RTP data form

Date: May 24, 2005

PERSONAL DATA

1. Name of Candidate: **Kevin Iga**
2. Application for **N/A**
3. Summarize your education, listing each school and dates attended, degrees conferred, special honors received, etc. Begin with the most recent.

1992-1998	**Stanford University**	**Ph.D., Mathematics**	**June 1998**
1988-1992	**Mass. Inst. of Technology**	**B.S. Mathematics**	**June 1992**
		B.S. Physics	**June 1992**

4. Pepperdine Employment History

a. Date of first employment with Pepperdine University: **August 1998**

b. Date of first employment in your present position: **same**

c. Rank at which you began: **Assistant Professor I**

d. List all promotions attained and dates they occurred:

2005 **Associate Professor I**
2004 **Tenure**
2003 **Assistant Professor III**
2001 **Passed Pre-tenure Review**
2000 **Assistant Professor II**

e. Total years of teaching experience at Pepperdine University: **7 years**

TEACHING

TEACHING

5. List all schools other than Pepperdine University at which you have taught, including your rank and dates of your appointments. Begin with the most recent. **N/A**

6. List all of the courses you have taught at Pepperdine University.

Lower-division non-math-major courses:

Math 214: Calculus for Business

Terms taught: Fall 2000 (2 sections), Fall 2001 (2 sections), Fall 2002 (1 section), Fall 2003 (2 sections)

Math 215: Probability and Linear Algebra for Business

Terms taught: Fall 1998 (2 sections), Spring 1999 (2 sections), Fall 1999 (2 sections), Spring 2000 (2 sections), Spring 2001 (2 sections), Spring 2002 (2 sections), Fall 2002 (2 sections), Spring 2003 (2 sections), Spring 2004 (2 sections)

These are both required courses for students majoring in business administration, accounting, international business, and economics. Math 214 is calculus, but unlike our usual calculus sequence (math 210–212), the courses assume somewhat less facility with algebra, and the emphasis is much less theoretical and much more directed to applications to business and economics.

Math 215 covers a small amount of multivariable calculus that does not fit neatly into math 214, and two relatively unrelated areas of mathematics: probability and linear algebra (matrices). It requires math 214 as a prerequisite.

Math 102: The Nature of Mathematics

Terms taught: Fall 2004 (2 sections)

This is a course that is intended to fulfill the math general education requirement for those whose majors do not require any other math course. It is the course that most directly presents mathematics in the context of the liberal arts. It seeks to build an appreciation for what mathematics is all about, more than building particular skills.

Lower-level and intermediate level math-major courses:

Math 212: Calculus III

Terms taught: Spring 1999, Fall 1999, Fall 2003, Fall 2004

This course is the third in the calculus sequence, and is required not only of math majors but also computer science, 3/2 engineering, and chemistry majors. It is also of interest to some other students (in biology, economics, etc.) whose majors do not formally require it, but for whom a strong mathematics background may be an asset in graduate school or research.

Students often take this course during their sophomore year, though some advanced freshmen also enroll.

Math 330: Linear Algebra

Terms taught: Spring 2000, Spring 2001

Not required of chemistry majors, but otherwise most of the comments about math 212 apply here. Some students take both courses concurrently, and in fact the classes complement each other in material nicely. Linear algebra is also the first course where abstract mathematical objects naturally arise, and students are expected to follow mathematical proofs more deeply than before. This course thus lies between the lower-level calculus courses and the upper-level theoretical classes.

Upper-level math-major classes

These courses are offered every other year, and require proof-writing techniques learned in the student's sophomore year, and therefore students take these courses as juniors or seniors.

Math 431: Algebraic Structures, part II

Terms taught: Spring 2002

This is one of the most difficult math classes we offer at Pepperdine. It is a continuation of Math 430 (Algebraic Structures, part I) and as such is heavily based on abstract mathematical concepts and students are expected to be able to use problem solving techniques creatively to come up with logical, understandable, and convincing proofs.

In Math 430, students learn about a panoply of abstract mathematical structures, and in math 431, they learn to use these structures to answer questions raised by algebra, such as solving high-degree polynomial equations.

Math 510: Probability

Terms taught: Fall 1998, Fall 2000

Math 511: Statistics

Terms taught: Spring 2003

These two courses form a year-long sequence. Though many departments (including math) offer a range of probability/statistics courses, these courses are markedly different in that they focus on the theoretical ideas underpinning these topics. Students are expected to work with proofs and derive formulas that in other statistics classes, we expect students to simply memorize.

The subject area is, of course, the same, with probability considering computing probabilities in a range of situations where uncertainty lies, and statistics involving working with data to reach various conclusions, again where uncertainty plays a role. The way in which these courses are taught varies considerably, and I will comment below on some of the choices I made in teaching these courses.

Upper-level computer science classes

Math 460: Automata Theory

Terms taught: Fall 2001, Spring 2004

This is a math class but one that computer science students, not math students, take. The historical foundations of computer science lie not in science, or in technology, but in mathematics and logic. This course exposes students to that foundation, with the result that students can think about computers and what they do from a broad perspective. There are some practical programming skills that can come from this course, especially from the part on finite state automata, but the most impressive insights involve recognizing what a computer cannot do, even in principle.

Math 110: Seminar for Freshmen (cotaught with all math faculty)

Terms taught: Fall 1998, Fall 1999, Fall 2000, Fall 2001, Fall 2002, Fall 2003

The Math 110 course is a course that is cotaught by the math faculty each fall for freshmen prospective math majors, and each faculty member is responsible for two lectures. Below are the topics I chose for my two lectures each year:

Fall 2002	Number theory and modular arithmetic
Fall 2001	Spherical and projective geometry
Fall 2000	Pythagorean triples
Fall 1999	The mathematics of classifying knots
Fall 1998	Polyhedra

The idea is to introduce prospective math majors to interesting topics beyond what they would see in their calculus classes, to make them more aware of what mathematics is all about.

One unit math seminars (Math 599)

These courses introduce math majors to a few advanced topics that are often available to interested students at larger universities as regular courses, but are not offered here. In a more standard setting, these courses would be regular semester-long courses meeting three or four times a week, but in this case, I have decided to offer these as one-unit seminars, meeting one hour a week, to provide not a full course but a cursory introduction. Typically, there is no homework or exams given, and grading is CR/NC. Much of the time is spent on projects where the students are expected to work together to find creative solutions to problems, and in the process develop the mathematics of the field. Typically called the "Moore Method", this approach emphasizes the technique of discovering mathematics over the course material itself, and is more suited to material for which coverage can be compromised. But since we only met once a week, in order to have some coverage, I also lectured on a few topics.

Course	Terms taught
Cryptology	Spring 2004
Putnam competition preparation	Fall 2000, Fall 2003
Mathematics for Graduate School	Fall 2002
Cryptology	Spring 2002
Game theory	Fall 2001
Topology	Fall 1998, Spring 2001
Number theory	Fall 2000
Algebraic Topology	Spring 2000
Projective Geometry	Fall 1999
Advanced Set Theory and Logic	Spring 1999

Most of the above are of this type, though some are unusual in other respects and therefore require some further comment:

The Putnam Competition is an annual national college math competition held every December. The Putnam Competition Preparation is a course where students are exposed to some interesting mathematical ideas and problem solving techniques, and where students can practice with old competition questions.

The "Mathematics for Graduate school" seminar covered a range of topics to better prepare students who are considering mathematics graduate school.

Cryptology was taught jointly to math and computer science students (there were some business and economics students as well). Both math and CS expertises were needed, and math students were expected to teach the relevant math to the CS students, and vice-versa. Much of this, though, was problem-solving, as I gave them codes to break.

Game theory was also a cross-disciplinary course, as it attracted interest from economics students as well as math students, and students were expected not only to use what they had learned in other classes, but teach it to others in a way that they could understand.

Reading Courses (Math 299, Math 599)

Although these used the same numbering system as the seminars, these courses were quite different. Typically these are more individually focused, based on reading a book, and often these are initiated by the students themselves. These were also offered as one unit CR/NC courses.

Math 299:

Spring 2004	Advanced finite math for business

This is a course where the student read through many parts of the math 215 book that were beyond what was taught in math 215. This included linear programming, game theory, financial mathematics, Markov chains, and other topics. The student was a business major, and had already taken math 215, and was close to graduating, but needed an opportunity to raise his GPA, so this course was offered with grade. It was a 1-unit course, and we met once a week.

Math 599:

Fall 2002	Financial mathematics
Spring 1999	Gravitation (General relativity)

The Gravitation reading course was initiated by four students who approached me when they knew I did some research involving black holes. Students would read a few sections from Misner, Thorne, and Wheeler's classic text *Gravitation* on general relativity, and would give summaries of the sections they read.

Similarly, the Financial mathematics reading course covered Baxter and Rennie's book, *Financial Calculus*, describing options pricing and the Black–Scholes model, as well as introducing notions of stochastic differential equations.

7. List teaching responsibilities not reflected above, including student advising, thesis and dissertation committee responsibilities, student research projects, development of new courses or programs, supervision of student interns, coaching debate, moot court or similar teams. Provide an analysis of your teaching methodologies, strategies and objectives, listing steps you have taken to improve your teaching. Provide reflective statements on teaching tools developed and on student evaluations. Provide evidence of student learning.

- Summer 2003: Guest talk for high school students at the Summer Science Program in Ojai
- Fall 2002: Led Club Convo: Understanding Islam
- Fall 2002: Supervised student research: points of finite order on elliptic curves (Leighton Cowart)
- Fall 2002: Mathematical modeling on water transport and cavitation in plants (Jason Fischer)
- Spring 2002: led Club Convo: Rich Christians in an Age of Hunger, by R. Sider
- Spring 2002: Supervised student research: Points of finite order on elliptic curves (Leighton Cowart)
- Spring 2002: Mathematical modeling on water transport and cavitation in plants (Jason Fischer)
- Fall 2001: led Club Convo: The Myth of Certainty, by D. Taylor
- Summer 2001: Supervised student research: Knot classification using a computer network (Leighton Cowart and James Krumrei)
- Fall 2000: Student advising: Got my first advisee
- Fall 2000: Organized a trip for students to the Mathematical Association of America Southern California meeting at Whittier College
- Fall 2000, 2001, 2002: Administered the Putnam mathematics competition for undergraduates at Pepperdine
- Summer 1999: Supervised student research (Parsons program): 2-dimensional Topological Quantum Field Theories (Jacob Chandler)

Teaching philosophy

Content

Teaching begins first with having something to say. Indeed, this is the idea of being a "professor", that is, one who professes.

Some may imagine that in a field like mathematics, the "something to say" is generally handed down to the professor from long ago (probably in the textbook), and the professor's role is more of a conduit to the already-known ideas, rather than a spring of new knowledge. This perception is mistaken, because although the mathematical facts have not changed, mathematics is more than the collection of mathematical facts. Mathematics also includes connections between facts, hidden relationships between apparently dissimilar mathematical objects, subtle distinctions between apparently similar ideas, and much more. It involves an art to approaching problems and a skill at finding the crucial perspectives to take when contemplating a situation.

When I teach, the actual mathematical facts I need to teach tend to be in the students' textbooks already. But it is my job to provide the rest of the structure surrounding these facts. And in this way, I profess that which is not in the textbook. I am constantly coming up with ways to connect ideas they are learning with other ideas they already know, so that facts are never handed down from on high, but appear to be a rational, even inevitable consequence of things they already know. By this I mean something more than simply providing a rigorous proof of every result I introduce in class; indeed, for many lower-level classes, the rigorous proof of important results is beyond the level that students are able to appreciate. Rather, it may involve showing how certain mathematical techniques are analogous, or it may mean understanding a number of mathematical statements as special cases of a general principle.

For instance, in math 214 I recently reviewed some standard formulas for areas and volumes of certain solids. Generally, students have seen these formulas before, but in my experience many students do not appreciate that the formula for the volume of a cylinder and the volume of a rectangular box are of the same form: the area of a side times the height. Instead of focusing on the formulas, I make it clear that they need to make sure they remember them, but I also emphasize that these two ideas are closely related, and students often find this helpful in not only remembering the formulas but seeing things in a way that obviates memorization.

In an upper-division class, math 460 (Automata theory), students learn that some mathematically-defined functions cannot be computed by any computer. I start the course by reminding students of Cantor's proof that there are more real numbers than natural numbers, even though both sets are infinite. I emphasize the importance of this proof. Then when they learn about the proof that the halting function cannot be computed by any computer, I show how these proofs both involve the same so-called "diagonalization" trick. Then, I show how Gödel's incompleteness theorem (that there are some mathematical statements that cannot be proved nor disproved) uses this exact same "diagonalization" idea.

These examples bracket a range of insights that I endeavor to make that connect ideas and mathematical objects. These insights, in turn, come from my commitment to understand the material I teach from many perspectives—many more perspectives than I would ever plan to teach from. In this way, the choice of my added content, that is, the connections and context I provide for the material in the book, is carefully orchestrated to clarify.

This becomes even clearer in upper-division math courses where students are expected to learn difficult proofs. My goal in teaching a proof of a major theorem is for students to be able to appreciate both a bird's eye perspective on the argument (seeing the general ideas that make the proof work), and the close-up perspective with all its careful detail. But if I had to choose between the two, it would be for the bird's eye perspective, because then students would be able to accept why such a fact is reasonable.

Serving students

Jesus taught us that a leader is one who serves. And so my approach to teaching should be as a servant. This does not mean, of course, that students make the decisions. It does mean, though, that I see my role as facilitating that which is in the students' best interest, even if it means some sacrifice. Here are some things I feel this means:

It means finding what students need to learn. I have spoken with Mike Summers and Andrew Yuengert in Business about what business students need to know from our classes. I have spoken to Jane Ganske from Chemistry and Stan Warford from Computer Science about how their major classes use the mathematics we teach. I have stayed in contact with several of our math alumni (Wes Skeith, Leighton Cowart, Jamie Pascua, Elliott Jones, Donny Havenhill, Dan Clough, Chris Richards, Jen Miller) and asked them to reflect on our program. And I have reviewed the results of CUPM national discussion papers about what students should know.

It means focusing on student learning. It is easy to measure how much we teach by how much we cover in class. But it is more relevant to find out how much students are learning. This means watching carefully errors students make in homework and exams, and addressing those points. It means building in flexibility to the syllabus in case students are missing important points, by prioritizing the topics. It means being sensitive to the idea that some topics require repetition and others do not. It means maintaining constant standards for grades. It means recognizing time pressures of the semester, and therefore planning material in such a way that the time pressure does not come all at the end of the semester.

Often, my role as teacher involves putting out stepping stones for students. This means thinking about the learning process as a sequence of steps taking students from where they are to where they should end up. It is not enough to give the axioms of probability; I must find a path from ideas they may be familiar with like probabilities of rolling a certain number on a die. In the past, it had been fashionable to think of mathematics education as a similar process to the doing of mathematics itself, but one thing I have learned is that students need to relate new knowledge to things they are already familiar with, even when this is not necessary from a logical standpoint.

It means aspiring for students. On the other hand, Pepperdine students are strong and often have great potential, and I hope to provide an environment that encourages students to reach their full potential. Many Pepperdine students today found high school easy and naturally expect to continue to spend very little time and effort to succeed in college. If I let such talented students get away with such minimal effort, I am not truly serving them in pushing them to reach their potential.

The tension between these two goals means some compromise, but it means watching student performance to find the level that students find challenging while not exasperating them. This is a difficult tension to hold, especially if the range of ability in the class is wide. My goal is to make sure the students in the middle of the class who are sufficiently motivated find the class challenging, and offer the top students other ideas to ponder to supplement the material, while offering the poorer students help outside of class.

I also try to make it clear what I expect of them, by stating in class what things should be second nature to them and what should be mastered by the next homework assignment. In some cases, the first homework

I give covers material they should know from previous classes, and when grading these I comment on any systematic deficiencies they should seek help on.

In some cases, I have scheduled regular weekly meetings with students who need extra help, though sometimes students decide to drop the course or are sufficiently caught up to the rest of the class to not need extra help.

In lower-level classes, especially in math 214 and math 215, some students are overly dependent on their calculators, and though I will use a calculator when needed, I often work out a problem without one when this is possible, even doing long division by hand, to emphasize that this is something they should know how to do.

It means coaching students. These past two points, in tension, could be thought of in terms of coaching. A coach wants the athlete to succeed at the goals, but also wants to set the goals so that the athlete reaches his or her fullest potential. Beyond this, Pepperdine affords me the opportunity to get to know students well enough to identify what they could do to improve their mathematics performance.

As part of this, I make it a policy to have students sign up to visit my office in the first few weeks of class so I can get to know them and they can feel comfortable coming to me in my office. I also try to visit informally with students outside of class, especially if they live on-campus. In addition, I ask students to write comments on their homework about how the class is going.

Furthermore, I often stop my lecture on the actual mathematics to comment on topics ranging from how to read the textbook to how to succeed in Pepperdine classes to what attitude to take toward grades and exams.

Teaching approaches specific to math

The previous section was devoted to my philosophy concerning teaching and learning, but there are some comments that are specific to the kinds of challenges involved in teaching mathematics.

First, mathematics is partly a skills-oriented subject, at least for many lower-level undergraduate classes. In this way, it is like beginning foreign-language or beginning musical instrument classes. The skills cannot simply be absorbed in a lecture format; they must be used and practiced regularly and often. For this reason, I assign daily homework for lower-level classes, though homework tends to be twice a week if the material warrants hard thinking and if the students tend to be more mature in their study skills.

In contrast, at many institutions, homework is assigned weekly for upper-division classes and twice a week for lower division classes. My policy, which is similar to others in the department, fits Pepperdine, where many students are looking for a structured learning environment, and may end up procrastinating too much otherwise. Some students have been in favor of this policy, and others have been against it, but I am convinced that their performance was improved because of this.

One challenge that daily homework poses is that students are not generally able to ask questions about the homework in class. My solution to this is to make the homework "due" at the next class period, but to be turned in at the class period afterward. This allows students to identify material they do not understand and ask about it in class before turning in their final work. Unfortunately, it also allows students to procrastinate and not try the homework until the day before it is collected, but there are always some who do not procrastinate, and these students provide a class environment where the "due date" is taken for granted. Another problem sometimes posed is that students are sometimes confused, since every homework has two due dates and at any given time there are two homework assignments they should be working on. But by writing up the due dates with each assignment, by putting this information up on the course webpage, and by announcing, when collecting homework, which homework I am collecting, I have mostly solved this problem.

Related to this issue, often, skills take more than one day to acquire, so in some cases I put some review questions from previous sections in with later assignments. These will typically be harder questions, such as those that require a greater familiarity with the subject. I have used this technique most with Math 212: Calculus III.

Second, in addition to building skills, mathematics learning involves problem solving, and understanding the concepts behind the techniques. Therefore, in every exam and homework assignment, I try to encourage students to think deeply about the course material. To this end, I have the following grading policy:

> **Grading**: A grade of C indicates an ability to do homework-like problems, and memorization of all techniques and definitions. In order to receive a B, a student must demonstrate a deeper knowledge of the material, being able to apply the course material to new circumstances where applicable. An A student must demonstrate this kind of deep understanding in all of the covered topics, as well as be able to draw new conclusions from known facts in a logical manner, and must also demonstrate persistence and dilligence. In the other direction, a grade of D shows only superficial understanding of the material, and shows inconsistency to do straightforward problems. An F grade indicates that the student has severe gaps in even superficial understanding of the material in the course.
>
> Although this is the philosophy, grading will be done by counting points received on each problem, as usual. But the difficulty level of the problems will be arranged in order to achieve the above grading scale.

As a consequence, a 70% to 80% performance (which I grade as a C) should ideally reflect the ability to do standard problems and use techniques taught in class, while higher grades should reflect deeper understanding and an ability to apply these ideas to new situations.

Therefore, I devote 20% to 30% of every test to various levels of testing the student's ability to apply the concepts to new situations, and determining precisely when a concept can be applied. The rest of the test covers techniques that have been practiced in familiar situations.

Sometimes students have complained that this makes the test too difficult, but this deeper understanding is only needed to exceed a C grade (which Pepperdine holds as an indication of "average"), and indeed, few students who work hard on the class receive lower than a C– in my classes (and these are often students who did not have the requisite background). Indeed, for me to claim to the registrar (and the student's future employers) that the student had a "good" or "excellent" understanding (B or A, respectively), I would have to insist that they understood the underpinnings of the techniques they learned, especially as Pepperdine is being viewed as an institution of distinction.

Incidentally, I have found that by putting 10% of the points on a test in true/false questions (distributed along the spectrum from rote parroting to deep and subtle distinctions), I can assess subtleties that are often not available with more standard math problems. For instance, I may have a problem where a certain technique can be applied, and having such a problem may test the students' abilities to apply this technique, but a single true/false question might assess the students' knowledge of under which circumstances this technique is valid, which is a deeper level of knowledge.

Beyond testing, of course, we need to teach deep understanding, and I have already mentioned above some ways I do this: finding the right perspectives to understand the reasons, and seeing the connections between the ideas. In some classes, there are opportunities to bring in problem solving techniques, and often homework problems are a strong impetus for discussions of this kind. I often mention tricks in solving algebra problems to my calculus classes, not because the material is about an algebra problem, but because a number of students ran into trouble doing some algebra that was incidental to the calculus problem.

Third, I find myself doing more lecture than other modes of teaching, such as group work or discussion. True, I often ask for volunteers to help work through a problem after I have done one for their reference, but this is still somewhat in lecture style. I had tried several approaches but found that in order to cover the material I wanted to cover, especially elucidating insights that only come by long familiarity with the subject, I was forced to use the lecture format most of the time. I was once concerned about this, since at the time many people were promoting exploratory learning and group work, but after reading Parker Palmer's *The Courage to Teach*, that I had to recognize who I was, what I had to offer, and find the style that suited that best. As I mention below, I offer seminars that are much more related to group work and exploration, and for those courses, that approach works best. Furthermore even in the more standard classes, I often find powerful group work activities that work well for my style. But given my strengths and the nature of the material, I find I use lecture 90 to 95 percent of the time, and this is effective.

Use of technology

I believe technology is an available means, not an end, in education. Instead of asking "how can we incorporate technology into the classroom," we ought to ask, "given what technology can offer, how should we teach and what kind of learning environment can we offer the student?" As illustrated below, I wholeheartedly support the use of all kinds of technologies in the classroom, whether it is a webpage or a pencil. But it is backward to take a technology and try to force it into a curriculum. Below I list several instances where I have used technology in the classroom:

- Use of course websites: Since 1999, I have been creating a course website for each course I teach, usually for announcements and posting homework, and describing other online resources. In 2001 I started incorporating some online assignments in my math 330 (Linear Algebra) class by using some web-based exercises developed at the University of Nice in France.

  The website has turned out to be useful to be a secondary check for students to get course announcements and homework, and has been particularly valuable for athletes who must plan ahead because of anticipated missed classes.

  I have not switched to blackboard, since what I can do directly using my course website on math.pepperdine.edu is more directly programmed into HTML. I do not wish to use blackboard to run tests since I cannot monitor the students to see if they are collaborating, and I do not wish to use blackboard to post grades since I think it is important for students to see what they are getting wrong or right, not just see how many answers they have gotten right (which leads to an emphasis on grades rather than learning). Everything else and more can be done more directly in HTML than in blackboard. It is also faster for students to access since blackboard is slowed down by a great deal of overhead, and is often taken off-line.

  In contrast, I administer the computer that runs my webpage (an old mac running MkLinux) and in case of any problems I can be on site to fix it.

- Course email lists: Since 2000 I have also been creating an email list on yahoogroups.com (formerly egroups.com) for students to use to discuss the material or the course, and for me to make announcements. This has been used rarely. I had originally anticipated some students to use this email list to ask questions and otherwise work together with other students, but given how close-knit the Pepperdine student community is, most students see each other in person far more often than they see each other on-line.

- Visual displays in the classroom: The two times I taught linear algebra, I used matlab to illustrate the geometric aspects of linear transformations in two dimensions to my linear algebra class. After this I wrote a java applet to do a similar illustration, though I have not taught linear algebra since so I never got to use it. Sometimes, especially in math 212 and math 215, I have used the computer algebra system Maple to develop my three-dimensional overhead illustrations, though sometimes writing a postscript program to output pictures is more convenient. I have written a java applet to simulate the "sixteen" puzzle for my math 431 class when discussing applications for group actions.

- Computer labs: For Math 212 (multivariable calculus) I introduce students to Maple and have students work in teams to develop their three-dimensional intuition by manipulating three-dimensional geometric figures on Maple and by creating examples using Maple.

  For Math 460 (automata theory), when we were discussing regular expressions, I felt students would appreciate using regular expressions in Perl. Using our new computer lab in the Keck science center, I had students work out practical problems in Perl that required the use of regular expressions.

  Furthermore, students can experiment with several different kinds of automata using the programs that come with the book we used (Taylor, Models of Computation and Formal Languagse).

- Graphing calculators: For math 214 and math 215 it is now standard for everyone to use graphing calculators. But I view the graphing calculator as a tool for pedagogy, not a way to avoid the students' lack of algebra skills. For instance, in developing the students' understanding of Riemann sums, I do not show the students how to use the Riemann sums feature, nor do I give the students a formula to plug in; rather, I use the data/matrix editor to have the calculator automatically develop an x-y table (something the students are very comfortable with and intuitively undestand) and use the table to compute the relevant values. The result is that students can visualize what arithmetic operations they are using, so that the process is clear. Similarly, with Gauss-Jordan elimination, I emphasize using the calculator's row operations separately, instead of using the calculator's built-in row reduction algorithm.

  I have specific ideas about the proper pedagogical use of technology because when I was in junior high school, I taught myself a great deal of mathematics simply by experimenting with a graphing program I typed in from a Popular Computing magazine issue. I found that I had an intuition about graphs of functions that I could only get by experimenting with this, and the computer allowed me to focus on the relationships between the formula and its graph, instead of focusing on the computations. If I were to teach a math 102 (general education mathematics) specifically for fine arts majors (an idea I have been developing), I would have them do the same kinds of experimentation and view graphing (including parametric curves and surfaces) as a medium for graphic art.

  Along these lines, I have included some room for creatively playing with graphics in my calculus labs, and although some students do the minimum work and do not derive benefit from those exercises, other students who are interested can be as creative as they like.

Availability to students

Especially at a place like Pepperdine, I feel it is important that I be available to my students. To this end I go beyond my usual office hours to be sure I am around the department most of the day, often even on Wednesdays when I do not usually have class. Beyond this, I try to be approachable and talk with students outside of class.

The first step is meeting with students in the first few weeks of the term, in order to get to know them better. Students are required to sign up for a 15 minute meeting with me in my office, where I welcome them to my office, find out some things about their background, answer any of their questions, and find out how the class is going so far. It is time-consuming, and it is difficult to fit my schedule around it, but I have found it allows me to better tailor the course to the students, and it makes the students feel more welcome to come to my office hours. In addition, it has started some conversations that have allowed me to be an influence in some of their lives, and led to a many friendships.

That leads me to the second step, which is to hang out with students. If students typically work on their homework together somewhere accessible, I offer to drop by periodically to see how they are doing. Some years the math majors all hung out together and made this easy, but other years the math majors were somewhat more dispersed. Also, the courses for business majors tend to be for freshmen so I find if I visit freshmen dorms I often run into many of my students from those classes, and often they are thrilled to see their professor come to their dorm. In addition, my involvement in Rotaract has enabled me to work together with many of my students in service projects.

Associated with this, each semester I use the student entertainment fund to have students for dinner at my house. Since I do not yet live on campus and since use of this fund has been restricted somewhat lately, I generally have used this only for my intermediate and upper-division classes. But I find this goes even further in getting to know students.

As the faculty member in charge of the tutoring room, which runs Sundays through Thursdays 7–10 p.m., I often have reason to drop by the tutoring room and in this setting students can come to me for help.

Interactions between faith and learning

In every syllabus I write, I have the following statement:

> **Christian attitude**: Although not part of the grading for this course, you are expected to approach this class with a Christian attitude, being willing to help your fellow classmates to understand the material outside of class, being willing to be corrected by your fellow classmates when you see they are right, but firm in your conviction otherwise, being bold to ask questions without feeling ashamed of looking foolish, encouraging one another in love, being patient with those who are asking questions, and preferring a grasp of the material, which is enduring and becomes part of you, over a grade, which is transient, external, and shallow. You should diligently devote the time you spend on this class as to the Lord. As cheating harms both the cheater and the rest of the class (though in different ways), you should not cheat, nor should you provide temptations for others to cheat.
>
> For my part, I commit to approaching this class with a Christian attitude, viewing my role as that of a servant, being concerned first for your personal, especially intellectual, development. I will also seek to produce an environment of encouragement and love, that fosters a sense of community and understanding. I commit to reporting grades that accurately and honestly reflect

the level of work done in the class, as described in the paragraphs above. I also commit the time I spend preparing for this class as to the Lord, and I will pray for all individuals in the class on a regular basis, understanding that even as I may seek to educate, God provides the true transformation.

Whatever parts of the syllabus I do not read to the class, I read this part out loud every time. This is the core of the way I think my Christian faith should impact the way class is run. I have gradually developed this statement over the years, based on my reflection on what the Bible teaches about how Jesus' sacrifice affects out whole life (and in particular the classroom) and this is the current form. It speaks for itself, so I will not expand further on it here. But to report on its effectiveness, it has convicted me to be deeper in my faith because of my commitment here, and I can only hope it has done the same for the students. Certainly there are days when God is not at all on my mind when I am teaching, but this statement continues to convict me to devote that effort to the Lord, since it is He I am serving.

Separate from this, though, I have found occasion to comment on my faith in class specifically. I believe mathematics is beautiful, and testifies to the glory of God. When I see a mathematical result that is particularly beautiful, whose truth is solid yet mysterious, I will comment that this is how I feel about it in class. I consistently say this about the derivative of $\ln x$ being $1/x$, for instance.

In addition, I have found, in some classes, the occasion to devote a class hour to reflecting on the material on a different level than is usual:

- Faith and randomness seminar: The first time I taught Math 510: Probability, one of the classes was devoted to the question of how "randomness" can be related to the concept of God's sovereignty. It was a short lecture followed by a class discussion, and I do not think the students quite grasped the question I wanted them to deal with. It was an "optional" lecture, in that I told students that this material was not going to be on the exam, and roughly half attended.

  The second time I taught this course, I did this during the regular time period, and spent more time focusing on the relevance of the meaning of randomness to ontology, creation, and metaphysics. Earlier in the term I asked students to consider more philosophical ideas of probability, so students were more prepared for this discussion, and the discussion went better than the first time I tried this.

  The issue is roughly this: what does it mean to say that the probability of you getting into a car accident is .0004 today (for instance)? Or that the Titanic would sink on its maiden voyage? The use of the terms "probability" and "random" betray an assumption that there are parts of what happen in this world that make no sense, as if God did have ultimate control of His own creation. Can these ideas still make sense if we have a sense of the ultimate sovereignty of God?

- Faith and automata: When teaching math 460, there were opportunities to discuss the philosophical ramifications of some of the material we were studying. In particular, in formulating the problems of what computers can and cannot compute, we considered the question of whether human thinking could be simulated by a computer. This raised questions about logical positivism, and we had an interesting discussion about the ontological foundations of human existence, and whether the "scientific" materialist view was satisfying, considering the ramifications for our understanding of consciousness.

In addition, the attacks on September 11, 2001, and subsequent actions by the United States, have occasioned times when students felt like they needed some time to discuss current events. Time was limited, but I moved around the course schedule to make time for these discussions. I made it clear how I felt, and how my views come from scripture, but tried to leave room for people to give dissenting views, which sometimes happened. I also used that opportunity to illustrate how my mathematical perspective affected the way I approached the question.

Lower division business classes

The above expresses my general teaching philosophy, and how it works out in math classes. There are additional comments that pertain to my teaching, but they are different for different kinds of classes. I will begin with the math 214 and math 215 classes that I teach for prospective business majors—the so-called "lower division business" math classes.

These courses are unusual in several ways. Although they are taught by math faculty in the math department, none of the students are planning on majoring in math. Rather, they are almost all at least considering one of the business administration majors (business administration, international business, accounting) or economics. It is definitely a service course for non-majors. On the other hand, since the range of prospective majors in this class is narrow (basically business), this course differs from general education classes in being more homogeneous.

In particular, I can point out applications of the material to business, and thereby convince the vast majority of the class that the material should be important to them. I certianly have used business examples, ranging from finance to marketing, and in a few cases have brought in real-life examples, such as the problem of designing the metals used for the Sacajawea dollar (to make it not look like a quarter like the Susan B. Anthony dollar did, but make vending machines already designed for the Susan B. Anthony dollar accept it without modification).

At the end of the semester of my math 215 class, I make sure we finish new material almost a week before the end of classes, and spend some time reviewing for the final exam. But to emphasize that they are not, in a sense, preparing for their final exam, but for when they will use this material later, I introduce ideas from their later classes that use the material in math 215. They are not responsible for knowing this new material, but they should use this opportunity to see if they truly understand the math 215 material well enough to continue. The actual topics vary, depending on how much time we actually have at the end of the semester, and the interests of the students. I have used Markov chains, decision analysis, a simplified Black–Scholes model for options pricing, and an introduction to game theory.

In another sense, these courses are similar to general education math classes in that although the particular math material was chosen by the business division to be particularly applicable to business majors, the business professors I have discussed this with (Mike Summers, Roy Adler, Marilyn Misch, Andrew Yuengert) have assured me that the most important goals they have for the course are more general. They want students to be able to think quantitatively, to approach problems logically, to solve problems, to have good algebraic skills, and to formulate problems in mathematical terms. These goals could be achieved in any number of different ways, not simply with calculus and probability and linear algebra. But the connections between these topics and managerial economics, operations management, quantitative methods, and statistics allow the business division to kill two birds with one stone, requiring mathematics that will be of use and building mathematical skills and perspectives.

Many students, as naïve freshmen, wonder what kind of mathematics they will learn in these courses that they will use to climb to the top of the Fortune 500, and they are skeptical that calculus could be it. Their skepticism is perhaps not ill-placed, since not all people on the Fortune 500 are any good at calculus, if they even know the subject. My job is to confront that skepticism but also suggest that the purpose of their education goes beyond what specific facts they need for the workplace, and touches on those qualities that a liberal arts education should provide: the goals like quantitative and logical thinking and creative problem solving mentioned above, but also good communication skills and the ability to work with others.

To help, I have made it a tradition to ask Mike Summers and Roy Adler, professors in the business division, to share with students why math is important, both in the working world and in their undergraduate business major. This has been a marvelous help, and often, students have had a much more positive attitude toward their math courses after they come in to my classes. It gets them excited about their future classes, introduces them to some business professors, and impresses on them how seriously the business professors take their duty. I think it also shows to them that I am committed not only to teach them math, but I am committed to leading them in a direction that they need to go, and that I can be trusted to get them there.

Beyond this, I have wrestled with the question of how my Christian faith influences how I should teach this course. In both math 214 and math 215, for instance, we discuss finding ways to maximize or minimize something, and for these classes we often have many examples where we find what would maximize profit. On the other hand, from my Christian perspective, there is something abhorrent about the economic dictum to maximize profits, if only because it implies that moral issues should be ignored. Some have viewed the Christian version as maximizing profit, subject to the constraint of following certain ethical and legal rules. Perhaps, however, the thing to be maximized is based on Biblical values, and the constraint is simply that enough profit is obtained to continue the project indefinitely. Certainly for many non-profits, the idea is not to maximize profit but presumably to maximize some other goal, whether preaching the gospel or healing the sick. I have brought this up in each of my math 214 and 215 classes for the past few years, and as these ideas coalesce, I have become bolder, but one day I hope to develop my ideas enough to design a section of the material on it.

Like all the math classes I teach, one goal is to get the students to become self-learners. I have tried a number of different ways to get students to read the section before coming to class. The most direct is by having random pop quizzes, not on the material, but on the reading. Of course, many students have difficulty understanding written mathematics, but even for these students, reading the material provides enormous benefit, if nothing else, by highlighting which words are key words to ask about, and which paragraphs seemed to make no sense. To make a quiz that rewards students who are in that situation requires that I ask very superficial questions. Not so superficial that they can get away with simply reading the section title (a flaw in some of my early quizzes) but not so deep that someone who didn't understand the reading fully couldn't get it. These quizzes are all single-question, multiple choice. An example is found in the teaching section.

The quizzes would only be used to determine borderline cases in grades. Also, it somewhat measured class attendance, since no make-up quizzes were given. This technique seemed to be effective, since it encouraged students to read beforehand, and come to class on time, even if it had only a minor impact on their grades (the students did not, on the whole, view it as "minor"). This is probably partly due to the word "quiz" which sets up automatic reactions in students.

Once a significant fraction of the class is at least cursorily reading the material before class, I can then begin the class by eliciting responses to the reading from them, which not only allows me to focus on the parts that students were struggling with, but also provides an atmosphere where everyone expects to read beforehand.

Beyond reading mathematics, it is not realistic to hope that pre-business freshmen will participate in self-discovery of mathematics, though in a controlled classroom setting, I can lead a discussion to have students "discover" something together. Indeed, I do this when teaching simple and compound interest, when explaining how to think of expressions like $f(x+h)$, when introducing conditional probability, and other situations where the right series of questions can get them to a particular insight.

There is always a tension between homework as a means to learn and homework as an evaluation of student achievement, and therefore connected to the grade. Homework is both, but sometimes its role in one can get in the way of the other. A fair grading system requires that students come up with answers on their own, but learning often requires that they first learn under the guidance of the professor.

To this end, I assign two kinds of problems: practice problems, which have answers in the back of the book and are worked out in detail in the solutions manual, and to-turn-in problems, which do not have answers in the back, but are similar enough to the practice problems that if they understand the practice problems thoroughly, they should have little trouble with the turn-in problems.

Of course, some choose not to do the practice problems, but by focusing class discussion of problems on practice problems before addressing turn-in problems, I hope to encourage students to work on the practice problems.

Math 102: Math as a general education requirement

This is the course for students whose majors do not otherwise require mathematics, but who need to fulfill their general education requirement for mathematics. The students taking this course range widely in mathematical background and ability, and while most come in fearing math, that is not always the case, either. A large number of different majors (as well as many undeclared students) are in this course, and these also represent a wide range of personal interests and intended career choices.

This variety presents a pedagogical challenge–anything that I might do to make the course more interesting to one kind of student might alienate another, and in order to keep it down to a level so that most students can follow, I risk making the more advanced students feel I am moving too slowly.

The second challenge is that most students sign up for the class expecting a bad experience of some kind. More students come in with a fearful attitude toward math than do not. Many may fear that they will not understand what is happening, and this can prevent them from being engaged enough to try to understand. In addition, many have viewed mathematics as a series of arbitrary steps to follow and memorize, and have never been taught that mathematics is a way of knowing.

The main goal of this course is the goal of any general education program in a liberal arts curriculum–to transform students into critical thinkers who can, in light of the where we've been as a civilization, think deeply, creatively, and critically about where we should be going, and who can communicate with others about these ideas effectively. Mathematics plays several important roles in this general education program: it trains students to think logically, quantitatively, and critically, it develops creative problem solving skills, it plays an important historical role in the development of philosophal thought as both a means to clarify thought and a subject of great interest in its own right, it interacted creatively with art, music, literature, linguistics, and drama, it provided the groundwork for many of the sciences (both natural and social) and continues to serve both as a language and a source of methodology for scientific theories. It continues to play a role today in framing debates on public policy, and an understanding of statistics is crucial in following and critically analyzing many debates in the news today. Furthermore, the ability to write a logically complete and understandable mathematical proof can contribute tremendously to being able to communicate logical arguments effectively.

If we hope for mathematics to play this role in our students' educations in a single semester course with no prerequisites, we must first realize that simply continuing their pre-calculus development will not achieve it. Nor, indeed, is any given mathematical skill, as a sequence of steps, by itself enlightening the way a liberal arts course should be. We would be better served by teaching the students the logical structure of mathematics and its rhetoric of mathematical proof. Students should learn that mathematicians are discovering new mathematics every day, and they should have an appreciation for what it means to do this. They should have an appreciation for the beauty of mathematics, and how it fits into our history of thought. They should also learn the difference between the certainty that comes from mathematical proof and other kinds of proof, including the uncertainty of applying the mathematical model to the real situation. And they should learn how mathematical proof is done and what it means.

If there is a skill they should learn, it should be creative problem-solving. This is a skill that intertwines with many general education courses. Mathematics can provide an opportunity to isolate this skill, allowing room to experiment with ideas while being held to a strict standard of truth.

My approach with this class is an adaptation of the teaching technique popularized by R. L. Moore (see below in the section on 599 courses), which itself is a variation of Socratic dialogue. Students are presented with a problem, which they do not know beforehand how to solve, and I lead the class in a brainstorming session, sometimes with leading questions. Along the way I highlight possible problem-solving strategies as they become appropriate. At some point, some students may feel they understand how the problem should be solved and I encourage them to try to convince others in the class, and encourage the others in the class to ask pointed questions to challenge them. Eventually, when we reach the true solution we will have not only a class consensus, but a sense for the logical reasoning behind the method.

This is heavily discussion-oriented, and requires class participation. Indeed, class participation is 10 percent of the student's grade. Some segments involve getting the students into small groups to work on a problem together, and in some cases, share their results with others groups.

The problem we start with is often presented as a game, a fun story, or some situation, not as an equation to solve or similar algebraic manipulation. I want to convey the idea that mathematics is not fundamentally about moving esoteric symbols about in a ritualized fashion, but about solving "real life" problems, and the symbols are abbreviations for us to record our insights as we go along. The quotes I just placed around "real life" indicate that the virtue I seek for these problems is not that they are actually problems that people work on in their occupations, but rather that they are contextualized in a situation or narrative. Often it has been said that students want "application" in their mathematics. This has not been my experience. Students do appreciate knowing mathematics is relevant to their interests, but if we tie the mathematics to one student's interests, we will alienate the others who are not interested in the specific thing we have tied mathematics to. It is more effective to engage the students in some narrative, game, or other situation, and then "apply" the mathematics to that situation.

The topics, in some sense, then, are not really relevant. It is not so important that students know particular facts than that they understand how they can deduce these facts logically. The topics are the canvas on which mathematical art will take place.

The actual topics are actually done by vote. The book I use, *The Heart of Mathematics* by Burger and Starbird, has a kitchy overview at the beginning of the book that throws out teasers that suggest what each chapter is about. I ask students to write a reaction paper, commenting on each chapter "teaser", and asking them which three chapters they most wanted to cover, and why.

The vote is somewhat rigged–we will already be into the first section (introducing games that will later motivate the other sections) by the time they turn in their reaction paper, so we do this one no matter what. Furthermore there are certain ideas I want them to have because of their relevance in a liberal arts class or their connection to our Christian mission (like the sections on infinity and probability). But overall I commit to shaping the curriculum in response to the vote.

I also have a bias toward seeing the development of our civilization in broad terms, and I tend to want to show the place mathematics serves here. Thus, I will tend to focus a bit on number theory, which includes the earliest Greek philosophies of the Pythagoreans and the cryptological issues that have enabled e-commerce and provoked new legal issues about intellectual property rights in our information age. The role of infinity, chaos, and non-euclidean geometry in questioning our previous ideas of certainty are also important as seminal ideas in proto-post modernism.

My hope is that students will find these situations, games, and narratives engaging, and that these will in turn launch us into thought experiments that will teach students to think philosophically and rigorously, while building their quantitative sense.

This is the first semester I am teaching this, so I do not yet know how this will turn out.

Intermediate and upper level math classes

To some extent, many of these courses are partly service courses as well. Computer science students are required to take many intermediate and upper-level math classes, and when this happens, they are often the largest group in the class. Some of the students are engineering majors, and for math 212, there are chemistry majors. This applies to most of the courses I have taught in this category (math 212, 330, 460, 510) but some (math 431 and 511) are only for math majors.

When the class has math majors and non math majors, it is an extra challenge to motivate both groups of students simultaneously. It is not merely a matter of bringing in applications, as if the virtue of having an application automatically makes the material more interesting or accessible. Chemistry students may not appreciate applications to computer graphics, and comptuer science students may not appreciate applications to thermodynamics. The challenge is to indicate to all the students how this material is relevant to their respective subjects while not alienating anyone. On the other hand, these students recognize that this is a serious math class, and often recognize the relevance of mathematics for their major or future career. Indeed, what students seem to require is not application per se, but connection to things they know and understand (which applications often provide). So I do mention applications when it is natural to do so, but for motivation I depend on connecting the material to other subjects, including the subjects in their previous math classes. Then students who are chemistry majors might learn that this material is connected to computer graphics, and in this way learn to appreciate that subject.

In these classes, a more significant challenge is to force students to excellence. The difficulty in mathematics courses ramps up considerably from the calculus sequence to the upper division courses, and students are expected to work and think harder and harder. For the most advanced courses, problem solving is taken to a new level as students are asked to prove theorems instead of applying techniques learned in class. It is not uncommon for students to require several hours for a single problem in such classes.

The trouble is that students, by this time, already have expectations of the difficulty of the material, and are resistant to the idea that they need to work hard. Students sometimes complain that their homework took hours, and assume it is my fault for not telling them some secret fact, rather than it being the expected work involved in solving hard problems.

Even in intermediate level courses, students are sometimes used to courses that focus almost entirely on skills and techniques, and have a hard time with being expected to do some creative problem solving, even though it is on a much lower level.

The only solution I have found is to continue to assign work at a challenging yet attaintable level, and be available for help. It means some students will complain, but it also means students are well-prepared for later classes or graduate school, and for life-long learning.

Emphasizing the need to be a self-learner, if important in lower-division classes, is crucial for upper-division courses. Ideally, I hope students will learn material several times: first, from the book, then put into context through my lectures, then, practically in the homework. In some cases, some of these stages will need to be repeated. Ultimately, I hope students will be able to learn from the book itself. To this end, I demand that students come to class having read the material beforehand. I don't use the quiz method for upper-division students since that seems a bit juvenile for that crowd, but I make my lectures supplementary to the book and try to indicate when I am omitting from my lecture the material from the text, when the material is self-explanatory or within easy reach of the students' abilities.

Beyond this, I have had some positive feedback on times I have spent explaining how to read proofs that are in the book. But this does take away somewhat from the material itself, so I don't do that often.

Some courses lend themselves to student projects. Math 511, Statistics, is fundamentally about dealing with data, and what better way to get students working with data than having them choose topics that interest them and have them gather the data? This gives students practical experience in other non-mathematical aspects of statistics, such as how to phrase survey questions and how to avoid sampling error.

One student in math 511, Eddie Policastro, chose a project that he later presented at a national conference (MathFest in Colorado, August 2003) as undergraduate research. In this project, he examined home run totals for different years, and constructed a mathematical model to predict when the next home run record would occur.

In math 431, I required every student to present some material on a topic not taught in class. I provided the students with mathematical reading material that they should fully understand (students could choose from a range of suggested topics), and had them present the mathematics to the class. The reaction to this was varied—some students liked the change of pace, but many presentations were hard to follow, especially if the student did not really succeed at getting at the heart of what was happening. On the other hand, the students gained experience learning mathematics on their own, they were responsible for being an expert on particular ideas, and they used skills gained from Speech 180. Since many of our math majors end up as teachers of one sort or another, this experience would most likely be good preparation for their future.

Beyond this, given the abstract nature of upper-division courses, the key is to make abstract ideas seem natural. Sometimes a historical approach is useful, but sometimes the most natural approach (connecting to concepts they already accept) is not always the historical one. In Math 431, the abstract concept of a field plays an imporant role. Though they were introduced to this concept in math 430, many students continue to struggle with the concept coming into math 431. Typically, they will have seen the definition of a field in terms of a list of axioms. Historically, however, fields came from considering expressions that could be written using the arithmetic operations of $+$, $-$, $\times$, and $\div$. It was only after the formalist push of the late 19th and early 20th centuries that the axiomatic definition of a field was developed. And indeed, it helps students to recognize fields as natural structures when asking whether certain formulas can be expressed using a combination of the standard arithmetic operations and n-th roots. It furthermore leads to a natural motivation for the definition of a field.

On the other hand, the concept of a group, originally developed as a specification of allowable shufflings of numbers (what is now called a permutation group) and axiomatized later, is well-motivated by a relatively late idea of Felix Klein of thinking of groups as symmetries of geometric objects. In this case, the historical approach may be more confusing than an ahistorical presentation. If we followed the historical presentation, we might be forced to familiarize students with quite a lot of mathematical material (like Tschirnhausen transformations) which, though commonly known to students in the 19th century, are completetly unfamiliar to most professional mathematicians today. We face a reality that the concepts that are difficult today may have been easy 100 years ago, and vice-versa, and we must teach with this in mind.

The two courses here that are of intermediate, that is, sophomore level, math 212 and math 330, also share another bond: they both are intersections of the two basic ways to think mathematically: visual intuition (geometry) and syntactic manipulation (algebra). I think it unfortunate that students can go through these courses and not see this link, so I make sure to emphasize this when I teach these courses. The geometry can motivate the algebra, and the algebra can help elucidate what happens when the geometry is difficult to see (as is the case when dealing with three, or even more dimensions). Most students can do one and have some trouble with the other, and these courses are prime opportunities not only to show students how both are important but also to leverage ability in one to overcome deficiency in the other. This is partly the goal of the computer maple labs I run (see above) where students get to link three-dimensional visual images with algebraic expressions, and of the computer visual to help math 330 students understand how a 2×2 matrix relates to a linear transformation of the plane.

Math 599 seminars

See above for an overview of what these seminars are about.

When I first arrived at Pepperdine, I would tell students about areas of math that we don't teach here, and soon, there was interest in learning at least something about these topics. I chose to offer a one-hour-a-week one-unit course to introduce students to such topics (one topic each semester) for those interested. There would be no homework or tests, and it would be graded CR/NC. Students would discover mathematics on their own, guided by me, of course. This, to me, epitomized what a university should be all about: students who have a burning desire for learning for its own sake, gathering to discuss and work with someone who is more experienced.

I chose the format to be least intrusive to the rest of the bureaucracy. Given how these would be organized as student interest became evident, I didn't want to have a several-year process to get a new course approved. I also wanted to have minimal impact on other classes' enrollment, and wanted to preserve the atmosphere that this was about learning, not grades. Given that I didn't want to worry about bureaucratic limitations or a long process of approval or negotiation, I chose to teach this one unit as a voluntary overload. It was, in fact, not really an overload, since I found the joy I had in these classes made my load seem less than it was otherwise.

There was another goal with some of these classes: to expose students who would possibly consider graduate school to ideas that would be taken for granted at such schools. Thus my heavy emphasis on topology and number theory, two topics that are common at the undergraduate level but we do not currently offer. I especially offered these when I identified students who were likely to go on to graduate school, like Wes Skeith and Leighton Cowart.

The format of these courses is roughly based on what is often called the "Moore method", named after the famous topologist Robert Lee Moore who revolutionized the teaching of mathematics by teaching topology to undergraduates in this way. The idea is that there is no textbook and almost no lecture. Instead, the facilitator poses a mathematical question and challenges students to find ways to approach it. By posing the right questions, the facilitator leads students to discover the material for themselves. In a way, he anticipates Parker Palmer's idea of teaching as being "subject-centered", where students come to learn, under guidance of the teacher, the material not because of the authority of the teacher but in a way that makes them discoverers.

The most consistent criticism against the Moore method is that it takes a long time–indeed, there is no guaranteed time limit to the process, but students almost always take longer than they would if someone presented it clearly and logically to them. A fortiori, it is always in danger of failure: if the students don't happen to follow the path to the relevant insight, they will never get to see the result. In these cases, though, since these courses are not a prerequisite for other courses, I have the freedom to take that risk to offer knowledge known more solidly than any other way at one hour a week. And I'm not dogmatic about the Moore method enough to let the students simply fail to see an insight: I'm perfectly willing to step in and ask more leading questions or even lecture if required.

Another criticism of the Moore method is that students often discover something, and invent their own notation for it, and thus do not know the already-accepted notation, and cannot communicate their insights to others. To address this, I follow what some call a "modified Moore method" whereby as students discover something, I then quickly explain in lecture format what the accepted terminology for it is.

This method provides students with the joy of discovering new mathematics and in a sense really doing mathematics in a less contrived environment than assigned homework. Unlike much of math classes and like the real mathematical world, math done this way is done in community. Students also tend to maintain their enthusiasm for these courses even as the semester reaches otherwise stressful periods.

Topology and number theory are topics that are most typically done in this fashion, and it was challenging to find ways to apply this method to other topics. Most notably, Advanced Logic and Set Theory covered formal logic and the Zermelo–Fraenkel axioms of set theory at a deeper level than our standard course for this topic, Math 360, ultimately reaching the proof of the Gödel incompleteness theorem (which says that there are some mathematicals statements that are true but have no proof). The necessary insights to reach there are not always obvious, so this included more lecture than is really strictly speaking allowed under the Moore method. But given that most of the class period was spent playing with the ideas in a free discussion setting, instead of listening to me speak, the elements of the Moore method were there.

Cryptology was unusual in that it used the previous knowledge of both math and computer science students, and the students themselves were responsible for explaining the material to the others. In a way, this was well-suited to the Moore method, because I could bring in codes for students to break and they eventually came up with many of the common techniques to break codes. These techniques, in turn, suggested new problems for the encoder: how to come up with codes that were not susceptible to these kinds of attacks.

Student Undergraduate research

One benefit that undergraduates should get from being at a place like Pepperdine is access to professors' research opportunities. Though other areas of study have had considerable success in fostering undergraduate research projects, mathematics has often struggled to make undergraduate research work, not only at Pepperdine but at many other colleges and universities.

One exception is Hope College, where undergraduate research in math is very strong. It is telling that even there, where mathematics undergraduate research is strong, biology undegraduate research is even stronger. But it does offer the hope that a successful mathematics undergraduate research program is possible.

I visited Hope College to evaluate their program and understand what made it successful. My report on this is included in the "undergraduate research" section.

Several years ago, we had a Parsons grant to do undergraduate research during the summer, but this funding ran out. In response to this, I put together a grant proposal to the National Science Foundation under their Research Experiences for Undergraduates (REU) program. Unfortunately, I was unaware of the role that Pepperdine had to play in this proposal process, and others, outside my control, prevented the proposal from going through.

Nevertheless, even after that, with no funding, I have had some success with undergraduate research, mostly because of very talented and motivated students. Here are the undergraduate research of students working with me:

1. Summer 1999: Jacob Chandler: Two-dimensional Topological Quantum Field Theories

In the late 1980s, M. Atiyah defined the concept of a topological quantum field theory based on an idea by E. Witten, and showed that a number of interesting ways to study topology could be described as three- and four-dimensional topological quantum field theories. For this project, Jacob explored two-dimensional quantum field theories and tried to find ways to classify them. He found a class of them and was able to describe what they measured.

This did not result in a paper or publication.

2. Summer 2001: Leighton Cowart and James Krumrei: Knot classification using a computer network

Classifying knots is an active field of research in mathematics. In this project, Leighton and James worked on a system to have a number of computers work together to store information about and compute knots. The amount of storage required and the length of calculation requires that this be done by many computers, scattered over the internet. Leighton and James wrote the foundational software needed to handle the networking, and organized the data structures needed to store the knots.

The project (which they called Knotscape) was in some sense successful, but there was no time to actually write the programs to do the actual mathematical computations, so the resulting program is not currently in use.

They also submitted to me a writeup of their work, including documentation for the computer program. It is not anticipated that this will be submitted for publication.

3. Spring and Fall 2002: Jason Fischer: Mathematical modeling on cavitation, strength, and fiber wall density in plants

Steve Davis and others have been studying certain plants and their resistance to drought, and various anatomical characteristics. Recently, a correlation was observed between resistance to drought and strength against breakage. Steve Davis and I both advised Jason in finding an approach to understanding this relationship.

Jason did a wide range of work, from field experiments to mathematical modeling, and discovered that the mechanical engineering behind breakage is too complex to give insight to this problem.

But along the way, Jason discovered what may be a key to the link between resistance to drought and strength against breakage: the correlation appears to go through a correlation to fiber wall density. Jason created a mathematical model of the cross section of the plant in order to measure the cross sectional area due to fiber wall, and measured this in various plants. The fact that this is correlated to resistance to drought may help explain the correlation between resistance to drought and strength against breakage.

Jason wrote up a paper from this experience, and presented his work as a poster at a plant physiology conference at Michigan State University in July 2003.

4. Spring and Fall 2002: Leighton Cowart: Points of finite order on elliptic curves

An elliptic curve over the rationals is a set of points satisfying the equation

$$y^2 = x^3 + ax^2 + bx + c$$

where x and y are rational numbers, and these points form a *group* (a set with a kind of rule of "addition"). When a point as added to itself many times, it may eventually return to itself. The number of times required is called the order of the point.

A lot of work has been done on elliptic curves over the rationals, and much of it is very general. For instance, Mazur's theorem describes which periods are possible (it is a short list of numbers). But not much has been done to work on the particulars of which periods actually occur in which elliptic curves, except for the periods 1, 2, and 3.

Leighton devised a test that will determine whether an elliptic curve has a point of period 4, and if so, how many. His solution also provides a way to characterize elliptic curves with points of period 4 in general.

Leighton is continuing to generalize his work to points of other order and to different fields than the rational numbers. He has written up his work, but this write up will need to be rewritten for a particular journal. Leighton wrote up a paper and submitted it to the American Journal of Undergraduate Research in March 2003, and created a poster for the Spring 2003 Southern California Section meeting of the Mathematical Association of America, for which he got honorable mention.

Assessment

The primary method of assessing student learning is by examining the students' work, in homework, exams, and classroom discussion. I try to keep my assessment standard fairly constant, even as I change individual questions.

In addition, I try to keep in touch with students by requiring them to put comments on the top of their homework about how the course is going. It allows students to give their feedback in a way that is less threatening than in person, and since it is expected of them, requires them to reflect on their learning process. Toward the end of the semester, the number of comments received goes down, partly, I think, due to apathy.

I also keep in regular contact with several of our math alumni (Elliott Jones, Jamie Pascua, Donny Havenhill, Wes Skeith, Dan Clough, Leighton Cowart, Chris Richards, Jen Miller, Jonathan Kassebaum) to find out not only how they are doing but get feedback on our program.

Finally, there are course evaluations. See the end of the "teaching" section for some data on my course evaluation scores.

SCHOLARSHIP

SCHOLARLY, ARTISTIC, OR PROFESSIONAL ACHIEVEMENT

8. List published written work, research projects completed, grants received, unpublished manuscripts being submitted for publication, papers read at meetings of learned societies, lectures to public groups knowledgeable in your field, participation in colloquia or panel discussions at your own or other institutions, creative work exhibited or performed whether outside or within the University, or appropriate clinical or consulting practice. If available, cite evaluations of your scholarship by your professional, off-campus peers (especially in the case of exhibits, performances, etc.). Provide a reflective statement on how you think your work contributes to one or more of the categories of the "Boyer model" of scholarship: discovery, pedagogy, integration, application. (See Ernest L. Boyer, Scholarship Reconsidered: Priorities of the Professoriate.)

Papers published:

1. **What do Topologists want from Seiberg–Witten theory?** (Review of subject)

Boyer model type: Scholarship of integration (explaining to physicists the connections between a particular area of physics of recent interest and a particular area of mathematics of recent interest)

In 1994, Nathan Seiberg and Edward Witten revolutionized a certain area of theoretical high-energy physics by discovering that certain kinds of speculative theories were actually closely related. This led Witten to conjecture that certain mathematical ideas in four-dimensional topology were related. This caused a great deal of interest in topology, and topologists were suddenly interested in learning about high-energy physics, much to the puzzlement of physicists who were unfamiliar with four-dimensional topology.

I gave a talk about this to Stanford University physics department in 1998, and another talk to the UCLA mathematics department in 2001, and based on this second talk I was asked to write this up as a review article for the International Journal of Modern Physics. The idea was to describe to physicists why topologists suddenly want to know about Seiberg–Witten theory, and what kind of problems they hope to solve.

This paper describes the historical development of classification of four-dimensional manifolds, leading through Donaldson theory (and the physics that underlies it), and relations to supersymmetry, and finally Seiberg–Witten theory and how it relates to the previous work done in the subject.

This is a review of the field, meaning that it does not constitute new mathematical discovery, but seeks to explain the historical development and current status of a mathematical field to others (in this case, to physicists). As such, it is not a traditional article per se and did not require a mathematical evaluation or test of the work. Nevertheless, the parts constituting this paper were previously scattered across a wide range of journals, and as a result, few people were aware of the entire picture, even among experts.

Although the impetus was the lecture I gave at UCLA, since the audience was different, the resulting work was significantly different, and I needed to delve into the physics literature quite a bit to connect the subjects.

The next phase will be to write a similar article for mathematicians to explain the physicists' side of the story. This is described below under current research projects.

Status: Published, International Journal of Modern Physics A, Vol. 17, No. 30 (2002), 4463-4514.

2. **Superharmonic functions in R^n and the Penrose Inequality in General Relativity**

Joint work with Prof. Hubert Bray, MIT (at the time; now Prof. Bray is at Duke University)

Boyer model type: Scholarship of discovery

There are many unsolved mathematical problems related to Einstein's general theory of relativity, and in particular with the fascinating objects called "black holes." Hubert Bray solved one such problem, called the Penrose Conjecture, in 1997, almost simultaneously with another solution of the same conjecture by G. Huisken and T. Ilmanen, though H. Bray's results are more general. This conjecture says that the mass of a black hole in general relativity as measured by its gravitational effect very far away is at least the mass of the black hole as measured by the smallest sphere enclosing it.

As one part of this problem, however, H. Bray needed a certain inequality that he felt was likely. H. Bray and I prove this inequality in this paper.

This inequality is a pointwise lower bound for positive superharmonic functions that satisfy an L^p lower bound on a collection of concentric spheres. The value of p depends on the dimension of the space. In a way, it is a boundary case of a Jensen-type inequality.

Status: Published, Communications in Analysis and Geometry, Vol. 10, No. 5, (2002), 999-1016.

3. A Dynamical Systems proof of Fermat's Little theorem

Boyer model type: Scholarship of discovery and scholarship of pedagogy

Fermat's little theorem is a result in elementary number theory dating back to Fermat in th 17th century, that states that if p is a prime number that divides n, then p also divides $a^n - a$ for all a. My result is a new proof of this result, from the field of dynamical systems. I construct a dynamical system that has a^n points of period p, and a fixed points, which results in the fact that $a^n - a$ points have minimal period p, which means that p divides $a^n - a$.

Since this is not a new result, but the proof is easy to understand, the main importance of this result is to motivate undergraduates who are interested in number theory to consider dynamical systems, and those interested in dynamical systems to appreciate number theory. It is also interesting to notice how apparently unrelated areas of mathematics have surprising connections.

Status: Published, Mathematics Magazine, Vol. 76, No. 1 (2003), 48–51.

Papers completed:

1. **Truck Drivers, Straws, and Sharing a glass of water**: Joint with Kendra Killpatrick

Boyer model type: Scholarship of discovery

This project began when Kendra Killpatrick (another math faculty member here was moving, and the movers, when finding she was a math professor, proceeded to ask the following question:

Given two glasses of water, and a straw, is it possible to transfer water from one glass to the other and then back, using the straw (and a thumb to cap the straw) in an alternating pattern in such a way that the glasses end up with the same amount of water in each?

Kendra and I worked on this problem and we found the range of possible starting points that would allow this to happen, and investigated some related questions.

Status: Submitted, Math Horizons, August 2003.
Rejected, Fall 2003.

Revised and submitted, College Mathematis Journal, July 2004.
Accepted, January 2005. Resubmitted with suggested changes, May 2005.

2. **Periods of Generalized Fibonacci Sequences modulo N**

Boyer model type: Scholarship of discovery

The Fibonacci sequence, $0, 1, 1, 2, 3, 5, 8, ...$ Is characterized by the property that each number is the sum of the previous two numbers. The analogous sequence for numbers modulo n has been studied since 1960, and has attracted a little attention since then.

My idea is that by generalizing the problem so that each number is a linear combination of the previous two numbers, we can characterize all the various behaviors that occur.

Although unrelated to my main area of research, this is a fun application of ring theory and group theory. I submitted this paper to the Fibonacci Quarterly in January of 2000, and was rejected in June 2000.

Status: rejected by the Fibonacci Quarterly, Summer 2000

3. **Manifolds that have degree 1 maps from spheres**

Boyer model type: Scholarship of discovery

When refereeing a paper by Sol Schwartzman, I noticed that a more general result was possible by taking a lemma Prof. Schwartzman uses and proving it using different techniques. The lemma is actually interesting in its own right. The question is: suppose an n-dimensional sphere gets mapped into an n-dimensional "target" manifold in such a way that the homological degree is 1. What must be true of the target manifold? I prove that it must be a sphere, up to homotopy equivalence. This essentially says that most manifolds do not admit degree one maps from spheres.

This uses some fairly standard algebraic topological results to address a question that is simple to state, and yet seems to be missing in the literature.

Status: Submitted January 2001 to Topology and its Applications
rejected June 2001
Submitted June 2002 to Homology, Homotopy, and Applications

Manuscripts to be submitted:

1. **Moduli spaces of Seiberg–Witten flows (thesis)**

Boyer model type: Scholarship of discovery

The plan is to publish this thesis, after making minor modifications to fix minor errors, extend results slightly, and reformat for monograph publication. I currently plan to submit this to the American Mathematical Society as a monograph in their *Memoirs of the AMS* series.

The work shows that the Seiberg–Witten equations on four-dimensional manifolds which are of the form $Y \times \mathbf{R}$ satify the same properties as Morse-Smale theory on finite-dimensional manifolds.

2. **Patterns of maxima, minima, and saddles for cubic polynomials of two variables**: Joint with Brad Brock

Boyer model type: Scholarship of discovery and scholarship of pedagogy

Given a cubic polynomial of two variables, what kinds of maxima, minima, and saddles can there be? Given a set of critical points, can we find a cubic polynomial that has those critical points? We completely address this question.

3. **Uniform distribution of points among triangles in a convex polygon**: Joint with Randall Maddox

Boyer model type: Scholarship of discovery

Lukácz and András posed the following question: Given a convex polygon, is it possible to find a set of points so that every triangle described by three vertices of the polygon contains exactly one point of the set in its interior? The answer is yes, but in this paper we seek to characterize all such sets. We actually characterize a large class of sets which is sometimes all of them, and give some indication as to how we can recognize when there are more such.

Colloquia talks given:

- **The Straw Problem: A truckdriver's question, Cantor sets, and an interesting probability distribution**, January 8, 2005, AMS/MAA Joint meetings in Atlanta, GA
- **The Semigroup of equitable distribution of points in a polygon**, January 5, 2005, AMS/MAA Joint meetings in Atlanta, GA
- **All about** G_2, May 31, 2002, University of Oregon Basic Notions seminar
- **Introduction to Seiberg–Witten theory**, June 11, 2001, UCLA Topology seminar
- **To infinity and beyond! On the limitations of human reason**. October 2000, Pepperdine University Natural Science seminar
- **Algebra, A French Revolution, and Other Problems Solved by Radicals**. October 1999, Pepperdine University Natural Science seminar
- **Morse Theory and Compactness in Seiberg–Witten Flows**. April 1999, U.C. Santa Barbara Geometric Analysis seminar
- **The Topology of Manifolds**. October 1998, Pepperdine University Natural Science seminar

9. List current research, artistic, professional, course or program development activities.

1. **Equitable distribution of points in a polygon**

   Joint work with Prof. Randall Maddox, Pepperdine University

   This is a problem that generalizes ideas from combinatorial geometry. A problem was posed to the American Mathematical Monthly in 2002 that asked for a proof that in a convex n-sided polygon, it was possible to distribute $n-2$ points so that every triangle formed by vertices of the polygon contained exactly one point.

   After Randy Maddox solved this problem, he proposed we work on trying to generalize this result. We have worked on two different generalizations. One was to characterize all such solutions, possibly providing a formula for how many solutions existed. The other was to specify that every triangle formed by vertices of the polygon contained the same number of points (say, k). A third kind of generalization, generalizing the number of dimensions, is harder to state because in general, a convex polytope may have many triangulations with differing numbers of simplices.

We have found that if each triangle must contain exactly one point, then there are exactly $2^{n-5}n$ solutions where the points in question are in chambers adjacent to the exterior of the polygon, though there may be other kinds of solutions using points that are more interior. Furthermore, we have characterized when such solutions exist, though we have only worked out the number of such solutions under certain assumptions.

Randy Maddox presented this work at the national MAA Mathfest in Providence, RI in July, 2004, and at the national AMS/MAA Joint Meetings in Atlanta, GA in January, 2005. Some of this work is written up in a paper described above, and other parts will be published later.

The other kind of generalization is also intriguing in that it is a semigroup (under set union) that does not satisfy unique factorization. That is, there are "prime" solutions that cannot be written as a union of two other solutions, and all other solutions can be described as a union of prime solutions, but not necessarily uniquely. For a few cases we have characterized the prime solutions.

I presented this work at the national AMS/MAA Joint Meetings in Atlanta, GA in January, 2005.

2. The Straw Problem and its connection to the Cantor set and Bernoulli Convolutions

When I was working with Kendra Killpatrick on the Straw Problem paper above, I noticed that if you allow movement of water (using the straw) in any order you wish (instead of alternating) then the set of limit points possible depends on the size of the straw, but for sufficiently large straws the limit set was a generalized Cantor set.

If the straw is moved randomly (a fair coin decides which glass you transfer water from), then the probability distribution converges to a very strange distribution, which has already been studied by Erdös and others, called a Bernoulli convolution. For large enough straws, the cumulative distribution function is the Cantor's staircase function (a very bizarre function that I always had thought was only invented to serve as a counterexample to wrong ideas) and for smaller straws, the probability distribution function is very strange–depending on the size of the straw it may be singular or smooth–even uniform!

This is a connection between these two problems that I believe is new.

3. Betting strategies in Poker-like games

Joint work with Prof. Hubert Bray, Duke University

The promotion of Texas Hold 'em on ESPN has led to a renewed popularity of this game, and suggests the mathematical problem of finding the best strategy for bidding. We started with some simplified versions, and found some intriguing patterns. It is not clear whether or not this will result in a comprehensive strategy for Texas Hold 'em, but the mathematical structures of some of the simplified games are interesting, and there may be applications to some kinds of auction bidding.

4. Furuta-like estimates for open four-manifolds with cylindrical end

Joint work with Prof. John Etnyre, Stanford University

This is work in progress, to generalize Prof. M. Furuta's argument to the case of open four-manifolds. It is not certain that this method will work, but we already have seen how much of Furuta's argument still works. At the present time, the main hangup seems to be finding a perturbation of the Seiberg–Witten operator which is large enough to have a significant discrete spectrum. We hope that a technique developed by Prof. Buehler to use weights obtained from a heat kernel will fix this problem.

If this works, this has implications for a project Prof. Etnyre is working on, to find examples of uncountably many diffeomorphism classes for a given open manifold, thus generalizing Taubes' result for euclidean four-space.

5. **Topics in Morse Theory (book)**

   Joint work with Prof. Ralph Cohen, Stanford University

   In 1990, Prof. Cohen gave a course for graduate students that focused on recent developments in Morse theory. He wrote up lecture notes for this course, and these notes have caught the attention of the topology community, who has asked him to publish it as a book.

   I have agreed to put it in book form, and include other work on Morse theory, including some work that Prof. Cohen (my Ph.D. advisor) asked me to do while I was a graduate student. Since then we have been in contact with a publisher, de Gruyter (see letter and contract in "research") and I have rewritten many of the first several chapters, adding more examples, explanations and pedagogically-oriented exercises. We hope to add more material also that covers developments in the field since 1990, including Seiberg–Witten Floer theory, graph moduli spaces, and so on.

   I was recently offered a sabbatical in Spring 2005 to work on this at Stanford University.

6. **The Seiberg–Witten equations from physics**

   Based on a talk I gave previously to mathematicians and to physicists, I will work with S. Baldridge to write up the main components of the relation (proposed by physicists) between Donaldson theory and Seiberg–Witten theory for mathematicians.

7. **Cobordism theory for manifolds with corners**

   This is in the preliminary stages, as suggested by R. Cohen. The theory of cobordism goes back some fifty years, and turned out to be a remarkable way to understand manifolds. But the generalization to manifolds with corners is very recent, due partly to Jänich but mostly to G. Laures (2000). I plan to extend their results, and work with framed manifolds with corners, in order to tie this into what is known about moduli spaces of gradient flows in Morse theory.

8. **Modeling structural integrity in plant vessel and fiber walls**

   Under supervision of Prof. Steve Davis, Pepperdine University

   An undergraduate, Jason Fischer, worked with us to understand relationships between resistance to drought and structural stiffness in chapparal plants (see above, with undergraduate research under teaching). Although Jason is done with this work, I would like to keep this line of investigation open, perhaps even bringing along another interested undergraduate one day.

9. **Using Two-photon microscopy for in vivo imaging of plant vessels**

Work with Robert Barretto, Stanford University, Amit Mehta, Stanford University, Steve Davis, Pepperdine University, Brandon Pratt, Pepperdine University, Dave Ackerly, Stanford University

No one knows what a plant water vessel looks like when it is functioning because when it is functioning, it is typically under very negative pressures, possibly causing some bending in of the vessel walls. The above project was an attempt to model this mathematically, but this should interact with actual observation to see if we are modeling the relevant phenomena.

When a friend of mine, Amit Mehta (then at Lucent Bell Labs, now at Stanford University) told me about his work using two-photon microscopy to image neurons in living mice, I recognized that this might be used to image water vessels in living plants. Steve Davis, Brandon Pratt, and Dave Ackerly suggested methods of dealing with the plant side, and Robert Barretto will be working the two-photon scanning microscope.

10. Applications of Microbiology techniques to New Testament Textual Criticism

Joint work with Prof. Tom Vandergon, Pepperdine University

This work is in the very preliminary stages.

Microbiologists have developed computer algorithms to compare strands of DNA from different living organisms, and derive a likely phylogeny (family) tree. Scholars studying the Greek New Testament compare manuscripts of the New Testament to hypothesize likely "family groups" and dependencies (textual criticism). My idea is to use the computer algorithms developed by microbiologists to draw up likely phylogeny trees for the various manuscripts of the Greek New Testament.

This may bring more quantizability and objectivity to a field that has developed little since the beginning of the 20th century. It may also reveal groupings that are more subtle than can be easily discerned by eye.

After a trial run on the first chapter of Mark on a limited manuscript evidence (those noted in the Nestle-Aland Greek NT 27th ed.) the evidence seems to support current scholarship on the main groupings, but there seems to be some discrepancies. I hope to make more trial runs on other chapters of Mark, then other books of the New Testament, in order to check the consistency of this method, and to see to what extent manuscripts may have used various source manuscripts for different parts of the New Testament.

11. Polynomial Morse Theory over Finite Fields

Morse theory plays an important role in topology, but an analogous kind of theory exists for algebraic systems that are more discrete. For instance, Morse theory talks about maxima and minima from the perspective of geometry, but maxima and minima may be discussed in purely algebraic terms if you restrict your attention to polynomial functions. I am investigating whether or not an analogous theory holds. In one case it appears that it does, suggesting that a general theory exists here. Perhaps an extension of this may be helpful to people in Algebraic Geometry.

12. G_2 manifolds

This is very preliminary. I hope to find geometric ways to understand manifolds with G_2 holonomy.

10. List courses, seminars, meetings or special study programs attended in the past 3 years, plus any other significant means employed for staying current in your field.

Conferences attended:

1. Joint Mathematics Meetings of the Math. Assoc. of America and the Am. Math. Soc.: January 2005, Atlanta
2. S. Cal. section of Am. Math. Soc.: March 2004, USC
3. Joint Mathematics Meetings of the Math. Assoc. of America and the Am. Math. Soc.: January 2004, Phoenix
4. 4th Plant Biomechanics Conference, July 2003, Michigan State Univ.
5. Association of Christians in the Mathematical Sciences conference, May 2003, Point Loma Nazarene Univ.
6. G_2 holonomy workshop, Institute for Pure and Applied Mathematics: April 2003, UCLA
7. S. Cal. section of Math. Assoc. of America meeting: March 2003, Harvey Mudd College
8. Joint Mathematics Meetings of the Math. Assoc. of America and the Am. Math. Soc.: January 2003, Baltimore
9. S. Cal. section of Math. Assoc. of America meeting: October 2002, Cerritos College
10. American Scientific Affiliation meeting: August 2002, Pepperdine University
11. S. Cal. section of Math. Assoc. of America meeting: March 2002, Cal Tech
12. Joint Mathematics Meetings of the Math. Assoc. of America and the Am. Math. Soc.: January 2002, San Diego
13. S. Cal. section of Math. Assoc. of America meeting: October 2001, Loyola Marymount College
14. Park City Mathematics Institute: July 8-29, 2001, Park City, Utah
15. Visit Hope College to review their undergraduate research program: July 3-7, 2001, Hope College
16. Great Lakes Geometry conference: April 28-29, 2001, Northwestern University
17. Symplectic Geometry and applications to Physics: April 12-15, 2001, UC Irvine
18. S. Cal. section of Math. Assoc. of America meeting: March 17, 2001, CSU Fullerton
19. Joint Mathematics Meetings of the Math. Assoc. of America and the Am. Math. Soc.: January 2001, New Orleans
20. S. Cal. section of Assoc. of Physics Teachers meeting: November 2000, Santa Monica College

21. S. Cal. section of Math. Assoc. of America meeting: October 2000, Whittier College
22. Interactions between Topology and Theoretical Physics: August 2000, UCSD
23. Mathematical Challenges of the 21st century (sponsored by the Am. Math. Soc.): August 2000, UCLA
24. Western States Mathematical Physics meeting: Feb. 2000, Cal Tech
25. Mt. Baldy Conference on Analysis: November 1999, Harvey Mudd College
26. New Directions in Homotopy Theory: August 1999, Stanford University
27. Santa Barbara Summer Conference in Geometry: July 1999, U.C. Santa Barbara
28. Gravitation conference: June 1999, U.C. Santa Barbara
29. European Research Conferences: Geometry, Analysis and Mathematical Physics: June 1999, Obernai, France
30. Southern California Geometry and Analysis Seminar: February 1999, University of California, Irvine
31. Mathematical Association of America (Southern California Chapter): October 1998, Pepperdine University

Other efforts to expand my research interests:

In addition to these conferences, I am meeting regularly with Greg Landweber from the University of Oregon to discuss both supersymmetry and G_2 holonomy.

Also, I helped organize a seminar for Pepperdine math faculty, where we would share knowledge of our respective fields with each other. The main rule was that the lecturer was not to prepare for the lecture. The advantage to doing this was to add flexibility to the seminar, so that participants could ask questions and not worry about getting the lecturer "off track" or keeping the lecturer from finishing the prepared talk. It was also to ensure that this would not detract from our teaching of undergraduates, and encourage people to talk.

I have worked through a book on group representation theory together with Kendra Killpatrick to expand my knowledge in that direction.

The time I spent advising Jason Fischer together with Prof. Steve Davis in Biology allowed me to learn a lot about plant biomechanics and I have spent some time reading more about this, in hopes of another undergraduate who might want to further this research.

I have also been reading several books on the philosophy of mathematics, since this is an area where my Christian perspective may give me an unusual vantage point. I've been reading through a collection of essays edited by Tymoczko, *New Directions in the Philosophy of Mathematics*, a book by Shapiro, *Philosophy of Mathematics*, a book by Eerdmans, written by a committee of the Association of Christians in the Mathematical Sciences, *Mathematics in a postmodern age: a Christian perspective*, and a book by Tasic, *Mathematics and the roots of postmodern thought*. I have also recently subscribed to the only journal in the philosophy of mathematics, *Philosophia Mathematica*, and joined the Special Interest Group of the Mathematics Association of America on the Philosophy of Mathematics.

I am not yet in a position to write articles in this area, but I hope to build my background in this area to offer my perspective as a Christian.

11. List and date relevant membership, activities, and offices held in professional associations and societies, including editorships of professional journals.

2001–present	**American Scientific Affiliation (Christians in the sciences)**
2001–present	**Association of Christians in the Mathematical Sciences**
1999–present	**Fibonacci Association**
1998–present	**American Mathematics Society**
1998–present	**Mathematics Association of America**

Papers refereed:

2000-2001	Sol Schwartzman, *Parallel Tangent Hyperplanes*, proceedings of the AMS
1999-2000	*Functorial equivalence between Graphs and Simplicial Complexes*, Proceedings of the AMS

Books reviewed:

2002	(followup on Tomastik, Calculus)
2001	Tomastik, Calculus: Applications and Technology, 2nd ed.

Papers reviewed for Mathematical Reviews:

2004	Miao, P., *Positive mass theorem on manifolds admitting corners along a hypersurface*
2004	Bray, H., Schoen, R., *Recent proofs of the Riemannian Penrose Conjecture*
2004	Mariño, M., *An introduction to Donaldson–Witten theory*
2004	Herzlich, M., *Minimal surfaces, the Dirac operator, and the Penrose Inequality*
2004	Meng, G., *A path integral formulation of* χ_y *genus*
2003	Miao, P., *Asymptotically flat and Scalar flat metrics on* R^3 *admitting a horizon*
2003	Bray, H., *Black Holes and the Penrose Inequality in General Relativity*
2003	Bartnik, R., *Mass and 3-metrics of non-negative scalar curvature.*
2003	Naber, G. L., *Gauge fields in Physics and Mathematics.*
2003	Gottlieb, D. H., *Topology and the non-existence of magnetic monopoles*
2003	Wu, Siye, *The Geometry and Physics of the Seiberg–Witten Equations.*
2003	Váňa, O., *On a topological* $N = 4$ *Yang–Mills theory.*
2002	Flume, R., Storch, H., Poghossian, P., *The Seiberg–Witten prepotential and the Euler Class of the Reduced Moduli Space of Instantons.*

Mathematical Reviews is a publication that keeps up to date with all mathematical papers and puts out reviews on them. Since August 2002 I have been a reviewer for them, and in that capacity have written the above reviews.

SERVICE

UNIVERSITY SERVICE

12. List committees served on, administrative assignments, sponsorship of student organizations, work with faculty organizations, general student advisement, and chapel/convocation involvement.

Awarded Helen Pepperdine Award for Outstanding Service, 2003.

1. **Physics Major planning committee (ad hoc committee to create a new physics major) (8/2004–present)**
2. **Arranging tutors for the math department (tutors: 8/01-present, graders: 8/01-present)**
3. **Teaching and Learning committee member (8/2000–7/2004), chair (8/2002–7/2004)**
4. **Advisor, Pepperdine Rotaract (8/01–present)**
5. **Administering the math computer lab (KSC 160): Keeping the math computer lab running properly and organizing faculty and student accounts (8/01–present)**
6. **Developing the Mathematics department website http://math.pepperdine.edu (9/00–present) (which also enabled me to do some developments with teaching, see above)**
7. **Math department curricular reform (1/99–present)**

   Currently helping the math department reformulate the mathematics major and reevaluate what course offerings we should provide to best prepare our students.
8. **Pi day (volunteer to have pies thrown at me as a fundraiser for the Pepperdine math club KME: 3/14/03, 3/12-14/04)**
9. **Putnam competition: Organized Pepperdine's participation in the national Putnam math competition (Fall 2000, Fall 2001, Fall 2002, Fall 2003)**
10. **Arranging graders for the math department (tutors: 8/01-present, graders: 8/01-6/02)**
11. **Hiring for math: Helping organize the math department's search for a candidate to hire (9/00-3/01, 8/01-3/02)**
12. **Mentor for new faculty (Erik Halvorsen) (8/00-4/01)**
13. **Admissions and Scholarship committee member (8/99-7/00)**
14. **WASC Standard IV (Seaver) committee member (3/99-8/99)**
15. **Advisor, Pepperdine International Business Club (10/98-4/00)**

COMMUNITY SERVICE

13. List all community service including church, civic or service organizations, including offices held.

1. **Elder, Malibu Presbyterian Church (June 2004 – present)**
2. **Rotaract Club member (March 2001–present), advisor (Aug. 2002–present)**
3. **Serve food, SOS (once a month, 2004–present)**
4. **Upward Bound House Kids' Night (4/99-present)**

   As a part of Opportunities to Serve (see below) I organized a team from Crossroads MPC to help with Kids' Night at the Upward Bound transitional shelter. Upward Bound is a shelter for families with children, and seeks to provide ways for families to get regain their self-sufficiency, by providing a safe place to live, and providing resources to find employment, including seminars on writing resumes and money management. During these seminars, they hold a Kids' night that provides supervision for their children, and fun activities. Our group volunteers as supervisors for this program, and I currently go every Thursday night from 6-7 pm. I have also involved a few Peppperdine students.
5. **Optimist club member (10/00–present), board member (10/01–9/03)**

   Member of the Malibu Optimist club, a service organization that runs projects for and raises money on behalf of youth.
6. **Adult Sunday Bible Study leader (Jan 2003 – June 2003, Sep. 2003 – present)**
7. **Free Arts day at Optimist Boys home (July 2004)**
8. **Deacon, Malibu Presbyterian Church (June 2001–June 2004)**
9. **Nominating committee member, Malibu Presbyterian Church (March 2004–May 2004)**
10. **Parking Cars at the Malibu Arts Festival (Pepperdine Rotaract) (July 2004)**
11. **PCH Cleanup (Pepperdine Rotaract) (Oct., Nov. 2001, Mar. 2004)**

    Helped pick up trash along PCH near Pepperdine University
12. **Step Forward Day participant/site leader (10/98, 9/00, 9/01, 9/02, 9/03, 9/04) (one-time events)**

    Participated in the Pepperdine University Step Forward Day, run by the Volunteer Center, to send groups of students with a faculty member to various community service projects around the Los Angeles area. Each of these years our group went to a different place: The Union Rescue Mission, cleaning PCH of trash, cleaning Tapia Park of trash, helping set up a garden in a church-planting group, and painting at St. Vincent Manning's shelter.
13. **Faculty project: cleaning a river of invasive crayfish (Aug. 2003)**
14. **Optimist Club Pancake Breakfast Fundraiser, volunteer (June 2002, July 2003, July 2004)**
15. **Chaperon, MPC sleepover (3rd–4th grade) (July 2003)**

16. **Vacation Bible School setup (MPC) (June 2003)**
17. **Easter sunrise service setup coordinator (MPC) (March 2003)**
18. **Search committee: Worship and Arts Director for Malibu Presbyterian Church (Sep 2002 – Mar 2003)**
19. **Christmas presents wrapping (Rotaract) (Dec 2002)**
20. **Christmas Decorating Malibu Presbyterian Church (Dec 2002)**
21. **Mission committee, Malibu Presbyterian Church (Sep 2002–Dec 2002)**
22. **Thanksgiving food drive shifts, Malibu Presbyterian Church (Nov. 2002)**
23. **Optimist club Haunted House setup and cleanup (Oct. 2000, Oct. 2002)**

    Helped set up for and clean up after the Haunted House for Point Dume kids, in conjunction with the Optimist club of Malibu.
24. **Thanksgiving food drive co-organizer, Malibu Presbyterian Church (Sep 2002 – Nov 2002)**
25. **Alumni coordinator and advisor, Alpha Phi Omega national convention bid for Anaheim 2004 (Aug 2002 – Dec 2002)**
26. **Facilitator, Chapter Program Workshop for Alpha Phi Omega (Aug 2002)**
27. **Taught CPR (American Red Cross) (Dec. 13, Dec. 20, 2000, Mar. 10, 2001, Apr. 7, 2001, June 15, 2001, March 2002)**

    Taught CPR for the American Red Cross, West LA chapter. The March 2001 and 2002 dates refer to the Super CPR Saturday, where we taught around 50–100 community members CPR for free.
28. **San Felipe painting project (Rotaract) (Jan 2002)**
29. **Christmas presents wrapping (Rotaract) (Dec 2001)**
30. **San Felipe painting project (Rotaract) (3/31/01-4/1/01)**

    Helped build a concrete platform for a multipurpose building at a Church of Christ camp in San Felipe.
31. **Salvation Army Toy Drive (Pepperdine Rotaract) (Nov 2001)**

    Help kids pick out $100 of clothes using money donated to the Salvation Army
32. **Habitat for Humanity (9/00, 10/00, Summer 2001)**

    I have volunteered three times at the Downey site of Habitat for Humanity in conjunction with Malibu Presbyterian Church.

33. **San Felipe painting project (Rotaract) (3/31/01-4/1/01)**

    Helped paint a multipurpose building at a Church of Christ camp in San Felipe.

34. **Food distribution on Skid Row (Rotaract) (3/3/01)**

    Prepared and handed out sandwiches to people living on skid row in downtown Los Angeles.

35. **People for People sorting donated goods (12/00) (one-time event)**

36. **Habitat for Humanity (8/99)**

    The Seaver Dean's office organized a day to work on a Habitat for Humanity building project in Piru. I participated.

37. **Union Rescue Mission project with Psi Upsilon (4/99) (one-time event)**

    The Pepperdine fraternity Psi Upsilon organized a project with the Union Rescue Mission in Los Angeles to prepare and serve lunch. I joined them for this project.

38. **Project Children's Hospital (4/99) (one-time event)**

    As a part of Opportunities to Serve (see below) we went to throw a party for children at the LA Children's Hospital.

39. **Alpha Phi Omega Section 1 Chair (3/99-3/00)**

    Alpha Phi Omega is a national service fraternity, in which I have been involved since 1988. As an alumnus in the Los Angeles area, I was elected to be section chair for section 1 (the Los Angeles area). The purpose of the position is to coordinate efforts between the chapters of Alpha Phi Omega and to make resources available to students in these chapters. Chapters in section 1 are at: Cal Poly San Luis Obispo, USC, UCLA, UC Riverside, and Cal State Long Beach. An interest group is at LA Community College.

40. **Honduras team with MPC (3/99) (one-time event)**

    As another Opportunities to Serve project (see below), I went with a team of ten to Honduras for one week to help with relief work in the aftermath of Hurricane Mitch. We mostly worked with children at orphanages, and we hope to arrange for other ways to help in the future.

41. **Tutoring at Sepulveda Middle School (2/99) (one-time trial)**

    As an exploratory mission to find projects for Opportunities to Serve (see below), I helped as a teachers' aide in a remedial mathematics class at Sepulveda Middle School, a school in a low-income neighborhood. A tutoring project is planned for next year, to be run by the university group at MPC, in conjunction with a Baptist church in the area.

42. **Sunday school at MPC (12/1998–6/2002)**

    I have been teaching the 3rd-4th grade children for Sunday school at Malibu Presbyterian Church.

43. **Rancho de los Niños (11/98, 1/99, 11/99, 2/00, 11/00, 4/01, 11/01) (periodic event)**

    On four occasions so far, Prof. Mark Coodey and I took a few Pepperdine students to help at a home for orphans and abandoned children in Mexico run by the Churches of Christ and Disciples of Christ. We painted a playhouse and kitchen, dug some ditches for piping, painted security bars, and played with the children.

44. **Opportunities to Serve committee, Malibu Presbyterian Church (11/98-4/00)**

    The Crossroads (20s-30s) group at Malibu Presbyterian Church started a committee to plan community service projects that Crossroads members would participate in.

45. **San Felipe trip with Psi Upsilon (10/98) (one-time event)**

    The Pepperdine fraternity Psi Upsilon organized a trip to San Felipe to build a meeting hall for a Church of Christ-run camp. I joined them for this project.

SUPPORT FOR CHRISTIAN VALUES

14. Describe your consistent pattern of support for generally accepted Christian values and the mission of Pepperdine University as these are described in the Mission Statement of 1999, and describe your active participation in a community of faith. If possible, discuss your integration of faith and learning in the classroom.

Pepperdine is a Christian University... As a Christian personally, I see my Christian duty as seeking to serve God by becoming more like Jesus Christ. In this regard, I have recently been working on understanding what Jesus Christ did and said, as separated from my cultural context. It is, of course, impossible for me to negate my cultural context, but by understanding the various ways different traditions have understood Jesus throughout history, I can at least recognize how my cultural context has assumed a great deal about Jesus that may not be true.

As a part of this broader perspective, I have deepened my appreciation for aspects of Christ's mission, such as service to all, and especially the marginalized, correcting legalism, fellowship with the Father, and to those despairing in a run-down world preaching hope for a God-centered kingdom.

I have concluded that particulars about ritual (including sacramental ritual) are only important in that they communicate to us more permanent realities, but are not themselves the permanent realities. Similarly, it is not of critical importance to understand a great deal about heavenly things, or even to agree on these things as a church. As a result, much of the disagreement among various branches of Christianity are about irrelevant points. And if we focus on the basic message of the Gospel, then we see a much more united Church than before. This, I have learned, is the starting point of Alexander Campbell's original vision to start the Churches of Christ.

There are other lessons I have been learning this year, but I wish to focus on the implications for this first phrase in the mission statement.

The term "Christian university" implies two dependencies: first, the idea that the university, a concept associated with a community dedicated to the search for knowledge, takes a world view that begins with the Christian world view; and second, the idea that the university can search for knowledge about Christianity (the usage of "first" and "second" here is not to imply priority).

My part in this mission, as a member of the mathematics department, is to first, use my Christian world view to do mathematics, and second, to use techniques inherent in mathematics to shed light on Christianity.

Doing mathematics requires a world view even as the actual mathematical facts are independent of culture. It affects the extent to which one views the subject as one to be invented or discovered. Most commonly, mathematicians view their mathematical subjects as things to be discovered, no doubt due to the subjective evidence that one is constantly surprised at the complicated relationships among seemingly-unrelated objects that coalesce into a certain concise simplicity that mathematicians call "beauty." Certainly much of this beauty is not due to the mathematician who sees them, since otherwise the mathematician would not be surprised to see it. This is, in part, why mathematicians speak of "discovering" a theorem rather than "inventing" it.

This is also my view, and I see it in very theistic terms. That is, I see the beauty in mathematics as having its origins in God. Although no different from what a Christian biologist might say about the beauty of nature, it has wide-ranging implications, inasmuch as it makes a much larger claim about the dependence of this universe on God, since the things of this world are not only following God-made rules of physics, the very mathematics that they depend on is from God.

In my scholarship, this comes through in the ways in which I search for truth, believing there is intricate and important truth all over mathematics if I can tune my eyes to see it. In my teaching, this affects the way in which I speak of mathematics, focusing on the mathematics as timeless truth rather than the proud fruits of some ingenious people.

It is not only the case that Christianity affects how I do mathematics. My mathematical training has an effect on my Christian faith. First, mathematical training clarifies many of the debates among Christians, and between Christians and non-christians. Both fallacies and options that were not considered become clear. Second, the model for scholarship in mathematics encourages extreme honesty in any argument, admitting when you are wrong and pointing out conditions under which your argument would fail. Third, in an age when many academic areas have given up on a concept of "truth" and have fallen into relativism, mathematics provides an example of truth that is beyond subjectivity, and suggests the innate objective reality of existence.

...committed to the highest standards of academic excellence... Academic excellence is interpreted in two ways at a university: teaching and research. In the realm of teaching, I hope to teach in a way that inspires students to achieve, and in a way that prepares students to be well-informed, reflective, and aware. In research, I hope to contribute to the dialogue that we call the research world, and have a lasting impact. Being at Pepperdine has some implications. Since the research expectations are less than at a research school, paradoxically this allows for a niche whereby we are allowed to be unorthodox or to ask unusual questions, without much risk. At research schools, people in my position would only be working on extensions of their graduate work, since anything else would slow the rate at which someone can churn out papers. But here I can ask questions that are not in the mainstream, or not in my area of expertise, and not have to worry about the fact that my research output will probably slow as a result. Some of the projects I am currently doing speak to that. Writing a book is unusual in math for someone without tenure for this reason, but I am helping write a book. Interdisciplinary research is similarly uncommon especially for someone in pure (not applied) mathematics, but I am taking that risk.

If I don't go in directions like these, then I fail to take advantage of an aspect that makes Pepperdine unique.

...and Christian values... Today the words "Christian values" are often misused. We think of the religious right and its use of terms like "family values" and "Christian values" to describe what are not, in some cases, values at all, but rather worldviews and opinions. When I see "Christian values" in the mission, I understand it to mean an understanding of the relative importance of people, things, and ideas, based on a Christian perspective. From my perspective, God is the source of all value, and He imbues creation with value. Humans derive their value from their being in the image of God. That which is of value in humans is profoundly internal and not categorized by labels. Christians are not more valuable than non-Christians since the term "Christian" is a label. For that matter, we can never assign to one human more value than to another, since we cannot fathom the internal.

There is a special call, I believe, to Christians, to be channels of God's agape love. This love is the kind of love that is not due to people being similar (philos), not due to sexual attraction (eros), or maternal instinct (storge), but due to who God is. Even when we were sinners, Christ died for the ungodly. As recipients of God's love, we are then, and only then, able to give this love to others, not because the people we love are lovable, but because of the agape love we received from God. Our love is for the Christian and non-Christian alike. But when we get together, there the unique phenomenon occurs where people love one another.

Of course, many people who are not Christians can experience this love and show it to others, but as Christians we are specially called to this since we know this love directly and fully realize how Christ's sacrifice demonstrates this love. Thus, the goal of the Church is to be channels of God's love through meeting people's physical and spiritual needs and extending the hand of God to all people.

We are also called to be holy. We are to take an attitude that counts the eternal as more lasting than that which has consequences in only the near future. Building a retirement account is for thirty to eighty years from now. Sanctification is for eternity.

In this context, I understand the value of impacting students as eternal compared to the temporal well-paying job I might get if in industry.

...where students are strengthened for lives of purpose, service, and leadership It is important to realize that a student is not a student for the sole purpose of being a student. Even as we hope our students will be life-long learners, we understand that we should be producing students who will be able to serve and lead, reflective of the true nature of their contribution. For this reason, the comments I made about teaching should be tempered with the understanding that students need to see their knowledge and mental development in the context of their spiritual development. On every class syllabus, I have the following statement:

Christian attitude: Although not part of the grading for this course, you are expected to approach this class with a Christian attitude, being willing to help your fellow classmates to understand the material outside of class, being willing to be corrected by your fellow classmates when you see they are right, but firm in your conviction otherwise, being bold to ask questions without feeling ashamed of looking foolish, encouraging one another in love, being patient with those who are asking questions, and preferring a grasp of the material, which is enduring and becomes part of you, over a grade, which is transient, external, and shallow. You should diligently devote the time you spend on this class as to the Lord. As cheating harms both the cheater and the rest of the class (though in different ways), you should not cheat, nor should you provide temptations for others to cheat.

After handing out the first midterms, I stress the idea that one's self-worth does not derive from a test score. In business calculus classes I stress the importance of applying these techniques not merely to turn a profit but to benefit others.

ADDITIONAL FACTORS

19. State other factors, if any, which you wish the committee to consider.

None.