My formal teaching experience has spanned more than 15 years, and includes more than 30 instructed courses. Through the use of different pedagogies and attention to student backgrounds and interests, I have been successful in consistently generating enthusiasm for the subjects I have taught. I promote active learning and classroom communication, particularly through the use of polling technology. Integrity and social justice have been important themes in all my student interactions. My teaching has provided me a wealth of tools of self reflection, giving me new insights into my own professional interests, and informing my research. From student questions and comments during class and office hours, and from my supervision of undergraduate and graduate research students, I have found new understanding and increased appreciation of combinatorics, probability theory, and even calculus. My teaching and advising experience has been recognized by an NSF CAREER Award (2013-2018); this is "the National Science Foundation's most prestigious award in support of junior faculty who exemplify the role of teacher-scholars through outstanding research, excellent education and the integration of education and research within the context of the mission of their organizations."

1 Teaching and Advising History

My teaching career began as a TA while I was still an undergraduate. It was clear to me from my first day in front of a class that teaching would always be an important part of my career, and my life. I have consistently received excellent teaching reviews over the years, and I consider my teaching to be one of my greatest strengths and pleasures, as well as a source of inspiration for my research. Since 2007, I have also taken an active role in advising undergraduate research, as well as directing the PhD dissertations of 5 students so far; these experiences have enriched my own research program, and have been enormously satisfying both personally and professionally.

I have received very positive feedback from students in the vast majority of courses I have taught. In my undergraduate teaching, my instructor approval ratings have been almost uniformly higher than 90%; notably, I was given a 100% approval rating for the three times I taught "Foundations of Real Analysis" in the last three years (each time to a class of over 30), and a 97% approval rating for Vector Calculus, a class of over 300 students, considered our hardest lower-division class (with the average instructor approval rating over the last 10 years of 78%). All my undergraduate teaching evaluations are public and can be found at `cape.ucsd.edu`. I have received a 100% approval rating in each of the 10 graduate courses I have taught at UCSD, and received similarly high ratings in every single class I taught at MIT and Cornell University. Some comments I have received on teaching evaluations include "Kemp is a <u>fantastic</u> professor, and had the ability to stimulate my interest in a new and challenging class." "Everything from his methods and style and examples were impeccable." "Kemp was an excellent teacher who inspired the entire class." "This class awakened in me a great interest for mathematics." "Thank you for teaching me probability theory back in 2010! It literally changed my life." (The last came from a UCSD student who changed his major from biology to actuarial science, based in part on his experience in my undergraduate course *Math 180A: Probability Theory* in Fall, 2010.)

1.1 Research Advising

I have served as the thesis supervisor for 5 PhD student: two who have graduated, and three who are my current advisees. I have also been very involved with undergraduate research advising for the past 10 years.

Natasha Blitvic graduated from the MIT electric engineering PhD program in August, 2012. Originally working in applied electrical engineering, she changed her focus to pure mathematics and formally became my student in Fall 2008. Her work is in free probability and related combinatorics. Her first two papers, based on her thesis work, were published in the Journal of Functional Analysis and the Annales de l'Institut

Henri Poincaré; she has three more papers either submitted or in progress (one of which is current joint work with me). She was a postdoctoral fellow at UC Berkeley and a Zorn Fellow at Indiana University; she is now a Lecturer (i.e. tenure-track Assistant Professor) at Lancaster University in the UK.

David Zimmermann graduated from UCSD with a PhD in mathematics in June, 2015. He became my student in Fall 2011. He works in random matrix theory and logarithmic Sobolev inequalities. He has two published papers (his first in the Journal of Functional Analysis) and one preprint joint with me. He is currently a prestigious Dickson Instructor at the University of Chicago.

Ching Wei Ho is my most senior current student; he came to UCSD to work with me beginning in Fall 2013. He works in free probability theory. His first paper was published in the Journal of Functional Analysis, and has 2 more nearly ready for submission. He plans to graduate in Spring, 2018; he could graduate earlier if he wants.

My two younger current PhD student are Alice Chan and Jacqueline Warren. They are in their third and second years, respectively. Both have recently started on directed research projects: Alice is working on a question in analysis on Lie groups, and Jaqueline is working on a problem in q-deformed probability.

Since 2007, I have advised more than 20 undergraduate students in research projects. In the summer of 2007, I was given the opportunity to design and run a *Research Experience for Undergraduates* project at Cornell University. Together with 6 talented students, we tackled problems at the intersection of free probability and algebraic combinatorics. All of those students went on to PhD programs in math or economics. It was so successful that I used it to form the basis for a Collaborative Undergraduate Research Experience (CURE) program I designed as the educational component of my NSF CAREER Award, which has run successfully and employed 4 students each summer since 2014. In addition, I have advised undergraduate honors these projects for three students: Lauren McGough at MIT (who went on to the PhD program in physics at Princeton), Camille Briat at UCSD (who won the Silagi Prize for the best student graduating in all of science, and went on to the PhD program at the Courant Institute with the prestigious MacCracken Fellowship), and my current honors thesis advisee Jessie Tong, who is continuing her research from this past summer's CURE project.

1.2 Instructor Experience

I have taught 16 graduate courses and 17 undergraduate courses from 2002–2016; a complete list with descriptions can be found on my CV, and also at `www.math.ucsd.edu/~tkemp/teaching.html`.

1.2.1 Graduate Courses

While still a graduate student at Cornell, I designed and taught a topics course on *Compact Operators and Schatten L_p-Ideals* to an audience of approximately ten graduate students and faculty. I found the process of course design thought-provoking and exhilarating. As the term progressed, I learned a great deal about setting the pace of lectures and designing helpful homework, and I documented my thoughts on my teaching so I could reflect upon them as the term progressed. Feedback from the students (and faculty) in attendance was extremely helpful. In the end, my reviews for the course were excellent.

As a CLE Moore Instructor at MIT, I had the opportunity to teach three graduate courses: *18.125: Measure and Integration*, *18.175: Probability Theory*, and *18.177: Stochastic Processes*. In 18.125, the audience was a mix of graduate and undergraduate students from math, economics, and engineering – a group that presented some challenges in finding the right level at which to teach. I followed the excellent example of my PhD supervisor, Leonard Gross, and succeeded in conveying the main ideas and philosophy of the subject, leaving many of the details to the textbook (Rudin's *Real and Complex Analysis*). One measure of my success in inspiring the students is the fact that the best graduate student in that class, Natasha Blitvic, later became my graduate student, shifting her research from the applied side of electrical engineering (circuit design) to pure mathematics. She, and many others in the class, continued into 18.175, which was a genuine pleasure to teach (out of Billingsley's excellent graduate text on Probability).

The third course, 18.177, is a topics course usually taught by the senior faculty in probability; I was fortunate to have the chance to use it to develop my understanding of stochastic analysis. The audience was quite varied, including graduate students and faculty from different departments and some members of the financial business community. After covering standard material on Brownian motion and stochastic integration, I continued with aspects of the Malliavin calculus and its applications to PDEs and stochastic processes. I learned an enormous amount from teaching this course; indeed, my paper *Wigner Chaos and the Fourth Moment*, published in the Annals of Probability, began with questions I developed while teaching 18.177.

At UCSD, I have taught 10 graduate courses: three topics courses under the number *Math 247A* (on free probability, and on random matrix theory), *Math 220: Complex Analysis* (the full year, three quarter course, core sequence), *Math 285: Stochastic Processes*, *Math 250A: Differential Geometry*, and *Math 251: Lie Groups* (a two course sequence). All have been illuminating and very enjoyable, and challenging. Teaching complex analysis was a delightful experience, having a full year to design the structure and flow of the course to suit my interests and the students needs. I learned more teaching these courses than I did taking them as a graduate student. The three course sequence in differential geometry and Lie groups was also a great learning experience for me, and through it I wrote polished set of lecture notes (over 300 pages in length, available on my webpage) which I may try to turn into a textbook at some point. For the topics courses, I spent a great deal of time synthesizing those aspects of the literature that could reasonably be covered in introductory courses aimed at students with only the usual core background courses in analysis and probability. These courses were extremely well-attended, with more than 20 graduate students enrolled in each along with three or four faculty members both from analysis, probability and other fields such as number theory, and faculty from engineering departments as well. I prepared detailed and polished lecture notes for each course (both availably on my website). My random matrix theory notes have been used and cited by dozens of researchers in the field. I am currently teaching *Math 241: Functional Analysis* (a two course sequence), and will teach another topics graduate course in Spring 2017.

1.2.2 Undergraduate Courses

My undergraduate teaching has been a mix of calculus and linear algebra, with upper division courses in probability theory and real analysis. My first official instructor position was in Summer 2002, teaching Calculus II to a heterogeneous mix of talented high school students getting advanced placement and junior and senior Cornell undergraduates who were taking the course to fulfill a pro forma requirement of their program. It took time to find a balance between the interests of these groups, but I was ultimately successful in engaging the entire class.

For the first two years following my PhD, I taught theoretical (vector) calculus – *Math 223* and *Math 224* at Cornell, *18.014* and *18.024* at MIT. These were rigorous courses aimed at the most mathematically talented freshmen. I devoted significant effort to preparing lectures, constructing challenging problems for homework sets, and maintaining a careful balance in lectures between fine detail and important concepts in my teaching. Later, in Fall 2009, I taught *18.022* at MIT: another advanced vector calculus class, though not as proof-based as *18.024*. 18.022 was larger (close to 100 students), composed of a wide range of talent levels. This was my first experience teaching a large class; it was a different kind of challenge than I'd dealt with before, and took some adjustment. I attempted to tailor class activities and assignments to varied levels of ability. My very positive reviews speak to how successful I was.

At MIT, I also had the opportunity to teach *18.100: Principles of Mathematical Analysis* twice. This course was designed by Walter Rudin when he was a CLE Moore Instructor; his lecture notes became his famous book of the same title. Of particular interest was the second iteration of the class, which I taught as a communication intensive course: in an extra hour of lecture per week, the students participated in various exercises (written, verbal, and otherwise) to develop their skills at mathematical writing and general scientific communication. This process was very useful for the students, to be sure, but even more so for me. The materials I developed are publicly available on MIT's *CI Space*, available through the MAA Mathematics Digital Library at `math.mit.edu/mathcomm/`.

At UCSD I have taught *Math 180A: Introduction to Probability Theory* twice, *Math 140A: Foundations of Real Analysis* twice with the sequence course *Math 140B* once, and various calculus and linear algebra courses for engineers. These courses presented new challenges to me, largely due to size. The lower division classes now routinely have more than 300 students at UCSD, and the upper division classes (like real analysis) are often close to 100. Teaching courses of this size is a fundamentally different job. I feel that I am as much a manager as an instructor: it is not possible to have much individual interaction with many of the students, and instead I coordinate a team of graduate student TAs and undergraduate graders. One method I have used to get accurate feedback in such large-class settings is through polling technology (see Section 2), which has had some success. There was an adjustment period in my first year, but since then I have performed well in this environment.

1.3 Beyond the Curriculum

I have regularly engaged in extra-curricular teaching activities since I was an undergraduate student. Following are five projects I have been involved with over the past fifteen years.

Math Extension. From 1997–2000, I organized and voluntarily taught *Math Extension*: a program at Western Canada High School (from which I graduated in 1996) to teach undergraduate level Calculus I and II in the early mornings for a group of 12^{th} grade students. I prepared and delivered 3 hours of lecture per week, graded homework, and created final exams which gave participating students credit for the relevant courses at the University of Calgary. Class size was 60–90 each year.

Cornell / Ithaca High School Senior Seminar. In 2002–2003, together with two other Cornell math graduate students, I create a mathematics outreach program at Ithaca High School. The goal was to expose advanced senior students to mathematics that they would not ordinarily see, even in a typical mathematics undergraduate curriculum, and to follow up for the last two months of the year with directed research projects. The program was a great success and continues to run today, taught by Cornell graduate students. Initially voluntary for the instructors, it is now integrated among the normal teaching assignments in the Cornell math department. It often has more than twenty student participants at the high school, and is considered one of the great successes of the Cornell mathematics department's outreach to the community.

Integration Bee. From 2007–2009 I organized and ran the MIT Integration Bee, which entailed writing a challenging qualifying written test (of integrals) and preparing a live computer-generated round-robin tournament of integration. There were more than 100 contestants for the qualifying exam each year, and between 12–20 who qualified for the Bee. There were frequently several hundred spectators (including some who traveled from across the country), and in 2008 the event was televised.

Undergraduate Colloquium. I organized the undergraduate colloquium for math majors at UCSD in Fall 2011. This involved finding speakers (mostly from within the department) to give weekly talks about their current research, made accessible to an audience of junior and senior math majors. I also gave the introductory lecture in the series (on random matrix theory and planar diagrams).

San Diego Honors Math Contest. Since 2011, I have served as the liaison from the UCSD math department to the Greater San Diego school district. I oversee all of the UCSD Mathematics Department's official outreach activities to San Diego County K-12 schools. In that capacity, my most important responsibility is the coordination of the San Diego Honors Math Contest, the state's oldest math competition (running continuously since 1958). Each year, between 120 and 200 high school students write the two-part exam. I chair a committee of UCSD faculty to organize the event; together we create the exam, and supervise its grading. I then organize an awards banquet for all participating students, which includes a famous mathematical guest speaker and awards donated by Texas Instruments and The Art of Problem Solving.

1.4 Curriculum Redesign

When I arrived at UCSD, there was a 6-course sequence taken by nearly all undergraduates on campus (and certainly by all science and engineering majors): *Math 20ABCDEF*, which were (in order) Calculus I and II, Multivariate Calculus, Differential Equations, Vector Calculus, and Linear Algebra. It struck me as odd that linear algebra was at the *end* of the sequence rather than at the beginning; indeed, linear algebra had vector calculus as a prerequisite, not the other way around (which meant time was being wasted in vector calculus on determinants and pieces of linear algebra needed to understand the implicit function theorem, etc.). I inquired and was told the engineering school wanted it this way and we had obliged for the past 20 years.

Once I was promoted to tenure, I collaborated with a Teaching Professor in my department (John Eggers) to suss out the real reason behind the prerequisite structure, which (we confirmed with some research) was out of line with almost all math departments throughout North America. After discussing the matter with associate chairs of several engineering programs, it became clear that whatever historical reason for this design had been long forgotten, and everyone agreed that it would make more sense to move linear algebra to the beginning.

I prepared a 15 page proposal on a thorough redesign of the Math 20 sequence, which would now be Math 20ABCDE, *preceded* by Math 18 (linear algebra) as a prerequisite for all but the single-variable courses. The proposal included research on the curricula at 20 universities considered among UCSD's peers, an analysis of how the changed prerequisite structure would affect *all* majors, programs, and colleges on campus, a pedagogical summary of why the changes were necessary, and support letters I had collected from several engineering departments and the cognitive science department. This proposal was approved by the department council, then dean, and eventually the Undergraduate Council of the university. It went into effect this past fall, and is running smoothly in its first incarnation.

I am currently working on a (smaller scale) project to revamp the curriculum, syllabus, and textbook choice for our upper division linear algebra course *Math 102*; I expect that to be complete and implemented by Fall 2017.

2 Pedagogy and Teaching Goals

In the more than fifteen years I have been teaching, I have learned a great deal about interacting with students both in and out of the classroom. As I teach more, my teaching philosophy has evolved and continues to evolve. For example, here are two points addressing some aspects of pedagogy that have been forefront in my mind lately.

Assessment. Timed examinations are an unavoidable reality of large lecture classes. Many students experience exam anxiety related in large part to time-pressure. To compensate for this, I always schedule evening exams and give the students essentially unlimited time. That is, I design an exam meant to be finished in 50 minutes, but I give the students 4 or 5 hours (and there are always folks still working at the end). This has measurably improved performance, and more importantly, markedly improved student confidence and interest in the subject matter.

Polling Technology. The iClicker is a real-time electronic polling technology that UCSD has accepted as a standard and has been used in many undergraduate courses on campus for the last 5 years. I have used iClickers consistently in lower-division courses, and I am a strong believer in the pedagogical value of this technology. (I was the first mathematics instructor at UCSD to use them.) I begin most lectures with a *Clicker question*: a mutliple choice problem designed to test the students' understanding of a key concept from the course material in the immediately previous lectures. After voting, I show the students the histogram of the responses, then give the students a short time to discuss the problem with neighboring students to decide whether they were correct, and then poll the class again. This well-documented technique (first utilized by Harvard physics professor Eric Mazur in his *Good Questions* project) gives the instructor a quick and accurate snapshot of the students' understanding of the polled concepts; as a form of interactive learning it is also very effective at teaching the concepts to the students, particularly through its peer instructional aspects.

To conclude, here is a summary of important issues I continually addressed in my own teaching style.

Student participation. While there are benefits to traditional lecture-style teaching, I find that most students benefit from some form of active learning. As an instructor, I strive to involve the class as much as possible in class activities and conversation; I frequently and strongly encourage questions from the class. With more focused preparation of thought-provoking problems, I can better foster class discussion. One technique I often use is to begin each lecture with a relatively simple multiple choice question that elucidates a key idea, and poll the class; this both gives me a quick sense of the students' prior knowledge, and (when done well) helps shape their perceptions of the material.

Written communication. I believe one of the most important skills for students to learn, and one that is widely lacking, is the ability to communicate mathematical ideas in their written work. In various courses, I have addressed this problem, pointing out style issues in class, making detailed comments in grading, and handing out documents with suggestions for writing practices.

Lecture detail. I have always favored lectures where the focus is on the ideas behind important theorems and proofs, while laborious detail is left to guided homework exercises or written handouts and textbooks. However, I sometimes find myself giving more detail-based lectures than idea-based lectures (particularly in graduate courses). I strive to find a balance between the two lecture styles which will result in effective instruction while maintaining a reasonable workload (for me and for the students).

Social justice in the classroom. Nearly every class at any level has both students who excel and students who struggle with the material. It is very tempting, as an instructor, to favor the more interested, more advanced students when answering class questions or setting homework and exams. Devoting time and resources to struggling students is an important priority.

Enthusiasm. It is important to teach any subject with passion and interest. This can be a challenge when teaching material one has taught many times before. When I teach calculus, I try to rekindle the sense of wonder the material gave me the first time I saw it. It is always my goal to leave a class excited about mathematics; in turn, I have the opportunity to see the material fresh again through the eyes of the students.