A Vision of Improved Learning and How the Net and the Web Might Fit into It

Stephen A. Fulling
Professor of Mathematics
Texas A&M University

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This morning you are hearing two talks about the use of the Internet in mathematics teaching at Texas A & M. Al Boggess has described present reality; I am presenting future fantasy.

I offered to take part in a "panel discussion", but to my surprise I was given a full 50-minute talk slot. I don't have 50 minutes of wisdom about the Internet to offer you, so the first part of what I have to say will be just about teaching methodology. I won't harangue you with my strong and sometimes heretical opinions about lectures, textbooks, tests, or computer labs; today I will focus on just one element, **homework**.

The Real World

I am concerned largely with teaching upper-level undergraduate mathematics to students in engineering and similar fields. For what am I preparing them? My understanding of life in corporate engineering (for instance) includes this:

- It is a peer activity:
  - All involved are adults.
  - It's a team effort.
  - Your boss or customer may be **less** technically competent than you; that is why you were hired.
- For these reasons and others, communication skills are very important.
- One works on large projects, done thoroughly, over a long period of time.
- The professional touchstone (besides keeping the contract that brings in the cash) is **Pride in a job well done.**

Homework

What is homework like in most of our courses, and how does it prepare a student for professional life?

- It consists of individual effort, done for a grade.
- The work is prescribed by the all-knowing instructor.
- The assignment consists of jillions of problems, done as fast as possible and as sloppily as you can get away with.
- The grader is usually a student assistant, who is even more pressed for time than the students and only marginally more competent. This is particularly true with respect to communications issues; the grader, even when qualified, seldom has the gumption or the credibility to critique students' writing. (For one thing, quite often the student's native language is English but the grader's is not.) Finally, because of time constraints and the academic mindset, the grader mostly renders judgment, not advice.

I suggest that **this system actively works to destroy pride in a job well done, and to hinder the development of adult behavior.**

Some Aphorisms

Let me interject a first indication of why I think the Internet is relevant to this problem. Look at those students (at the high school or college level) who have discovered computers; how do they primarily use them? Recently Orson Scott Card wrote [column in *Windows Sources*, August, 1995, quotation rearranged to fit new context]:

> The network doesn't replace the classroom. It replaces the [high-school] corridor. It replaces the McDonald's parking lot. It puts literacy at a premium in kids' voluntary social interaction. Even when the kids are saying stupid things or "wasting the school's precious resources," they are reading and writing as they do it.

The point is that even at its most frivolous, the computer seems to be capable of undoing the devastating effects of television on the intellectual habits of our young people. We stand at a crossroads: **Educators can use computers to restore literacy, or to drive the last nails into its coffin.** It all depends on how we use them.

A second point is that computers become effective tools when people use them spontaneously to accomplish their own perceived goals. I want my students to use a computer the way I use a computer: as a very useful tool that I use whenever I need it, not something I am required to use every Wednesday between 10:20 and 11:10 as a course requirement (and have difficulty accessing at other times).

I have assigned term papers to students and observed a tremendous difference in their behavior, compared to their work on tests and homework. Most of them **can** write intelligibly and properly when they know it is expected and they have the time. A word processor does wonders for pride in a job well done. At last, we can include decent graphics without being a talented artist or spending hours plotting points. Revisions can be made, invisibly, without retyping. The creation of a document of excellent **appearance** lifts the morale of both writer and reader, and I really think it spurs the student to improve the **content**.

In case the social computing described by Card seems too frivolous to be relevant to our educational concerns, let's turn to the words of a real curmudgeon, professor Melvin Henriksen of Harvey Mudd College [You Can and Should Get Your Students to Write in Sentences, *Using Writing to Teach Mathematics*, ed. by A. Sterrett, **MAA Notes No. 16**, Mathematical Association of America]:

> I [insist] that the students in mathematics courses that I teach write in complete English sentences on all written work that I grade. [Equations count, if the logical relationships are made clear.] ...
>
> Good writing is a reflection of clear thinking, and clear thinking rather than memorization is the key to success in mathematics....
>
> Why not [just] assign a term paper?...It is difficult to teach students how to write well if they regard writing in sentences as the equivalent of dressing up and going to church at Easter time. They can write in sentences, and doing so helps them break the habit of doing mathematics by throwing some symbols on a page and stirring them in hope of getting the "right" answer.

The Easter-suit syndrome reflects our tacit attitude that **presentation** of scientific or technical material is something added on at the end, and only when necessary. We need to change the student culture so that the presentation is seen as an integral part of the creation; it starts back at the beginning. Therefore, it belongs in every homework problem.

Peer-Reviewed Homework

For several years I have been trying to promote literacy and mature behavior among my students by treating every homework problem like a real research paper or engineering report. The students are consumers of these papers as well as producers, and part of their classroom responsibility is to criticize and improve one another's work.

I tinker with the system every semester; I'll describe it as it exists now. Full instructions for the students are currently available at the URL

`http://www.math.tamu.edu/~fulling/m311/handout.dvi` [or `.ps`]

Here is a summary:

- Instead of doing the entire assignment, each student concentrates on just a few problems. (In a course on partial differential equations, one problem a week is plenty; in linear algebra, one or two; in calculus, perhaps 5 would be appropriate.) The student's attention is supposed to be focused on quality, not quantity. In my research career, I have not been required to publish every year a paper describing my progress toward proving Fermat's last theorem and finding a cure for AIDS; I submit a paper only when I have something to say. (The student is still responsible for learning **how** to solve each assigned problem in principle; the final exam will still be there.)
- The student is instructed to create a **carefully written, complete, formal solution**, "comparable to a worked-out example in a textbook".
- The class, collectively, will solve most of the problems, thereby producing a "solutions manual". They should think of this as a class project, their legacy to the students of future semesters. (Old solutions manuals are available in the library reserve room and the Learning Resources Center in Heldenfels Hall, under the imprint of Caveat Emptor Press.)
- All the solutions received for a given problem are reviewed by a small committee of students. (They earn class-participation points for this work.) These referees –
  - Write a critique of each paper, presented to the author.
  - Write a summary report on the problem, read by the course grader and me; if it contains something instructive, the report is presented to the whole class.
  - Choose one or more solutions for "publication". If necessary, the papers are revised by the authors first. (Occasionally a composite solution is produced from the submitted papers by the referees and the grader or the authors.) The selected papers are made available for the students to photocopy at their own expense, and they become the next year's solutions manual.

  In previous years I have had the referees assign numerical grades to the papers, but now I leave this to the paid grader.
- The criteria for evaluating papers include presentation as well as correct content. In descending order of importance, the criteria are

- mathematical correctness
- completeness
- organization
- pedagogical effectiveness
- sentence structure and punctuation
- brevity and style
- grammar and spelling
- neatness

Problems

There are problems with this system. It tends to bog down in paperwork.

- The most obvious problem is the slaughter of the forests (or, more immediately, the Xerox bill). Of course, each student should be using less paper, but from my point of view, I need to deal with
  - the collections of old problems ("solutions manuals"),
  - forms for the committees to write their reviews and reports,
  - "published" copies of the selected papers and reports,
  - any example problems used for class discussion.
- The procedure uses a certain amount of class time (and creates a fair amount of confusion or disruption) for
  - initial collection (the solutions of each problem into a prelabeled large envelope),
  - referral to committees (not overlapping with the authors),
  - recollection from the committees,
  - redistribution to the authors (who must in some cases revise and resubmit),
  - publication at a local copy center.
- There are some other inconveniences:
  - The whole process takes so much time that the results are usually not available to the students until after they've been tested on the material concerned.
  - There is not time in class for most of the reviewing. Therefore, students must get together outside of class for this joint work.
  - How should the reviewers attach comments to the papers? Do they write on them, use sticky notes, or just write a separate report?
- The quality of the papers, with respect to aesthetics and legibility, still leaves a lot to be desired. Even when a computer program is used, it is usually "WordCreature" – some commercial word processor whose attempts to typeset mathematical expressions are atrocious. Students' carefully handwritten work is often rendered unreadable by a photocopier.

It is surely obvious that computer technology (especially networking) can alleviate all of these problems, if it can be properly deployed.

Utopia

Here is my vision of Utopia:

- Every dorm room and apartment must be equipped with a networked computer.
- Every student must be able to produce a high-quality mathematical document in a portable format. In my opinion, that means TeX! There is no substitute. Therefore, every student must either

  A) learn TeX, or

  B) get software that makes it possible to write TeX without knowing TeX.

  (At present the only candidate known to me for B is *Scientific Word/WorkPlace*.) I stress that **both** A and B exist in my Utopia. The student chooses the work style most congenial to him or her. Also, I must admit that graphics are still a problem, if they are to be easily produced, portable, and transmitted electronically.
- The network software must include `.dvi` or PostScript viewers — preferably both.
- As many as possible of the preliminary steps (such as submission of papers) will be transacted by e-mail.
- Reports (the summary reports for each problem, not the individual reviews) and published papers will go onto the Web.
- The reports might also go onto a private newsgroup (or something of that nature — it might use ListServ, VAXnotes, or plain old e-mail). This can be used for additional purposes:
  - class announcements,
  - virtual office hours,
  - virtual study groups.

  Such course-related forums are already being created for other classes.
- Large numbers of courses must operate this way, to justify the investments by the students, and to create a culture where this style of learning is normal. (By "investments" I mean not only the purchase of personal computers and software — which I think is necessary if the computerization is to be a help to a student instead of an additional burden — but also the investment in learning how to use the software, the network, etc.)

A Modest Proposal

What can we do now to move in this direction?

- The university's networking software for PCs, TAMUPPP, must include `.dvi` and `.ps` viewers.
- Get more dialup lines!

- The university has a partial site license for PCTEX, but most people don't know about it; it should be publicized and expanded. Also, we should get a site license for Scientific WorkPlace.
- Develop a LATEX style file for homework solutions.
- Assist faculty and graders in setting up Web pages, and newsgroups or mailing lists.
- Make computer technology (including networking, TEX or SWP, and symbolic computation (such as Maple)) a standard freshman course, rather than squeezing it into courses on other subjects.

Apart from the LATEX remark, these pleas are directed at the University's computational Powers that Be. However, the most important commitment must be made at the grass roots:

- **More effort and cooperation among faculty are needed.**
- **Students must take this learning opportunity seriously and make it work.**

A Poll

In connection with this last point I polled my current class about the computer facilities and expertise available to them now. I also asked them why they have made almost no use of the network in the homework reviewing process, although I had encouraged them to try to do so (at least with regard to the review and report forms, where pure ASCII text usually suffices). Their responses fell into three categories:

I. Some students do not see any advantage.

Takes way too much time to do.

It's easier to just turn it in in class.

I didn't feel that it seemed necessary to the implementation of the class.

I'm too lazy to try anything new and I am happy with how things are normally done.

It was extra work so since it was optional I didn't do it.

I believe the main reason why the class has not made use of the network is lack of time. Maybe if you required it for a grade then I am sure we would make use of it.

It is MUCH simpler and quicker to use paper. The technology is there, but people will typically choose the path of least resistance. Without computer, review can be conducted anywhere, not just at a terminal.

Writing mathematical expressions on a commonly available word processor is difficult. Using applications designed for mathematical expressions, like MS Equation Writer, is very cumbersome and time consuming.

II. A few students have genuine problems of access.

Lack of access to computer with suitable software.

Access is far from my dorm.

I do not have a computer at my apartment. It would take too much time to come to campus and do the review on the computers.

I do not have a computer at home. I would use the labs at school but they are usually slow and inconvenient. I have not had a good opportunity to teach myself to use the net efficiently. I have found the labs to be overcrowded and the people at the help desks not so helpful.

III. Some students simply need to be told what to do.

I'm not sure how.

I don't know how to comfortably use computer.

I went into the Internet and saw the review, but didn't know what to do [next;] how to download it or type in it.

Many of us do not know exactly how to send the reviews or use the network.

It wasn't emphasized enough.

You didn't specify exactly how to turn in the stuff (what format, how do we send this in, etc.).

I think that the best way to accomplish this is for you as the professor to educate the students on how to do specific tasks. It is definitely not because we don't have access.

What we need is a set of instructions to guide us through the process. Have some for on campus, some for off-campus modems and such. I think if I had a guide I would use it. It would be a good introduction for the future.

I think an Internet class should be integrated into the freshman curriculum.

There were 35 responses to this poll. The typical student in this course (Mathematics 311) is a junior majoring in electrical engineering. Here is a tabulation of their responses to factual questions:

University computer systems I have experience with:

PC labs: 33	VAX: 19	Calclabs: 13	UNIX: 10

At home (dorm or apartment) I have:

None: 15	8088/286: 3	80386+: 18	Mac: 2

and it has:

TAMUPPP: 12	ProComm etc: 12	(9 of these have both)	
WWW browser: 12 (the TAMUPPP 12)		.ps viewer: 2	.dvi viewer: 1
TeX or LaTeX: 1		SciWord/WP: 1	
MSWord: 10		WordPerfect: 1	
PS printer: 2		Graphics/CAD program: 9	

My computer software background:

Maple: 19	Mathematica: 1	Macsyma: 0	MathCad: 2

Others: MatLab, Derive (1 each)

FORTRAN: 33		Pascal: 23	C: 15

Others: Basic (7), C++ (3), ObjectiveC, LISP, COBOL, Ada, Perl, REXX

Also: Palasm (4)

TeX or LaTeX: 1 (the one who owns it)