MTH courses: What I do and why I do it.

Lee Townsend, Fall 2010

My methods for teaching math tend to be non-traditional but they are well thought out and the students seem to respond well. The methods described below result from over ten years of experience teaching technology math. I try to adapt my methods to match the capabilities and learning styles of my students. Although my methodology is pretty well set at this point, I am always on the look-out for changes in the current students as compared with previous ones. Their secondary school math knowledge varies from year to year so I must adapt.

My students are learning how to be guideline-based problem solvers in their majors. If you ask a group of audio students to design a system given very detailed specs, you still won't get back identical solutions. They use their knowledge and intuition to create the optimal system from the guidelines they have learned. Math problem solving skills are rule-based. What's the pattern? What's the rule that goes with that pattern? Apply the rule. Recurse until the solution is achieved. There may be more than one set of rules that will lead to the solution when multiple paths are possible but all students will have the same answer.

Below I give the rationale for what I do in my MTH courses.

1) **In class**:

In class I present the subject(s) du jour (at most two sections per class), do a couple of the book's example problems for them, have them go through a couple of example problems themselves to see if they can follow the author's explanation, then they solve problems from the end of the section. From the work Natalie Segal and I did when we had an MET FIG of EN and MTH first year courses, we found that the MET freshmen were about 95% S's in the Meyers Briggs test sense. i.e. They are very concrete thinkers. They see all details and miss the overall pattern structure, i.e. how they identify which rule to use. Pattern recognition is what will lead them to the solution. They must see every step explained. Even my best students need this kind of presentation. Pattern matching skills are then enhanced as they see the rationale behind the identification. They build their intuition by practicing pattern matching.

I have found that if the students solve a set of end-of-the-section problems in class then, when they run into trouble, I am right there to help them. They also work with nearby students – their peers. They don't make up math, they ask how to do the math correctly. They focus all their attention on the math – probably impossible in their dorm room. They learn to use their TI-89 correctly. At first they are overjoyed with its capabilities and the fact that they can get the answer immediately. Then they realize that calculators are like the perfect child. Calculators do exactly what you tell them to do. Sigh…..

To build student intuition on how to solve problems, about a month into the semester I go through every problem at the end of a section. The question is "What do I do first?"

Once that question is answered, the students are well on their way to solution. I am trying to show them how *I* approach math problems.

I have found that the hardest part of solving a problem is figuring out what the problem actually is. For example, on the first day of my MTH 112 class I present the following problem:

> How much are you (or your scholarship/loan) paying per minute to be in my class?

I hand them a copy of the web page that outlines the costs associated with going to UH.

http://admission.hartford.edu/financing/costs.php

It's an interesting problem. At first blush, it is straightforward. However, what numbers do you use? How long is an hour, if that is your time basis? Note that the UH hour is 50 minutes. How long are you in class (it is not typically equal to the credit load)? The answer, of course, depends on your schedule. It is approximately $1.20/minute. So, a 75 minute class costs the student $90. That's alot of money to throw away when you cut my class. This problem is typical of what they will find in the working world. The student has to figure out what question is and what numbers are important. The actual math is simple.

2) **Homework**:

I have found that if I assign homework to be graded, those that know how to do the math get annoyed because it is a waste of time and those that don't, either make up their own math (eek!!) or don't do the homework or copy somebody else's. Hence I don't assign homework per se. It is typically a waste of time for all.

Note that the students *are* responsible for all problems assigned in class so some problems may be left over as home work. I tell them to please not make up math. If they have problems with solutions, bring their questions to the next class. If one student is having problems, probably there are others with the same issues.

3) **Exams**:

I split my courses into three mini-courses. The exams are not explicitly cumulative as the theme is just math grammar. I want the student to be able to focus on a finite set of problem solving skills. The "literature" is presented in their major courses. I tell them the problems that will be on the exams by pointing to similar problems in the book. I explain how I make up exams. I need to be able to do them in 10-15 minutes at most. If I find a problem interesting, it is probably too difficult for a newbie. After all, I have at least 45 more years of experience solving math problems than they do. I need to cover all relevant sections on the exam. That limits the number of problems I can take from any one section. Hopefully, by giving them those details, I have organized their studying. Many times I will give a review session during the weekend before the exam. It is free form with no time limits. Typically about 1/3 of the students show up.

Here is the stated exam information from my MTH 112, 122, 232, 241 syllabi.

> There will be three in-class exams, the last one taken during the final exam slot. You must show details of your work to get full credit. Extra credit is given for checking your work using a different solution method. You may take an optional auxiliary exam within one week of my handing back the graded exams in class. This second exam must be taken during my office hours. The second exam will be multiple choice with no partial credit given. The grade used for the exam will be 75% of the second exam grade added to 25% of the in-class exam grade or 100% of the in-class exam, whichever is greater.

The original, in-class, exam tests their knowledge of the details of how to solve problems we have been looking at in class. The tests are open-note, open-book. I want them to learn to take good notes and to prepare worked our problems in the manner in which they understand the material. i.e. They annotate their solutions. They have then written their own mini-textbook for their exam and future use on how to solve that type of problem. The exams are open book since our students need to know how to teach themselves from a book. They can make annotations in their books to help them. Since we did in-class examples and problems from the tested sections, the material as presented in the book should be familiar to them. I designed the fuel system for a gas laser by teaching myself engineering thermo and fluids. Note that those two topics usually form two separate courses. My laser system, of course, had fluid flow with thermodynamic properties. You just never know when you will have to learn a complicated topic on your own. Reading and comprehending a text book is a critical life skill for technologists. Complicated math itself will probably be done by someone else.

The students are encouraged to use their TI-89 to create their own answer key to the exam. It is a good feeling to get the same answer as the calculator and provides feedback to the student about the correctness of their solution. i.e. they know if there is a problem with their solution that they can fix in situ. My courses are not meant to be punitive but educational. Each exam problem is worth 10 points when I grade it (scaled at the end to a total baseline of 100 points). Checking their work properly gives them a bonus point. If they start on a solution and think it is wrong, I ask them to only cross it out, not erase it. It might have actually been correct so they will get partial credit for having some knowledge of the solution even if they drifted from it at the end. If they think the answer they get is unreasonable, I ask them to identify it as such. If the answer is actually correct, I ignore their comment. My favorite line is "Give me something to grade." I am trying to teach them to provide all details of their solution. When on the job, they will need to be able to explain to the boss how they got their answer. They practice that skill on my exams. Note that I typically give three similar exams at once. Only some numbers have changed. I always assume my students will not cheat but if the person next to them has a different exam, copying the solution leads nowhere except trouble for the student when I find it.

As noted in the syllabus, the students can take a multiple choice exam to pull up their grade (it will never lower it so there is no risk in studying some more). The problems I choose are the hardest ones I can find in the test bank that test their knowledge on the

material they have studied. This exam serves several purposes. It gives the student a chance to bring up their grades. They hone their TI-89 skills. They can test their intuition about what might be a correct answer. I give them a second chance on problems they miss in round one. In my opinion, they take math to not only know how to solve problems in their major but to build their intuition about whether or not the answer makes sense. i.e. When an engineer presents his/her bid to an architect, does it make sense? Is the proposed structure mechanically sound? Does the price quoted make sense given the proposed mechanical design? Etc. The second chance gives them more intuition testing opportunity.

Note that if the student opts for only taking the second exam (after all, it is multiple choice – their forte), then the best they can do in my course is a 75, i.e. a C. I think that C reflects the level of their learning. They have clue about how to solve the problem but lack the details. Note that getting a 90 on one of the three multiple choice exams lowers their grade to a C–. It is probably not a good idea to cut the in-class exams (VBG).

I use a different method in MTH 352, Differential Equations. There are three sections in the course: first order DE, second order DE, Laplace transforms. Usually the first exam is culture shock. Differential equations can be complicated if you don't practice solving them. Instead of multiple choice auxiliary exams, I offer exam 1 on first order DE, exam 2 on second order DE, then a combined exam on first and second order DE. At this point in the semester, the solution pattern is becoming clearer and they understand first order equations much better than during the first exam. I drop the lowest of the three grades. Then, the final exam covers only Laplace Transforms. i.e. Once again, I am focusing their studying to a specific area.

4) **Conclusion**:

Technology students are not math majors. If they are that good at math, I encourage them to take A&S math. That is the math required for graduate school. My understanding is that tech math will not be acceptable. My view is that technology students are learning math as an underpinning grammar for the theory they learn in class. The theory becomes applied in the labs/studios and *that* is the knowledge/skill base the students take away from their major courses, not the math itself. I want them to be responsible calculator users as they take that little black box with them as well. Note that the responsible use of the TI-89 means that class time in their major courses can be spent discussing the implications of the solutions instead of taking the time to actually do the details of the math. This statement is especially true with differential equations. Let the calculator find the solution then the professor can discuss the implications of same. It can take the full class time just to solve a differential equation correctly. That is a class lost to technical content. In my experience, most students' algebra skills are so weak that they will not do the math correctly. Then, in their major courses, they are fussing with math instead of meaning. There is only so much class time available and it needs to be spent wisely.

That's all I can think of at this point. Opinions and suggestions are welcome. Teaching is like raising children. Each class is different. What works for some students will not work for others. My job is to do the best I can to educate the most students. For some, it just won't happen. They need a different professor or a different major.