TEACHING STATEMENT

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Personal History

My first experience with teaching was in the summer of 1985. D.H. Tucker (Univ. of Utah), who later became my dissertation advisor, was running a special program to teach mathematics to in-service secondary mathematics teachers who wished to upgrade their teaching levels. He hired me to do the tutoring for the program. The students would attend his two-hour calculus lecture in the mornings, and in the afternoons I would try to answer their questions and coax them through the homework. That experience was formative for me as a teacher, for it was there that I had my first taste of what it is like to see the light bulb going on in another human being's head as s/he finally grasps a concept. Although I had had a vague idea of wanting to be a college professor for many years prior to that, it was that tutoring job that firmly cemented my desire to teach college level mathematics.

In my third quarter of graduate school, I was asked to teach a class of my own. That was not as common then as it is now; it was normally reserved for students who had completed a full year of leading recitations. Unlike many of my fellow graduate students who did little teaching because they were supported by their advisors' grant money, I taught a class every quarter of graduate school from then on. I enjoyed it immensely, and the department apparently thought I was doing reasonably well; in 1988 I won a teaching award (this was back in the days before departments started giving nearly all of their graduate students teaching awards), and in 1991 and 1992, I was given honors sections of calculus to teach. In the years since then, I have taught a variety of courses throughout the undergraduate curriculum, and a couple of graduate courses.

All this is by way of introducing myself, and laying the foundations for the remarks to come. As anyone who has served on a hiring committee is aware, there is a certain sameness to teaching statements, especially those written by fresh Ph.D.'s. And who can really blame the new graduates: they have had no time to reflect on teaching in a meaningful way, and not much experience on which to draw. Although I do not think I am going to say anything especially controversial, I hope this statement will strike the reader as being a bit different from most.

Tried & True: Quizzes, Tests, Homework

In the calculus class I taught my first year (1992-93) at IUSB, I performed a crude experiment. In addition to giving tests a few times in the semester as most people did, I also gave a quiz every week. (Remember: for a young assistant professor just out of graduate school, this is a *big* experiment.) More importantly, every day when neither a quiz nor a test was scheduled, I gave an "unquiz" right at the beginning of class. The point of this experiment, which was carried out without controls or a formal design, was to see if I could make a dent in solving a problem I had already seen as a graduate teaching fellow: the tendency of students not to study as a term wears on. I think it worked, and to some extent it still works whenever I use the method. The daily unquiz ritual seems to tune students' minds to mathematics right at the beginning of class. I encourage them to look at their class notes and check with their neighbors to see how well they are doing. The standard corny joke I tell my students about unquizzes is: "If you are not cheating, you are probably not doing it right."

I have nothing negative to say about any method for evaluating student progress, including projects, graded homework, or even group work. I have used all of these with varying degrees of success. But the traditional quiz/test/exam still has an important place. I say that not merely because it is currently fashionable in our society to insist upon standardized tests as a gauge of institutional success (a fashion

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I find deplorable, incidentally), but for more pragmatic reasons: besides providing a mechanism for assessing students, traditional tests serve as a motivational tool. I grant that it might be a bit of a stick to students who have come to expect carrots in their educational experiences, but I take seriously what my students have said: they appreciate a forced march. I don't "teach to the test" (whatever that means). I have no qualms about covering material on which I have no intention of testing (though there is no reason that students need always be informed of this), nor do I have qualms about testing material from, say, the textbook which I do not have time to cover in class (provided I give the students plenty of warning).

In recent years, I have alternated between weekly quizzes and assigning daily homework in lower-division courses. Which I use depends mostly on the number of times the class meets per week. Weekly quizzes with their unquiz counterparts work pretty well in classes that meet at least four times per week. For those that meet less often, daily homework has the advantage of eating up less class time, though it certainly means more work for me. In either case, students, especially freshmen and sophomores, tell me in office hours that they appreciate being forced to study at a regular pace throughout the semester. They also appreciate being given constant feedback on the homework.

During my year at Western Michigan University, a colleague recommended I try using Gateway Exams in second semester calculus. In a "typical" college or university calculus class, integration by substitution is taught in the first semester. However, since it is one of the last topics taught, tired students often don't absorb it to the extent that we expect them to in the second semester. So I tried the following: in Calc II, after a couple of days reviewing integration by substitution, I gave a Gateway Exam consisting of ten indefinite integrals to compute, nine of which required substitution. They had to score at least a 76% (in my scale, this is about a C) to pass it. If they failed or were not satisfied with their score, they could take it again the following week (outside of class), but could not score more than 94%. The following week, the max score was 88%, and so on, until finally the max score was 76%. Anyone not passing the Gateway Exam by that time failed the course.

The Gateway worked very well; most students passed after three attempts, a couple needed four attempts, and a couple of more withdrew after realizing they were in over their heads. If I made one mistake in that experiment, it was overemphasizing integrating by substitution to the detriment of other calculus topics. I ended up with a roomful of students who could integrate by substitution rather well, but couldn't remember the quotient rule for differentiation. In any case, Gateway Exams seem to be a useful way of toning up students' abilities to do routine calculations. I am not convinced that they are such a good idea for more conceptual issues; for that there needs to be a certain amount of trust in how one's colleagues taught earlier courses.

Tried & True II: Lectures

For decades, the lecture as a mode of teaching has been a favorite object of derision, especially by the sorts of people who like to start sentences with the phrase "Studies show ...". Nevertheless, lecturing remains the dominant mode of teaching at colleges and universities. As a discipline in service to so many others and as a technical field, mathematics is still a subject well-suited to the lecture, however denigrated it is. Certainly I am still in a generation of academics who came into the profession enjoying lecturing and hearing good lectures. There is a certain amount of performance involved, a certain feeling of being on stage, which, provided it does not rule the day, can be very addicting. (As my advisor once said of this type of teacing: "If the state legislature knew how much fun this is, they would make us pay them to allow us to do it.") I reject the argument that lecturing is not a student-centered mode of teaching; it depends on the lecturer.

I will be the first to grant that attention spans are not what they were. I have seen a significant drop in the last decade in the amount of material students can absorb from a one hour lecture. Students are certainly not stupider, nor would I like to think that my lecturing style has become more boring over the years. Rather it is just that increasingly busy lifestyles leave less time for reflection in private life, which translates into less time spent reflecting while in the classroom. More often than not, students seem to be trying to just "get it all down in their notes".

Wherefore lecturing? Does it still have a place? I think the answer is yes, and it is an important place. Any student, however unpracticed at listening, can respond to a carefully organized but simultaneously spontaneous lecture. Those who disparage this type of teaching claim that it is not while listening to a lecture that a student constructs knowledge, grasps the fundamentals, or more generally, just puts it all together. I will not disagree with the basic premise here: mathematical knowledge is certainly something each student needs to construct anew in his/her own mind. However, I claim that in addition to being an efficient information-delivery system, a good lecture serves another important function: it gives the student a sense of the *possibility* of putting knowledge together in a coherent package. For who among academics has not had the experience of hearing a gifted lecturer talk at length on an unfamiliar subject, and come away having a vision of the subject *as a whole*, knowing that with additional time and study, one could grasp all the details coherently? And having had that experience, let us ask if we should we deny our students the same opportunity?

Perhaps it will be argued that such lecturers are few and far between. Certainly I am not claiming to be one. But I do think that on those days when I use the lecture as my mode of teaching, I at least can give the students a taste of the unity of the subject and a feeling that with further reflection, it will all make sense.

Having defended some of the "traditional values", it is time to look at what is sometimes (wrongly) perceived to be the opposition.

New & Improved: "Reformed" Courses

Although reformed courses have been around long enough that the moniker "reformed" is starting to be an oxymoron, there are still those who view such courses as a passing fancy. I think that they are here to stay, and it behooves me to address them here. The focus of the reform movement was (rightly) calculus, which, in variations, is the course that has been the one constant in my teaching. IU South Bend even tried a reform calculus textbook (Ostebee & Zorn) for one year, though by an odd coincidence, that was a year I wasn't teaching a regular section of calculus. In 1993-1994 academic year, I taught an experimental reformed section of calculus using the textbook/software combination *Calculus&Mathematica*. All reformed calculus courses use computer technology to some degree; *C&M* was one of the first ones to advocate the teaching of calculus entirely as a laboratory course.

I will not describe in much detail here the outcome of this experiment; I will just summarize a few basic conclusions. While it is certainly true that students learned a great deal and enjoyed much of the laboratory experience, it is also true that they felt the class lacked direction or focus, and felt cheated that they were not getting the benefit of *my* knowledge for their tuition money. (This is a paraphrase, not severely rewritten, of what some students said.) To put it a different way, they noticed that what was missing was that to which I alluded at the end of the last section: they did not have the guidance necessary to put it all together. By the end of the first semester, I had to agree, and I was lecturing (to a very appreciative audience) at least one night a week. In the second semester, I scheduled two nights a week for lecturing. From this I concluded that one needs to be careful about what "student-centered" learning means; it does not mean guidance-free learning. In addition, it was too often the case that the software was getting in the way of the mathematics. Students would have to jump through hoops to get demonstrations to work when I could easily have walked them through a concept in five minutes, and the net outcome would have been the same level of understanding on their part. I am not convinced that improvements made to the software since then do much to alleviate this problem.

One difficulty was that early versions of *C&M* encouraged students to cut-and-paste the *Mathematica* code, and rewrite and modify it as necessary. I think this is the wrong approach. An example will illustrate my point: *C&M*, as a computationally-oriented reform calculus textbook, introduces Euler's method for solving differential equations early in the *first* semester. Mathematically, I have absolutely no objection to this, and in fact, I think it is a great idea. Euler's method is easy to understand, and its equivalent numerical integration method, the left endpoint rule, is a staple of the calculus curriculum. Unfortunately, as users of early versions of *Mathematica* know, the code for a reasonable implementation of Euler's method is very tricky. My own students were never able to get past this to an understanding of the method itself, until I finally dragged them into a regular classroom and walked them through it on the blackboard.

So much for my first laboratory experience. There is nothing wrong with hands-on experience, but sometimes the wrong kind of hands-on gets in the way of conceptualization. Other problems were specific to my institution. It is very difficult to run a laboratory-based intensive course on a commuter campus. There is too much of a commitment of time in the laboratory for the students, many of whom have full-time jobs. Also, at the time few students had their own computers, and this coupled with the price of the software made *C&M* inaccessible to nearly all of them anywhere but on campus.

The above experiences probably sound familiar. Many who experimented with reform, especially in its early days, got burned and turned against the whole idea. However, I am still sympathetic to many of the goals of the reform movement. In a version of this statement dated several years ago, I wrote "...the teaching of calculus, and the mathematics curriculum in general, needs to take better account of changing technology." I think most institutions have done this by now, and in ways that could not have been anticipated in the early 90s. My own experiment with laboratory-based reform took place before it was feasible even to distribute materials over the web, and before the advent of supercalculators such as the TI-89. I'll say more on technology in the next section.

Turning to course content, I still think that certain traditional topics in calculus need to be revamped or as much as it might hurt to say it, scrapped (e.g., some of the pseudo-applications of integration), while topics from what used to be higher level courses (particularly differential equations) need to be brought into calculus. Many of the more popular "middle of the road" textbooks, such as those of Stewart, support these ideas.

Going further, there are some reform-oriented topics I like to teach which are usually relegated to the exercises in calculus textbooks, reformed or otherwise. Let me just discuss just one case of this. This is a bit of an aside, but it will serve to illustrate more of my thinking on these issues.

One of the standard, if rather tired, debates in the construction of the calculus sequence is where to put the logarithmic and exponential functions. One argument, the so-called "late transcendental approach", says that these functions should not be used until they are properly defined, and since the "correct" definition of the natural logarithm is as an integral, it follows that these functions should be introduced at the beginning of the second semester. The "early transcendental" counterargument is that students have some grounding in precalculus, and have already experienced the logarithmic and exponential functions without having them rigorously defined. Why not then take advantage of their intuition, rather than wait a semester by which time they will have forgotten what they knew about those functions? Furthermore, no student really *believes* that the logarithm is defined by an integral; they think it is simply a "fact" that $\ln x = \int_1^x (1/t)dt$; the better students think it is just one of the many unproved theorems they encounter.

I come down pretty heavily on the side of those favoring early transcendentals. I think the centerpiece of the late transcendental argument is based on a double standard. The trigonometric functions are not rigorously defined in precalculus or calculus: the precalculus definition depends on the notion of arclength. And yet those favoring late transcendentals would never say that the introduction of the trigonometric functions should wait until the functions can be defined rigorously!

However, there is one piece of the late transcendental argument which is *very* compelling: it is important for calculus students to understand what it means for a function to be defined by an integral. As above, I do not think that the natural logarithm serves this purpose very well. So my view is: why not use the occasion to introduce *other* functions they are likely to encounter in applications. Thus if I can squeeze it in, I spend almost a whole unit (probably the equivalent of two textbook sections) analyzing the error function, the Fresnel C and S functions, the sine integral function, and others. We thoroughly examine how the properties of these functions follow from their integral definitions: it is the calculus itself, especially the fundamental theorem, which is giving us the information. If I ever write my own calculus textbook, I will make this a centerpiece.

Returning to the main point of this section, what few reservations I have about reform are not related to curricular goals, many of which I support, nor to the zealotry of its advocates, which I am willing to tolerate up to a point, but rather some of the methodological goals. While I do not think that calculus is just "analysis with applications", as was the view back when I was a student, I do think that calculus has a theoretical framework, and that knowing this framework is part of what knowing calculus is. My red flags go up when some advocates of reform deny that the framework–which consists of theorems *and their proofs*–is important. However much the curriculum may evolve, I still teach the Mean Value Theorem and I expect my students to know it and to understand what it means to say that the MVT is the theoretical foundation of the differential calculus. I don't care what proof they are exposed to (I prefer the semiconstructive nested interval proof over the one that depends on Rolle's Theorem), as long as it is part of an overall package. Students need to master quite a bit of material, but they also need to be given tastes of more than what they will master.

I have additional personal experience which allows me to be simultaneously supportive and critical of reform efforts: I have successfully taught reform courses in differential equations. In the fall of 1996, I took the plunge and adopted a reform textbook in differential equations (Blanchard, Devaney, and Hall). There is, however, a noticeable difference between what passes for reform in differential equations versus reform in calculus. A reformed differential equations course still contains a good deal of theory, and that theory is used in deep ways in the course. What makes it "reform" is the restructuring of the curriculum to emphasize dynamical systems, and the reliance–not to the exclusion of all else–on technology as a medium for understanding the solutions of differential equations. This course, which I now taught a few times, is the one of which I am the proudest in all my years at IU South Bend. I enjoyed teaching it, the students enjoyed learning it, and they came away from the course with a deeper understanding of some aspects of differential equations than I had when I was in graduate school! It continues to work each time I teach it in that fashion.

This is probably as good a segue as any to a discussion to the happy medium.

"Something Old, Something New..."

I have defended traditional modes of instruction while admitting their weaknesses, and I have both criticized and expressed admiration for the reform movement. Now it is time to put it all together.

Whatever may have been the downside of my experiment with a laboratory-based calculus course, I did come away from the experience with a sense of the importance of *student-centered* and *project-oriented* learning. I do think it is unacceptable for an undergraduate student of mathematics today to be unexposed to mathematical software such as Maple, *Mathematica,* and the like; these are the tools of the working user of mathematics. It is shocking to me that majors are being allowed to graduate who have never used any such software pakcage. In many courses I teach above the level of calculus, I require students to complete a certain number of laboratory projects. From auditing a couple of courses myself, I learned an important lesson from my colleagues in computer science: it is OK to require students to go to a lab on their own time and figure out software for themselves. It is not unreasonable to expect students, even commuters, to spend some time in a laboratory outside of class. The fact that students expect to do this in computer science but not in mathematics is cultural habit, not something intrinsic to the subject.

I think it is important for departments of mathematics to give their faculty some direction as to how mathematical software is used. A few years ago, when I was at Western Michigan University, instructors in differential equations and linear algebra were required to assign Maple projects over the course of the semester. However, there was no uniformity to this, and the workload for constructing projects was dumped entirely on the instructor. This seems ridiculous to me. People have been using Maple and *Mathematica* to support courses for well over a decade and a half, and there is no reason that an individual instructor should still be expected to construct his/her own projects, just as chemistry departments do not expect professors to keep reinventing student laboratory experiments.

Most textbooks now come with interactive CD-ROMs. When I teach differential equations, I use the Interactive Differential Equations CD-ROM package which is bundled with the Blanchard, Devaney, and Hall book. It is a triviality to make syllabi, handouts, etc., available to students on the web, and some institutions go further with such tools as WebCT, Blackboard, or OnCourse. Further integration of web-based instruction into the curriculum is only now creeping into four year schools. (Community colleges have been way ahead in this issue.) It is still labor-intensive for individual instructors to make more interactive material available, but as it becomes less so, I will certainly move in that direction.

The balance I may have achieved in matters technological should be seen as a dynamic equilibrium, not a static equilibrium. Indeed, I have oscillated with regard to the technological sophistication I require of students by the end of a semester. Certainly a minimum, at least in lower-level courses, is proficiency with a graphing calculator. I have had enough experience at different curricular levels with this to be sold on the efficacy of their use. Of course, technology brings its own headaches; everyone who has taught precalculus knows that some students never get the idea that calculator-drawn asymptotes are not part of a graph. However, the increase in students' conceptual understanding which I have seen over the years outweighs these minor considerations. I should add that I do not think that textual materials have kept pace with technology. Even now, so many years after calculators became commonplace in the curriculum, most books which claim to be calculator-friendly simply have the use of the calculator as an add-on. This is surprising, since graphing calculators will soon be passé. At many schools, nearly all calculus students already own a TI-89 or the equivalent, and at some places, students are *required* to have them.

Let me turn from technological issues to cooperative learning. I have tried assigning students to teams and having the teams present assigned homework problems in class, but in lower-division courses, I have had almost no success with this method. For instance, in one class of 40 students, I found that by the third week of the semester, *none* of the students were meeting with their fellow team members. Nothing I could do with threats or rewards could get them to work together outside of class. I think that for routine daily homework, especially at schools with a large number of commuter students, it really doesn't make much sense to force students into the team mode. They resist it, and I am somewhat bothered about the ethical implications of trying to force them to do it.

By contrast, teams work fine for project-based learning, especially in upper-division courses. I have assigned teams to give project presentations in various courses, including differential equations and the history of mathematics. These generally go quite well. I use the standard methods to assess teams, such as asking the individual team members to rate how much work each team member did on the project. I have divided up the students myself, and have let them divide themselves up on other occasions, and I cannot say that I have noticed much difference in outcomes between the two approaches.

Let me also mention a thread I did not bring up earlier, and which lies outside the "tradition versus reform" dichotomy I have been artificially toying with here. This is that the present and future of my teaching lies partially in the past. By this I mean that I have become more convinced of the importance of the historical perspective in mathematics, and I try to transmit this perspective to my students. To quote the historian of mathematics Carl Boyer, "No scholar familiar with the historical background of his specialty is likely to succumb to that specious sense of finality which the novitiate all too frequently experiences." I do not want my novitiates, that is to say, my students, to experience any sense of finality regarding mathematics; I want them to experience it as a living field. Besides having taught the history of mathematics as a course on various occasions, I have also taught a historically-based introduction to analysis (using Bressoud's textbook). In all cases, I think the historical approach added life to the courses.

Final Remarks

I hope these notes have conveyed some sense of what has gone into the construction of Michael Kinyon as a teacher of mathematics. To recap: I began with history (my own), traced my views of traditional modes of teaching and efforts towards reform, described my attempts at compromise, and ended with history (of mathematics). The subtext that I hope came through it all is an aesthetic one. In particular, I wished not merely to describe the joy I take in teaching, but to show through the example of the preceding narrative my commitment to the *art* of teaching.

Quod erat demonstrandum.

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