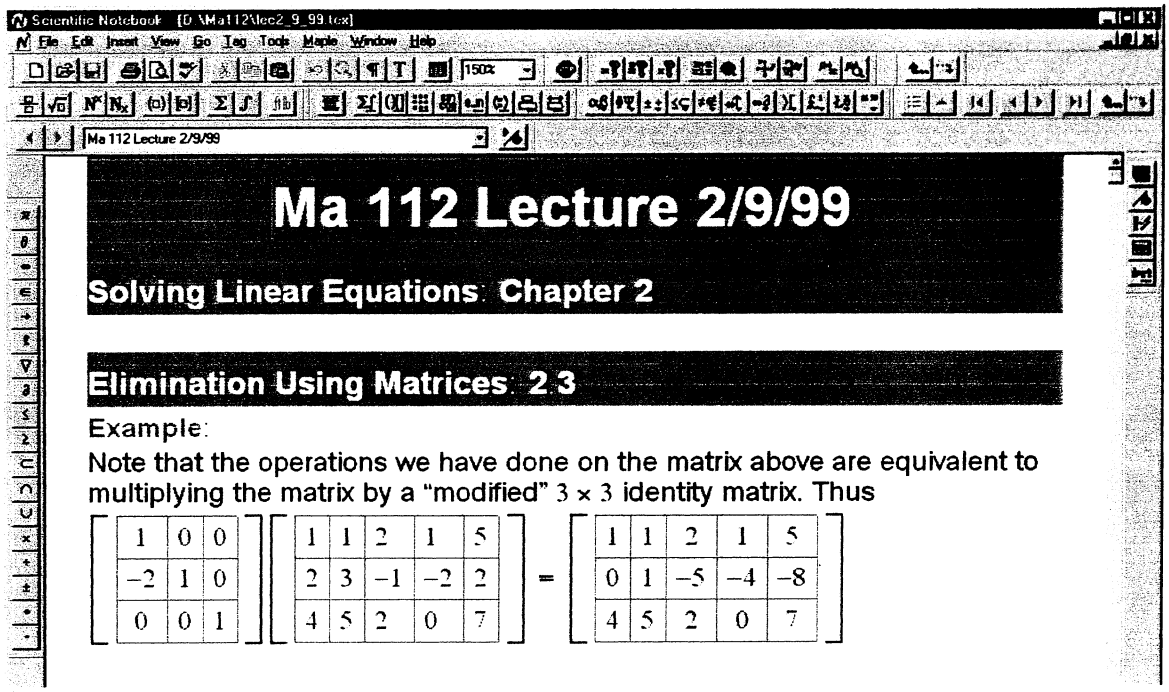
There are other technological resources that an instructor might want to have available such as an overhead projector, a VCR, a document camera, software that allows one to monitor the laptop of a student, etc.

Scientific Notebook

Scientific Notebook (SNB) is a word processing package that incorporates Maple and MuPAD kernels. These CAS kernels allow one to perform a wide variety of mathematical operations. A particularly nice feature of SNB is that one can use the Maple kernel without typing any code. One simply types the mathematical expression and then clicks on the appropriate operation to be performed. SNB then performs the operation. Thus the "front end" of SNB is extremely user friendly, and it has been our experience that

students are able to use SNB almost from the first introduction with little or no difficulty. The program contains extensive Help files that further foster ease of use.

Information about SNB is available at http://www.mackichan.com/. A typical SNB screen is shown below.



$$\begin{bmatrix} 1 & 0 & 0 \\ -2 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 1 & 2 & 1 & 5 \\ 2 & 3 & -1 & -2 & 2 \\ 4 & 5 & 2 & 0 & 7 \end{bmatrix} = \begin{bmatrix} 1 & 1 & 2 & 1 & 5 \\ 0 & 1 & -5 & -4 & -8 \\ 4 & 5 & 2 & 0 & 7 \end{bmatrix}$$

The author has used SNB in a variety of ways. For several years he has used it in Stevens' second year mathematics sequence taken by almost all undergraduate students. These two courses cover such topics as ordinary differential equations, Fourier series, partial differential equations, multiple integration, matrix methods, surface integrals, and the theorems of Green, Gauss and Stokes. In these courses use of SNB was necessarily limited, since students did not have use of computers in the classroom. They were required to use SNB to complete three projects each semester. They were also encouraged to use SNB as a tool for checking their work. For example, when topics dealing with multiple integration were presented, the concentration was on setting up the integrals. The evaluation of these integrals was to be done with SNB. A complete set of notes for the material covered in these courses as well as an extensive database of old exams, all in SNB format, were made available on the Web. Thus while SNB was an important component of these courses, it use was not integral to presenting and learning the material presented in the course.

For a more comprehensive discussion about what has been done in these courses see http://attila.stevens-tech.edu/~llevine/webnet.html.

Teaching in a Laptop Classroom

The author has taught linear algebra utilizing a classroom in which all students had laptops that were connected to the Internet. SNB was as an integral component of the way the course was run. A complete set of course notes was prepared in SNB. These notes were used as the basis of each lecture. Whenever possible, the notes incorporated in-class exercises that the students worked on during the lectures. Most of these in-class exercises required using the Maple kernel in SNB. Thus each class meeting was a combination of lecture and hands-on doing. When the instructor was lecturing, laptops were required to be closed, whereas when the students were working on the exercises, the laptops were open. In this way the

class moved seamlessly between the two environments of a "standard" classroom and a computer laboratory.

Homework was assigned regularly and had to be done using SNB. **No written work was accepted. In this spirit the instructor taught a mathematics course in which he did not write one single word on the board the entire semester.**

Before each class the notes for that class were posted on the instructor's Web site. A nice thing about SNB is that one can put a tex file on the Web, and then this file can be downloaded by simply clicking on it once the Web browser has been configured to open tex files in SNB. Thus each lecture began with the instructor downloading the lecture from the Web to his laptop and then projecting it for the class to see.

All homework assignments were also posted there. In addition, solutions to homework problems and exams were put on the Web site. A good portion of the quizzes and exams were also given over the Web. (See below.) Thus the Web served as a crucial resource for the course. To see what was actually done go to http://attila.stevens-tech/edu/~llevine/ and click on the Ma 112 Button.

Given that use of SNB was an integral part of the course, many of the short quizzes and portions of exams given in the course were designed so that the students had to use SNB to solve the problems. These quizzes and exams had to be downloaded by the students, worked on, and then uploaded to a site. All of the major exams and the final were in two parts. On one part the student worked with the classical paper and pencil, whereas on the other part s/he had to use the Maple kernel in SNB to solve the problems. Having a networked laptop classroom made this approach possible.

One of the goals of a good educational experience is to engage the students in the teaching/learning experience. Active learning is certainly more desirable that passive learning for a wide range of reasons. However, within the classical lecture format this instructor has found it most difficult to get students actively involved in what is going on in class. A number of times this instructor has had the feeling that students come to class with the idea that, "I was good enough to come to class, now it is the professor's job to pour the material into my head." They seem to shun class participation especially when it comes to mathematics.

Given the approach taken in this linear algebra course, namely prepared lecture notes interspersed with exercises that students were required to work in right in class; active student involvement became the rule rather than the exception. Usually the in-class exercises that the students worked on were homework problems that had to be turned in and that were graded. This further encouraged students' active learning in class. In this instructor's experience of over three decades no other format has led to as much "active" learning.

A discussion of this "laptop" course appeared in the March 2000 issue of **Syllabus** magazine. See http://attila.stevens-tech.edu/~llevine/ma112/syllabus_1.html

Mathematical Slide Shows

The author has developed a number of what may be called "mathematical slide shows". Each slide show presents a typical problem in calculus or differential equations together with a step-by-step solution. Each slide has narration attached to it that explain to the viewer what is being done and why. The slide shows run from a Real Server and are viewed using Real Player G2. Real Player G2 may be downloaded from www.real.com at no charge.

A slide show is created in several steps. Microsoft Power Point allows one to create a slide show with narration. Real Presenter G2 is available from www.real.com. It interfaces with Power Point and allows one to convert a Power Point slide show into Real media format that can then be run on a Real Server. Stevens ha installed a Basic Plus G2 Server that plays the shows.

The major problem to be overcome is the fact that there is no easy way to write mathematics in Power Point. However, one may easily create nice mathematics files in Scientific Notebook Unfortunately, one cannot directly import the .tex file created by SNB into Power Point. The solution worked out was to capture portions of the SNB file as graphics files. These can then be imported into Power Point as .gif or jpeg files to create slides. It does require some editing of the graphics files as well as preparing the SNB file so that it uses only half of the page space in SNB (about 3 inches as opposed to the default of 6 inches or so).

It is worth noting that the conversion from Power Point to Real Media format involves a compression factor of about 1/80, so that the Real Media file is not that large compared to the rather large Power Point slide show with narration.

Almost all of the slide shows take less then 4 minutes to view. This is intentional, since the author does not believe that students are willing to spend large amounts of time viewing solutions. All but two of them are meant as supplements to the normal lecture format. The fact that they are available 7 days a week 24 hours a day from anywhere is a big advantage for students.

For more on these slide shows see http://www.math.tamu.edu/ms-online/99b/newsletter.html#levine. To view some of these slide shows go the http://attila.stevens-tech.edu/llevine1/slide/.

Mathematics Research Motivated by Technology:

The author has taught a special topics course in differential equations in which the nature of the solutions of the classic equations of Chebyshev, Hermite, Legendre and Laquerre when they have polynomial right hand sides was studied. This investigation of this topic was motivated by the use of SNB.

Conditions were obtained that insure that these equations will have polynomial solutions. The approach was as follows: SNB will not solve an initial value problem for one of these equations with x^n on the right hand side for any n. However, it will solve the initial value problem for any *specific* value of n. By looking at the solutions to the initial value problem for a number of specific values of n one then attempts to extrapolate to a general result. Then one uses this extrapolated result to prove that this is indeed the required condition and to obtain an expression for the solution to the initial value problem for any n.

Summary

This ICTCM workshop presented a number of ways in which technology can be used as a teaching/learning tool. These approaches are by no means exhaustive. Each has advantages and disadvantages. The challenge is to select the best from each, develop new uses, and then incorporate all of these into a meaningful, dynamic learning experience. This is no small challenge, and faculty will struggle with this for many years to come. While this requires considerable effort, the rewards to be gained from such efforts are well worth the time investment and can lead to meaningful enhancements of the teaching/learning environment.

Final Note

The participants were provided with a list of references related to the material presented at the workshop. There references are at http://attila.stevens-tech.edu/~llevine/workshoporlandoref.html .