Melvin Leok: Teaching Statement

I am enthusiastic about interacting with students, and take pleasure in watching them grow in understanding under my mentorship, but my primary goal is to convey the sense of joy and satisfaction that comes from taking intellectual ownership of the learning process by exploring and discovering new ideas. Additionally, I aim to communicate the importance of unifying concepts that bridge various fields, since cross-fertilization of ideas is fundamental to the interdisciplinary approach that permeates modern thought.

Mathematics courses are often criticized for being boring and irrelevant, but as any professional mathematician knows from personal experience, mathematics as a subject is beautiful, exciting, and unreasonably effective in applications. How then should we convey this in our courses? Perhaps the first question to address is what is the added value of attending a lecture, as opposed to simply reading the textbook. In teaching an introductory service course, it is unrealistic to expect students to be automatically motivated and enthusiastic. Motivating examples need to be realistic, convincing, and relevant. A half-hearted toy example only sends the message to students that what they are about to learn is of purely theoretical interest.

The individual threads of knowledge that we convey in our lectures need to be anchored by prior experiences and learning, and woven into a tapestry of understanding. Therein lies the value added in having a professional mathematician teach introductory mathematics courses, that by illuminating the connections between apparently disparate areas of study, we are able to offer students a glimpse of the bigger picture, and in so doing inspire students to draw upon their full body of mathematical knowledge in approaching problems, as opposed to narrowly compartmentalizing what they learned in individual courses.

An essential aspect is the manner in which one structures the material presented in a course. Knowledge has a intrinsically hierarchical and modular structure to it. Mathematical theorems typically have the structure of a tree, where the main theorem depends on a number of subsidiary propositions, which may in turn rely on lemmas. The traditional approach to presenting a theorem in class is via a depth-first tree traversal, where one first establishes the basic lemmas, proceeding to the propositions, before finally arriving at the theorem to be proven. Such a depth-first approach to conveying mathematical content stems from a constructivist and method driven approach to mathematical education, which is fundamentally at odds with the mindset that science and engineering students bring to our service courses.

In service courses, a problem or goal driven approach to presenting the mathematical techniques is most likely to be effective. By motivating the mathematical content with a judicious choice of examples and applications that arise in physics and engineering, one is naturally lead to stating the main mathematical results that are relevant to the problem at hand, which in turn entails adopting a breadth-first approach, with an emphasis on the big essential ideas early on, and delving into the more technical details only after the motivation and overarching intellectual framework has been firmly established. At its heart, the most important aspects of mathematical literacy in non-mathematics majors are logical and deductive reasoning, and the ability to abstract, which allows one to see the commonality and unifying structure in apparently disparate problems. As such, the breadth-first approach serves an important pedagogical role, by emphasizing the high-level connections, as opposed to technical proficiency in performing computations which are easily forgotten, and increasingly obsoleted by modern mathematical and scientific software tools.

These issues are paramount in lower division calculus and differential equations courses where it is essential to convey to students the fundamental role mathematics plays in other scientific disciplines. Studies suggest that the inability to establish this connection between mathematics and applications with social impact and relevance lie at the heart of our recruitment and retention woes, particularly of women and minorities. My background in engineering and physics makes me particularly effective at making these connections explicit.

In teaching numerical analysis to a cohort consisting predominantly of engineering students, one is provided with an excellent opportunity to clarify to students the important connections between the particular needs of an application area, the mathematical analysis of numerical algorithms, and the implementation issues. For example, the application area determines the quantities that need to be estimated from a computational model, and the accuracy requirements, which in turn affect the modeling and numerical approximations that are acceptable to render the computation tractable. In addition, implementation issues play a critical role in deciding the kinds of algorithms we adopt.

I believe that enthusiasm is contagious, and that students will rise to the challenge if they believe that their instructor is sincerely concerned about their understanding. I have been described by students as "a nice teacher, and willing to help," as well as "very approachable, and concerned that students understood the material." This perception has allowed me to overcome the hesitation of weaker students to attend office hours, and ensure that these students receive the additional and individualized attention they require.

When presenting proofs, I adopt the breath-first approach by first sketching out the logical structure of the proof. This introduces, by example, the divide and conquer approach to problem solving. Emphasizing the logical structure of the material provides the students with the necessary mental scaffolding to build a deeper understanding. By breaking up the proof into smaller steps, students are often able to provide the details involved in each step, thereby engaging them in the process, and increasing their fledgling confidence in their mastery of the material. Appropriately chosen counter-examples to a theorem, that illustrate what goes wrong when specific hypotheses are violated, give students a better sense of the critical ideas involved in the proof, and allow them to develop the insights necessary to independently approach the problem.

In contemporary engineering, the most efficient processes are intrinsically at the brink of instability, and it is only with feedback control that these processes are stabilized. An analogous situation arises in teaching, as we thread the thin line between challenging and overwhelming our students. The key to achieving this is by periodically checking throughout the lecture that students understand, and adapting the pace and presentation as appropriate. Student understanding can be gauged by direct questioning, but more accurately by paying attention to non-verbal cues like their facial expressions. This approach is well-received by my students, who cite my ability to adapt the pace to their needs as one of the strengths of the course.

Computational labs provide a rare opportunity to observe students first hand while they are grappling with conceptual problems, which can otherwise be difficult to detect in a large course setting. This is particularly true with students from cultures that are more deferential to teachers, as it can be difficult for them to approach the instructors for assistance during office hours or after class. As such, these labs provide an opportunity for instructors to deal with a student's conceptual stumbling blocks before they become critical.

I would enjoy teaching lower division courses on engineering mathematics, differential equations, linear algebra, and calculus, and would incorporate concepts that are not traditionally covered, but are of importance in numerical computation, such as the condition number of a matrix in linear algebra and its relation to the accuracy of iterative solvers. I would offer reading courses and individual student projects in current research topics that are not serviced by regular courses. Providing these opportunities for students to explore their individual interests will aid in efforts to improve the recruitment and retention of students in mathematics.

Teaching courses in differential geometry, mechanics, scientific computation and numerical analysis, at both the graduate and undergraduate level, would also be of interest to me. I aim to introduce modern topics like geometric integration to numerical analysis classes, and incorporate the computational aspects of mechanics into advanced courses on modern and geometric mechanics. Courses should reflect the rich interplay between the geometry, physics, and numerics in many problems of engineering interest.

At Purdue, I have taught the graduate qualifying examination courses in differential geometry and numerical analysis, and an advanced graduate topics course in geometric numerical integration. I modernized the treatment of the differential geometry course by also discussing the applications to geometric mechanics, and this resulted in record course enrollment and retention of both mathematics and engineering students. At UCSD, I taught the graduate geometric numerical integration and the geometric mechanics courses using a project-focused format, which allows students to study an advanced topic of their choice in significantly greater depth by building upon the techniques introduced in the graduate course.

More recently, my coauthors, N. Harris McClamroch, Taeyoung Lee, and I have been working on creating an introduction on the modeling, analysis, and simulation of mechanical systems that evolve on manifolds. The two-volume set, entitled, "Global Formulations of Lagrangian and Hamiltonian Dynamics on Manifolds," is under contract with Springer-Verlag, and it which will provide a self-contained and comprehensive introduction to the use of Lagrangian and Hamiltonian mechanics to model mechanical systems evolving on Lie groups, homogeneous spaces, as well as more general manifolds. The first volume will focus on the modeling of such problems in continuous time, and the second volume will address the development of geometric structure-preserving numerical discretizations of such problems through the use of discrete variational principles in combination with Lie group integration techniques. The first volume is currently under review, and is available at `http://www.math.ucsd.edu/ mleok/pdf/LHDynamics.pdf`.

The two-volume text described above will provide a strong foundation in mathematical modeling and structure-preserving numerical integration of mechanical systems evolving on manifolds. Even if one is only interested in the continuous time modeling problem, the first volume will develop in students the ability to model complex multi-body systems globally as opposed to locally, which dramatically simplifies the analysis of global controllability issues, and yields globally valid equations of motion that are amenable to more traditional analytical tools. As such, it would be of broad appeal to both mathematics students interested in pursuing research in geometric numerical integration, geometric mechanics, or geometric control, but it would also be of interest to engineers who wish to work in the area of articulated robots and autonomous aerial and underwater vehicles.

Perhaps more importantly, the manner in which the material is presented addresses how one can make explicit use of the underlying Lie group structure of configuration spaces such as rotation groups and Euclidean groups, as well as homogeneous spaces like n-spheres, Stiefel manifolds, and Grassmannians, to compactly and efficiently model a broad range of practical engineering problems. This global approach is something that is typically omitted in even the most sophisticated textbooks on geometric mechanics and geometric control, or even in the research literature.

In the longer term, I would like to introduce a capstone course for applied mathematics students modeled after the Oxford Study Group with Industry, the PIMS Industrial Problem Solving Workshop, or the Harvey Mudd Mathematics Clinic, that address the solution of real-world industrial problems though an innovative blend of theoretical and numerical methods, in a group environment.

Comments from Teaching Questionnaires

He is a wonderful professor. He teaches not only math but the importance of learning.

Very fair and knowledgeable instructor. Would definitely take another course that he is instructing.

Professor Leok made me feel really comfortable. He made me understand interesting topics with ease. He was a really friendly person and knew his material really well. I would definitely recommend this professor to others

Professor Leok's lecture style is clear and facilitates note-taking. His email response speed is amazing, and he is always friendly and helpful in person. Don't change a thing and rock on!

Very clear and a professor that truly understands what he is teaching.

Very accessible and easy to approach.

Knows the material quite well and explains in detail. Always willing to answer questions.

Leok is interesting and tries to be humorous which is cool, makes the information less tedious.

The professor shows concern about the students' learning. Has good interaction with students and tries to inject humor into his lectures.

I really recommend this teacher! He is really funny and nice. The way he teaches is really easy to understand.

He's a good-humored guy who is clear and knows what he's talking about. Sometimes he makes inaccurate assumptions about your knowledge in some areas, and resultantly goes too fast over some axioms.

The Professor is very good, and shows incredible concern about students learning compared to many other professors at UCSD. The professor is very fair and I would highly recommend Professor Leok!

Very fair w/ grading, understands that sometimes it takes longer for some students to grasp the concepts.

I feel like he actually cares that we learn

Prof. Leok did an excellent job teaching this course. His explanations were clear, and he made himself very available outside of class. I would very much like to take a course from him in the future.

I really enjoyed the course. The material was interesting and the presentation was clear, concise, and easy to follow. I was not very fond of the book, but the lecture notes made up for this.

Melvin is THE MAN!!

Seriously though, the instruction was excellent.

Melvin's lectures were very clear and they actually contained the material needed to do the homework, something I really Liked.

Melvin was also very approachable and concerned that students understood the material.

Instructor was very accomodating to students with conflicts during his office hours. He would sit and help students past office hour time.

Overall, this course was well-taught.

I feel that the material was interesting & relevant.

I feel that Prof. Leok taught well & covered important topics in the course.

The lecturer explained materials well and explained hard-to-grasp concepts in multiple ways during the lectures which helped me understand the material better.

I appreciated the job you did with this course.

I like your teaching style, and the pace at which you covered material.

I really loved your class. Thankyou

for being a great lecturer.

You were a very good teacher. I would take another class from you because you actually cared about how each student was doing and always offered help.

He was very well prepared for class and helpful during office hours.

Professor Leok was an excellent teacher. He was dynamic as a lecturer, and clearly knew his stuff. Moreover, he was a great guy who the students could relate to.

Overall, an excellent course! Well taught, and very applicable! Well done!

HWs covered lecture material very well. Office hours were also very useful. Leok is a cool guy and deserves a raise

The (extra) office hours were really helpful. & the review sessions were very focused, which was very beneficial. E-mail correspondence was amazing. & saved our homework grades.

Sample Student Evaluations

University of Michigan
Math 371 - Numerical Methods for Engineers and Scientists

	Course Median		College Median	
Item	Winter 2005	Fall 2005	Winter 2005	Fall 2005
Overall, this was an excellent course	4.00	4.06	3.93	3.95
Overall, the instructor was an excellent teacher	4.31	4.64	4.16	4.16
I learned a great deal from this course	4.04	4.19	4.00	4.00
I had a strong desire to take this course	3.27	3.43	3.50	3.43

(Maximum score = 5)

Purdue University
MA 266 - Ordinary Differential Equations
MA 562 - Introduction to Differential Geometry and Topology
MA 366 - Ordinary Differential Equations

	MA 266	MA 266	MA 562	MA 366
Item	Spring 2007	Spring 2007	Fall 2007	Spring 2008
Overall, I would rate this course as:	3.9	3.8	4.1	4.1
Overall, I would rate this instructor as:	4.2	3.7	4.6	4.3
My instructor was well-prepared and organized in class	4.7	4.3	4.8	4.6
My instructor gave clear and helpful explanations	4.6	3.9	4.7	3.8
The course increased my mathematical understanding	4.0	4.0	4.7	4.2
The course increased my interest in mathematics	3.4	3.5	4.9	3.9

(Maximum score = 5)

University of California, San Diego
MATH 20D - Introduction to Differential Equations
MATH 170A/B/C - Introduction to Numerical Analysis
MATH 174 - Numerical Methods for Physical Modeling

	MA 20D	MA 170B	MA 170A	MA 170B	MA 174
Item	Winter 2010	Winter 2010	Fall 2010	Winter 2011	Fall 2011
Recommend Class:	88%	88%	76%	100%	83%
Recommend Instructor:	87%	100%	72%	100%	83%
Command of material:	4.60	4.75	4.27	4.88	4.67
Well-prepared for classes:	4.59	4.62	4.35	4.75	4.67
Learned from Course:	4.26	4.25	3.68	4.67	3.67

	MA 170C	MATH 170B	MATH 170C	MATH 170B	MATH 170C
Item	Spring 2012	Winter 2013	Spring 2013	Winter 2013	Spring 2014
Recommend Class:	100%	64%	100%	86%	71%
Recommend Instructor:	100%	73%	100%	100%	86%
Command of material:	4.50	4.40	4.50	4.42	4.28
Well-prepared for classes:	4.50	4.50	4.25	4.85	4.57
Learned from Course:	4.00	3.50	4.50	4.28	3.71

(Maximum score = 5)