TEACHING CALCULUS USING INTERNET: SOME EXPERIMENTS AND EXPERIENCES

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ABSTRACT

Experiences of teaching of a Calculus course using screen projections from the web pages of the course or from transparencies, are discussed. Pedagogical advantages and disadvantages of this method as well as some technical problems are also discussed.

INTRODUCTION

Usually, the first year Calculus courses at IIT (= Indian Institute of Technology) Bombay are taught for most part using traditional methods such as with chalks and a blackboard. Of course, this is possible if the class size is within a reasonable limit, say up to 100. If the total number of students is large then one has to split them into several divisions, with a separate instructor assigned to each division. Around 1997, it was felt necessary for various reasons to make an experiment to increase significantly the class size (to around 250). But this meant that traditional chalkboard methods would have to replaced by more modern methods. To this effect, it was envisaged that we should utilise this opportunity to make use of the Internet. Thus, the idea was that the course material prepared in advance by the instructors would be put on the web, and in the classroom this material would be projected from the web page onto a screen. The sequencing and the delivery of the course material would be controlled by the instructor who would now wield a remote mouse instead of a chalk!

Being one of the instructors associated with this experiment, I shall narrate in this article some of our experiences and discuss the advantages and disadvantages of the above method, which I loosely refer to as ‘Teaching Calculus using Internet’. I will also mention certain technical problems we had to face at the time we made the above experiment. It is hoped that these experiences may be of some value and interest to teachers, educators and policy makers at various levels.

PREPARATION

The method of ‘Teaching Calculus using Internet’ that was outlined in the Introduction above presupposes that the instructors have thought carefully about the material to be presented in the entire semester (or an year, as the case may be). If a bulk of the course material is being presented from web pages (or even from transparencies) on a screen in a dimly lit room, then it is evident that
it will be extremely difficult, if not impossible for the students to take notes. Students need to concentrate on what the instructor is saying but they should also have ready access to the material presented in the class. Accordingly, we felt that it would be desirable to have a comprehensive set of ‘Notes’ covering the course material in the manner it will be presented in the classroom. These notes were typeset using LaTeX, and then converted to HTML format so that they could be put on the web. As a part of the technical preparation, we ensured that the classroom is equipped with a projector that is connected to the Internet or at least to a PC containing the relevant HTML files on its hard disk, and a remote mouse.

It may be worthwhile to digress here to discuss the style in which the ‘Notes’ could be written. As mentioned above, it is desirable that they are comprehensive in so far as the syllabus is concerned. But at the same time, it seemed essential that the ‘Notes’ be written in a concise, almost telegraphic manner so that they are not conceived by the students as a replacement for the instructor and for classroom participation. So rather than simply reading what is projected on the screen, the instructor will have ample opportunities to expand, and to supply motivation, heuristics and examples. For this purpose, supplementary aids such as a spare projector and blank transparencies may also be used to draw pictures, work out problems, and so on. Another point that was made earlier about the ‘Notes’ was that the students should have a ready access to them. In a way, this is automatic if the ‘Notes’ are on the web, provided of course that each student has ready access to the Internet and is able to print parts of this material, if so desired. An alternative is to simply provide the students with a hard copy of the ‘Notes’, and this is what we did because it was more convenient at that time. The ‘Notes’ also give us an opportunity to include a number of problems that could be discussed in the tutorial sessions (usually conducted in small batches of about 25 students) or relegated to homework and self-study.

It may be argued that with an abundance of Calculus books available world wide, the effort required in creating the ‘Notes’ along the lines mentioned above seems largely unnecessary. This is certainly a valid argument. However, the pace and the level at which the course is taught, often differs from institution to institution, and it may be difficult sometimes to agree on a text which fulfils all the needs. Secondly, it should be remembered that in the case of teaching using Internet, much of the course material has to be available on the web. Now if one agrees on a textbook, this material can be produced by scanning or retyping the relevant portions of the textbook. But then the output may not always be suitable for use in classroom instruction, not to mention problems with copyrights. An attractive alternative that is recently emerging is to follow an online textbook such as (Cain & Herod, 1997). But in this respect, the choices available are far less than those in a print form. Another point in favour of creating a good set of ‘Notes’ is that the subsequent teams of instructors in the same institution can simply use the ‘Notes’ prepared by the past instructors with little or no modification, if they so desire. For the initial team of instructors, a side benefit of writing the Notes’ could be the following. If they have spent considerable time and energy in preparing the ‘Notes’, and gained good feedback from the students and tutors, then it may be worthwhile and relatively easy for them to try to convert their Notes’ into a book. In the end, it is really up to the instructors in a given year to make a choice that suits them best.

ADVANTAGES

Some of the advantages of ‘Teaching Calculus using Internet’ and of preparing the ‘Notes’ in a way
that was discussed in the previous section and making them available to the students, seem to be as follows.

- **Large Classes can be managed this way.**

  This was of course the *raison d'être* of making the experiment in the first place. The desires and demands on academic institutions, in general, and Mathematics Departments, in particular, to offer basic undergraduate courses such as Calculus to an even greater number of students but with no significant increase in faculty strength, appears to be a world wide phenomenon. To deal with this, innovative ways to utilise the available resources have to be made and the method described above is certainly one of these.

- **Students love to have a ready-made set of ‘Notes’.*

  The ability to take good notes in the class is not a skill that is mastered by the majority of undergraduate students; nor is it particularly sought after. If the students find themselves relieved of having to take notes or borrow from others, they are certainly happy. In principle, the students can now concentrate better on the lecture and study more effectively after the class.

- **The course can reach, in principle, the entire world.**

  If the course notes, the exercises, etc. are on the web, then in principle, they can be accessed by anyone in the world. Thus the instructor can have a vicarious thrill of making the whole world just a little wiser! Of course, in reality only a small fraction of the outside world may look at this material and benefit from it. But if this turns out to be a nonzero number, then it may still be worth it.

- **Teaching is easier if everything in planned in advance.**

  It is no secret that good preparation is one of the keys to effective teaching. The modalities of ‘Teaching using Internet’ forces the instructors to think in advance about the course contents and make a detailed planning. Experienced teachers who know the subject well usually have a fair idea of what they are going to teach and for them, the preparation may just consist of going over the course material in their mind and occasionally jotting a few important points. But experience shows that even for such people, greater preparation will yield better results.

- **Teachers have more time at their disposal.**

  With just about everything planned in advance, and no writing to do on the blackboard, the teacher would often find more time than what might be the case while teaching in a traditional way. This time can be put, in principle, to a better use and for the benefit of the students.
DISADVANTAGES

There are also several disadvantages in ‘Teaching Calculus using Internet’. A partial list, mainly borne out of individual experience and by talking to students, is as follows.

- **Lack of spontaneity**

  When almost everything is planned, and the instructional material, which is readily available to the students, rapidly flashed on to the screen, the class can become rather monotonous and lack spontaneity. It is easy in such a scenario for student’s mind to wander over other things and lose interest in what is being taught. Often, students can learn a great deal from what a teacher does spontaneously, be it a digression to a related theme or a historical detail or working out a question or a problem that has unexpectedly come up. But when one has ready material, written with near perfection, that is shown on the screen, there is less scope for spontaneity.

- **Students don’t see the material developed before their eyes.**

  This point is related to the previous one, but it is still important enough to note separately. When a lecture is presented using chalkboard, the material develops itself before the eyes of the students. The time taken to write might seem like a waste but it is essential for the natural course of comprehension and assimilation. The pauses, the emphasis or otherwise on certain things, and all such things contribute to one’s understanding. It is possible to try to get this effect while teaching using Internet, by hiding a part of the screen and releasing it gradually. But in practise, this can be quite awkward unless one is exceptionally dexterous with the remote mouse.

- **Teacher’s natural style may be constrained.**

  After all, most Mathematics teachers are used to teaching with the chalkboard and have over the years developed a certain style. Making a shift to teaching with a remote mouse or even using transparencies, is not easy and can significantly constrain the natural style of a teacher, at least initially. A plausible consequence is that the amount of pictures and heuristics normally employed will get sacrificed, sometimes just for the lack of some technical skills.

- **Possession of the ‘Notes’ gives the students a false sense of security.**

  Students, especially those who consider themselves smart, can easily get the idea that with the ‘Notes’ of the entire course at their ready disposal, there is no need to attend classes. This is almost always a major mistake and is realised as such by the students much too late.

- **Teachers have more time at their disposal.**

  Recall that this was listed as an advantage. But it is also a disadvantage. Because there is a real fear that with more time at their disposal, teachers would be tempted to proceed faster and try to cover in an hour more than what might be appropriate.
TECHNICAL PROBLEMS

Technology, especially in computer related objects, has been changing very rapidly. Thus some of the technical problems we had to face while trying to teach using Internet in 1997 may no longer be relevant today. Yet, it is fair to make a mention of the following.

- **Inadequate resolution of web pages on an overhead projector.**

  For a large class, the material from a web page, when projected using the highest available text size, was found to be rather poor, especially for students sitting in the back. There was a modest improvement when instead of black lettering on a white background, we opted for the opposite. Nevertheless, the fact remained that HTML pages are primarily meant to be viewed by a single person in front of a computer or at best by a small group of people. As the semester progressed, one had to confess that transparencies made directly from a suitably sized LaTeX printout, are much better in terms of resolution and visibility.

- **Remote mouse is not so easy and convenient to operate.**

  At first, the remote mouse seemed to us a rather remarkable device. But as we got around to using it in the actual classroom, we realised that it is not so easy and convenient after all. At least, not for a working mathematician!

- **LaTeX to HTML converters are not sufficiently intelligent.**

  For about a decade, the canonical choice for mathematicians to typset their work has been to use TeX or its variants such as LaTeX. There are ‘converters’ which will transform a LaTeX file into a HTML file that can be viewed on the web. But often we found that the automatic conversion doesn’t quite have the desired effect and from time to time, we had to modify or insert some HTML code to suit our needs. Again, this is usually not a pleasant or easy task for a mathematician.

Admittedly, there are now ways to get around some of the problems listed above. For example, instead of HTML, one may try to use Java tools or the XML architecture. Even within the TeX family, there are powerful alternatives such as PolyTeX [see: http://www.dma.utc.fr/polytex] or PDFLaTeX [see: http://www.cs.berkeley.edu/~mdw/proj/texslides/] using which a high quality output suitable for the web and with hyperlinks can be created. But then, your average Mathematics teacher has to become increasingly computer literate or receive significant assistance from experts in the relevant technical aspects.

RELATED PROJECTS

Calculus courses are a universal phenomenon and there is a great deal of literature available on pedagogy, methodology, content alternatives, and the subject itself. A project closely related to ‘Teaching using Internet’ in the sense described in previous sections, and perhaps a step further, is to conduct online courses with possibly no direct human involvement. For instance, the survey
(Allen, 2000) gives an overview of the latter. For more information on this and a number of related topics, see the *Calculus Resources On Line*, at http://archives.math.utk.edu/calculus/crol.html, which has extensive links.

Web based courses are also becoming increasingly relevant in view of the growing trends towards virtual universities attempting to provide quality education through the Internet. An example of this is the Singapore-MIT alliance [see: http://web.mit.edu/sma/] which is trying to create new paradigms in global education and research. Closer home, there is the e-m@th project, currently underway, aimed at setting a French-Indian Cyber University for Science (FICUS) [see: http://www.wemex.com/aef18.html].

**CONCLUSIONS**

Trying to teach Calculus using Internet was an interesting experiment for those of us who were involved in it. In view of the advantages listed earlier and the growing trends mentioned in the previous section, there is perhaps an increasing need to conduct more such experiments. However, personally, I feel that the disadvantages outweigh the advantages and given a choice, I would prefer to teach in a more traditional way. I believe this will also be better for the students. As for the teaching community, learning about the experiments and views such as above can be useful. But it may be even more useful to conduct such experiments by themselves. In the end, it is for the individual institutions and the constituent faculty and students to decide what is best for them.

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**REFERENCES**

