CONTS

MATHEMATICS AND THE WEB:
LESSONS LEARNED

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THE BEGINNING

In 1992, faculty members of the Mathematics and Computer Science Department of Manhattan College received a grant from the General Electric Foundation to develop a computer orientated calculus course. The purpose of this project was to develop effective ways to enhance the teaching of mathematics. The focus of the project was the three-semester calculus sequence which is taken by all engineering and most science students at Manhattan College. A new curriculum was developed which embraced the use of the computer algebra system Maple.

When we began, we agreed on some general goals. We felt that students should be problem solvers. They should be able to analyze problems and subdivide them into more manageable parts. They must be able to organize cogent arguments both written and verbal. Students should be able to use computers as one of the many tools at their disposal. They should know when such use is appropriate and how to accomplish what they want to do. We recognized that students want to learn how to solve problems, but that they do not usually mean the same thing that we do. We felt that our traditional testing methods reinforce the computational concept of problem solving. We hoped that teaching calculus with Maple might help to change the common understanding of what problem solving is.

IMPLEMENTATION

Workshops for the faculty who teach calculus were held during the summers of 1993 and 1994. In each semester of the 1993-94 academic year, four sections of calculus were taught using the new curriculum. In the 1994-95 academic year, all calculus I and calculus II sections were taught using the computer algebra system Maple. At the end of the Spring, 1995 semester all calculus I students were given a questionnaire concerning their Maple experience.

SUMMARY OF STUDENT REACTIONS

The results of the questionnaires depended largely on the teacher. There were mixed results within each section, but on the whole, students either enjoyed using Maple or disliked it as a class. Two groups of students reported that they did not use Maple very often. Many of these students did not answer the entire questionnaire, and those who did had limited comments. These students were generally dissatisfied with their Maple experience and thought that it was a waste of time. They reported that they learned nothing new and were concerned that Maple detracted from their lecture time. The students claimed that Maple provided them with the answers to their problems, but that it

did nothing to increase their understanding of calculus. These students tended to see Maple as a glorified calculator and they were unimpressed.
Six groups of students reported that they did use Maple regularly and their responses were generally favorable. It was obvious that faculty members used Maple in different ways, and the student responses were varied. It should be noted that the majority of these students were serious about their answers, and they expressed their concerns and/or enthusiasm quite thoughtfully.

Students who thought that Maple was worthwhile were also the students who felt that it was introduced satisfactorily and was interwoven with the course. These students enjoyed seeing connections between what they learned in the classroom and what they learned in lab. Most spoke about the lab work as reinforcing what they had learned in lecture or vice versa. Most students thought that Maple did not teach them calculus. Rather, they saw Maple as an effective tool useful to solve certain problems. Most agreed that Maple can solve problems that could not be done by hand. However, only a slim majority thought that Maple helped their problem solving skills. It was obvious from their responses that students have different ideas about what should be considered "problem solving."

Some students were very concerned that Maple was doing the work that they should be doing. They said that the kind of work that Maple was capable of doing so quickly was precisely the kind of work that appeared on tests. They felt that Maple did not help their problem solving skills. Other students liked Maple because it freed them from tedious algebraic work and allowed them to concentrate on concepts and ideas. These students knew that they could do the algebra if they wanted to, but they were happy to have a tool to do it for them. Some of these students thought that Maple helped with their problem solving skills. The students who had the most positive Maple experience seemed to be those students who saw Maple as a tool. These students saw themselves as the thinking power behind the tool and Maple as the worker. They were not intimidated by Maple's ability to perform certain functions; rather, they were empowered by it. They could now do things that before they could not do. They could tackle harder problems, visualize something interesting, or investigate on their own.

1995 CONCLUSIONS

These results seem to prove that a clear decision must be made. Maple must either be used a considerable amount of time or it should not be used at all. There does not seem to be any middle ground. Furthermore, this decision must be a departmental one. It simply cannot be left up to the individual teacher. As students who have not used Maple take subsequent courses with those who have used it, problems will increase substantially.

Our pilot project results showed that, although teachers thought that students could learn Maple syntax quickly enough to catch up to more advanced students, the students themselves disagreed. Underprepared students used their lack of Maple expertise as a major excuse for any problems they were having in subsequent calculus courses. We will be creating a major problem for ourselves if we do not make a definitive decision and have the complete participation of all faculty members.

The results also showed that some faculty members are very successful in incorporating Maple into the curriculum. We must capitalize on this. Faculty members must continue to speak to one another about their successes and failures in the labs. Good labs and problems must be shared with colleagues. This must be an evolving, team effort.
Maple seems to have real potential. Some students have discovered it already. They have seen Maple as a powerful tool with which to explore a new learning environment. If we can foster an atmosphere of discovery learning and exploration using Maple, and if students begin to understand mathematics better because of their Maple experience, then our time has been well spent. The decision to use Maple in a classroom must be accompanied by a serious commitment requiring a significant amount of time, effort, and frustration. The teacher must be willing to immerse himself or herself in the environment of the classroom and give up the role of the performer on center stage.

As a consequence of the above results, the department agreed to make Maple mandatory in all calculus classes.

A 2004 REFLECTION ON THE 1995 CONCLUSIONS

We were hopeful that the above suggestions would be taken seriously by the entire department. The truth is that there is really no way of knowing. There has never been another attempt to find out what our students think about using a computer algebra system. There has never been an attempt made to make sure that faculty members actually use the computer algebra system. There is anecdotal evidence that students who have certain teachers come into subsequent mathematics courses with no knowledge of Maple, while others have an enthusiastic appreciation of the power of the computer algebra system.

The truth is that the department seems to be divided into camps on the computer algebra issue. Some faculty members use it regularly while others do not. The department has settled into a kind of "live and let live" mentality. Gone are the days when spirited discussions would prevail. Faculty members have simply decided to do what they want and no one is trying to convert anyone any more.

The students do survive in this atmosphere. They find out about our educational practices before they sign up for our courses. The system seems to be working for the students. Of course, this situation begs a question that cannot be answered here. If several senior faculty members do not recognize the importance of the proper use of technology in the mathematics classroom, then how much credit will be given to junior faculty members who spend their time and efforts trying to use technological tools appropriately? How can issues of promotion and tenure be dealt with in a fair and equitable manner?

THE EVOLUTION OF OUR LABS

During the rest of this paper, we will talk about how the faculty members who presently use Maple in the classroom have changed their laboratory exercises over the last decade.

STAGE 1: Sophisticated Labs:

Faculty members initially tried to use the computer algebra system as an aid in teaching concepts that traditionally were difficult for students. Such labs might have involved the professor's writing a short program--a limit table program or an iteration procedure for example--or might involve an application that was too messy to do by hand. In the latter case, students might be given a fairly complicated set of instructions mixed with Maple code, to lead the students through the first steps. Our feeling was that these labs were failures. Although the students were able to complete them, they did not seem to enhance understanding, and students regarded them as busy work.

STAGE 2: Complicated labs involving applications:

Most of these were selected from lab manuals for calculus, and projects developed by NSF sponsored groups. A typical lab of this kind might involve so many details that it didn't reinforce a concept. Details might be algebraic. Often the lab would be drawn from a realistic problem. The aim was enrichment and to teach the relevance of calculus. This type of lab failed because it asked the wrong kind of questions. Students might be asked to fill in algebraic details. The questions to be answered were invariably computational in type. Students were seldom asked "Why" or "What if?" or "Explain."

STAGE 3: Present labs:

We learned to give labs which involved less code, fewer Maple commands, and which primarily asked the students, over and over, to analyze. We verified their act of analyzing by asking them to write. We used Maple to plot. We asked students to annotate the graph. Where was the graph increasing? Where was it concave up? We asked them to explain.

We discovered that it is very powerful to ask students to solve problems and allow them to use any method they want to use. For example, a student who is asked to find the area between curves might decide to attempt to solve the problem without using Maple. This method tends to be abandoned quickly when appropriately selected problems are assigned.

We encourage students to speak the language of mathematics. We ask the students what they want to do. What is the verb? Plot? Solve? Expand? Students must decide exactly what they want to do mathematically, before they are allowed to ask questions about syntax. Once they decide exactly what they want to do, questions about syntax are often unnecessary. Labs have become teaching sessions, often one on one. We are happy to talk to the students, answer questions, and give hints. The goal is student understanding.

THE INTRODUCTION OF A CLASSROOM MANAGEMENT SYSTEM:

Have a vision of your overall hierarchy before trying to create a new course with a course management system. When you start to create your course, have your syllabus completed. This helps you decide what headings and subheadings you want. It also helps you see which parts of the syllabus should be treated in a similar fashion. Decide on a color pattern, and whether you will use capital or lower case letters. Be careful of color and contrast. Be consistent. This makes the course material more readable and accessible. Don't get too involved with bells and whistles. There is always time for extra features later.

From the outset, be specific about your expectations. Explain your grading system thoroughly. If you have an online component, then you should tell the students how many times per week that you expect them to participate. If you post a discussion question, and you expect that students respond to each other's comments, then you should tell them if a statement like "I agree with Mary" counts as a comment. Be specific about your expectations concerning the content of these comments.

Familiarize the students with any online component in a non-threatening way. Give the students a few days to familiarize themselves with this new environment and with each other. Sometimes this can be accomplished by giving an assignment that has little or no credit attached to it. You can begin to establish a classroom community online by asking students to tell the class something about themselves. If you decide to do this, you can set the tone for the rest of the class by being the first one to respond. Let your personality shine through. Give the students the type of response that you would like to receive.

It is extremely important to be specific about your expectations concerning Internet etiquette. If you expect students to use proper grammar, tell them. Students are very used to using abbreviations while conversing online. If this is unacceptable, say so. It is a mistake to let students post responses anonymously. Students should be held as responsible for their comments online as they would be for their comments in a classroom setting. Allowing anonymous comments can undermine the academic integrity of the classroom.

Respond to students' questions in a timely fashion. Whenever possible, use students' names. It is important that students are told that email is to be sent to the teacher only when it contains private information. Questions about class material are to be shared with the class. This is exactly what happens in the classroom setting. Everyone should benefit from the questions of others. Be strict about this policy. If you start to respond to individual questions via email, you can easily get overwhelmed. There is simply not enough time to respond to individual questions. You will find yourself repeating the answers that you have already given to another individual.

Be timely. For example, if you tell your classes that an assignment will be available at a certain time, be sure it is posted by that time. Students are new to this medium. They are anxious. If you make a mistake, some students can panic. Such students are sure that it is their fault that they cannot access the assignment. If you do make a mistake, admit it. Post an announcement that explains what happened. Be flexible. If necessary, change the due date on an assignment.

CONCLUSION

Using technology in any course changes the way we teach. The decision to use technology will significantly increase your preparation time. You have to be ready to spend a significant amount of time in this endeavor. The Internet is prompting more pedagogical changes. What we must not forget is that technology is only a tool. We must learn how to use that tool to make our subject clearer, to make our subject more interesting, to help us solve problems that we were unable to solve before, or to make it less tedious to solve problems. These principles hold whether that classroom is a virtual classroom or one made of mortar and bricks. The tail must not wag the dog. The lessons must not be driven by the technology. We each have to ask ourselves what our goals are and then figure out how to use technology to help us accomplish these goals. A person must be acquainted with the capabilities of the technology in order to make informed decisions, but it is the subject that must shine through. Our goal is to have the students forget that they are using technology and focus on the subject at hand.