Teaching Statement

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Introduction

I consider teaching an essential part of my growth as a scholar. Being able to communicate abstract ideas effectively to an audience, part of who might not share the same level of enthusiasm for the subject and help them gain an appreciation for it, is a vital part of my role as a mathematician. The 2018-2019 academic year marks my fifth year as an instructor of record for a range of undergraduate Mathematics course at Bowdoin College and at the University of Chicago, during which time I have taught introductory and advanced classes geared towards freshmen, Math and Science majors, and advanced high school students, both with pure and applied/interdisciplinary elements, all with great feedback. Additionally, I have mentored several undergraduate students through independent study sessions, the Directed Reading Program (DRP) and the summer Research Experience for Undergraduates (REU), and trained students for *Mathematical Olympiads* and *Putnam Competition*.

Philosophy and goals

From the first day of class, I try to make lectures as much engaging and interactive as possible, and make sure that the material is fun and challenging to learn while being accessible at the correct level to my students. I frequently ask questions and take enough pauses to ensure that they get a chance to catch up with hard concepts. My students have praised my enthusiasm, positivity, and willingness to help them both in and outside the classroom, and often commented that my colorful mathematical drawings on the blackboard and physical cues helped them understand difficult materials easily. Two of my U. Chicago students wrote the following comments in their evaluation.

> ''he is just fantastic at instilling a love for math. I had no intention of majoring in Math at the start of the year, and these 2 amazing quarters completely changed my mind.''
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> ''[he] goes out of his way to explain things, and even beyond his role as an instructor, he cares about his students.''

Inclusive classroom. I am constantly working hard on developing new teaching techniques in order foster an inclusive classroom and effectively help every student coming from diverse backgrounds, both mathematical and cultural. While actively monitoring the classroom dynamics to make sure no one feels isolated, I try to provide equal attention and helpful honest criticisms to both the capable and the less experienced students. To encourage collaboration among them, I often engage them using *Think-Pair-Share* or *Small Group Work* techniques using handouts. For example, in my Differential Calculus class, I divided the student body into (rotating) small groups as each group is assigned a blackboard to work on particular multistep or difficult problems. A part of assignments each week are marked specifically as teamwork to ensure everyone learns from and with their peers. I have also had interested students work on projects to *mathematically model* real-life scenarios relevant to them. For example, in my Integral Calculus class, I asked them predict the ticket availability over time for the 'summer breeze' concert at the university using ODEs and calculate the probability for getting their preferred seats; allowing various contingencies such as black-market or loss-of-interest over time. In my Multivariable Calculus class students identified effects of climate change by looking at contour plots of icecap levels; and in Linear Algebra class, they did projects on basics of Machine Learning and various Optimization techniques. Some of the students used words like 'quest's and 'adventure's to describe these small projects in their feedback.

Commitment to diversity. It is important to me that students are treated as individuals, multiple perspectives and experiences are valued and promoted, and each of them is encouraged to push through challenges and setbacks in order to achieve their goals. Coming from a middle-class family from rural India, I am aware of the problems faced by students with disadvantaged backgrounds as I strive towards being able to provide guidance as a teacher. In this regard, I am fortunate to posses the unique experience of teaching

a group of academically talented incoming first-year students at UChicago through the *Chicago Academic Achievement Program* (CAAP), many of whom were first-generation college students or from low-income communities. Apart from the regular coursework, I also helped them develop social networking skills and explore ways of utilizing campus resources. Continuing my commitment to outreach at Bowdoin College, I also recently participated in the *Bowdoin Science Experience*, an orientation program designed to develop talented students from groups underrepresented in the science - including students of color, women, and first-generation college students; and I plan to remain an active resource for those students throughout the academic year.

I have found that my students have an enormous amount to teach me and I strive to learn from and to adapt both the style and content of my teaching material to reflect the diversity of my students. This has included mundane but important steps like learning to lecture more effectively to non-native English speakers by incorporating technology in lectures (e.g. beamer slides for presentations) to promote *visual learning*, employing various *digital and computational tools* (e.g. Mathematica) to complement the lectures by designing creative, globally conscious, and practical lab work, spending extra times with students with disabilities, as well create *class notes* and *handouts* that are more heterogeneous in nature. My liberal arts teaching experience at Bowdoin College is of particular import, which allowed me to successfully implement new pedagogical strategies such as a partially *flipped classroom* and use Blackboard (previously, Canvas) to maintain an *online community* where they can grow by helping each other. Besides keeping track of their own performance, many of the shy students find their confident voice in the online forums when they realize that others hold similar opinions or that it is entirely acceptable to have differing viewpoints.

Teaching outside the classroom. I firmly believe that the process of teaching is not confined to the classroom and it is important to keep curious minds busy by engaging them in intellectual discourse in their spare times. E.g. in my Linear Algebra course, I encouraged interested public policy students to write computer programs implementing algorithms like Gauss-Jordan elimination and QR decomposition. In an optimization and linear programming course, I worked with some economics majors on game theory projects about prisoner's dilemma and lowest unique bid auctions.

As a Visiting Assistant Professor at Bowdoin College, I got the opportunity to guide an independent study course with a talented Math Major in Spring semester as he found my research interests aligning with his own future grad school expectations. At the University of Chicago, I mentored eight undergraduate students through the *Directed Reading Program* (DRP) and the summer *Research Experience for Undergraduates* (REU) on a wide array of topics from geometry, linear algebra, topology, dynamics of group action etc. We usually met twice a week for about 10 weeks, where the students would discuss a paper they have read and any original work they have done, followed by me outlining the next possible direction of approach and available useful literature. In both cases, I also helped them learn mathematical writing and coached them for an end-of-quarter presentation or written paper.

I have experience in training high school students for *Indian National Mathematical Olympiad* at both regional and national levels, and have worked with *Math Circles of Chicago* as a volunteer TA and once as a judge for their young math symposium, QED. Currently, I am working with several senior students at Bowdoin College in a Problem-Solving Seminar to train them for the *Putnam Competition*. Several times over the last years, I have also given colloquium style talks in lunch seminars, specialized invited talks in student seminars, and in joint faculty seminars in front of my peers. Through these, I have tried to expose the student community to interesting nonstandard mathematical ideas in an effort to destigmatize math education.

Assessment policies. I have always prioritized rewarding academic growth of a student throughout the course over raw examination scores. Although my syllabi are usually geared mainly towards summative assessments with weekly quizzes, midterms and final exams, I incorporate some aspects of formative assessments with regular feedback on assignments and opportunities to make up grades. The students can make up their grades partially by taking follow-up in-person oral quizzes to show that they correctly identified their mistakes in exams and understood the concept afterwards. I encourage my students to attend scientific seminars and write a small report on them, which they can use to replace their lowest assignment/quiz scores. In one of my intro to proof class, students were required to write a project report on their choice of an interesting Math problem and give a presentation to the class at the end of the course. All of these are clearly communicated to the students at the beginning of the course through a sufficiently

detailed syllabus. I have often been praised for my fair grading policy despite moderately hard exams.

Self improvement. As a way to improve my teaching and my students' experience, I always strive to create a supporting environment where they feel comfortable to approach me with their queries. I conduct anonymous student evaluations every three-to-five weeks and try to continually improve myself based on their suggestion. In a complimentary direction, I have attended several teaching seminars at Bowdoin College and participated in a *Teaching Triangle* program where I got an opportunity to gain new insight into teaching and learn new techniques through reciprocal classroom visits with other departments. Additionally I have participated in teaching workshops (organized by *Chicago Center for Teaching*), and improv classes (led by Heather Barnes from *Second City Training center* in Chicago) in order to learn about handling unexpected questions during lecture and ensure more active participation from my audience.

Conclusion

I have been and always will be very passionate about teaching. While I believe to have presented an excellent track record of success at varying level of subject material and teaching styles, I continue to learn new techniques and improve my skills to this day. I enjoy working with undergraduate students both in classroom and on extracurricular math activities and look forward to any future endeavors to that end.

List of courses taught

1. Bowdoin College

Over the 2018-2019 academic year, I have been fortunate to posses a liberal arts teaching experience at Bowdoin College. As a Visiting Assistant Professor, I was responsible for designing my own course curriculum, planning lectures and handouts, designing and grading exams, holding office hours, and assigning individual and team homeworks. I also coordinated and mentored several graders, teaching assistant and study group leaders. Brief description of each of the courses I have taught are listed below.

1.1. **Math 1600, Differential Calculus.** In the Fall semester of 2018, I taught Math 1600, Differential Calculus. The class, geared mostly towards freshmen and sophomores, consisted of two one-and-a-half hour of class meetings and one-and-a-half hour of lab sessions using Mathematica per week. Building on the traditional outline of the course structure, I decided to also include numerous practical examples and applications of derivatives via relevant topics, questions regarding optimization, and related rates etc. A main focus of the course was not just being able to calculate derivatives using different rules, but also to be able to interpret and describe symbolic equations using words and vice versa. Additionally over the semester, I created a number of lab sessions which helped solidify the abstract ideas by doing numerical estimations through Mathematica, and by implementing various root-finding algorithms e.g. interpolation, and Newton-Raphson method.

A typical class meeting for this course consisted of my lecture, individual thinking by the students using the 'think-pair-share' strategy and occasional small group board work on challenging or multi-part problems. I also kept track of student progress through weekly quizzes and occasional problem set handouts in class. I made practice problem sets before the exams and had individual follow-up discussions with the struggling students. I tried to be available as much as possible outside the class as well, because for a lot of the students, this was the first college Math course and I wanted them to get the correct idea of how to learn Math properly from the very beginning. A set of evaluations for this course will be available soon.

1.2. **Math 1800, Multivariable Calculus.** I have and will be teaching Multivariable calculus at Bowdoin college both semesters on 2018-2019 academic year. This class is geared towards mathematically inclined students who have learned differential and integral calculus, and would like to broaden their horizon. My class in Fall semester, taught three times a week for an hour and a one-and-a-half hour lab session, was unlike the other sections because I had only eight students and so I could incorporate a lot of group discussion style techniques fairly regularly. I could easily keep track of every students' performance and struggles, and could create individualized work for them to catch up with the rest of the class. The set of handouts created for this class is available through my website. A tentative syllabus for my upcoming spring semester is available on my website.

The short class size also allowed me to create a list of very interesting and challenging collaborative projects for the students, e.g. they learned applications of regression techniques in data science, an introduction to the Gradient descent method of optimization techniques used in machine learning, practical modelling of climate change evidences, the Normal probability distribution, and estimating expected values of real-life functions. Next semester, I plan to also include some discovery projects that are more geometric in nature. In the later half of the course, I heavily relied on demonstrations using Mathematica and flowchart summaries in class when talking about Green's theorem, Divergence theorem, and Stokes' theorem. We used *Desmos* and *Mathematica*, both to visualize three dimensional pictures of surfaces, vector fields etc. as well as to get help with particularly laborious calculations for the group works.

1.3. **Independent Study - Undergraduate Mentoring.** In Spring 2019, I will be working with Sam Harder, a Junior at Bowdoin College, guiding an independent study course in Dynamics. Having finished the Analysis course at Bowdoin, he is currently enrolled in intro to dynamics, complex analysis and functional analysis courses at Eötvös University at Budapest. Although the structure of the course is not entirely fleshed out yet, I plan to help him pursue his interests with graduate level topics on Dynamics. In particular, the goal is to have a crash course on geodesic flows and Ergodic theory of Anosov diffeomorphisms, with an aim of learning about the Marked Length Spectrum Rigidity and the Hopf conjecture.

1.4. **Math 2000, Linear Algebra.** I will be teaching Math 2000, Linear Algebra in spring semester of 2019. The students taking this course are not expected to have experience with writing proofs, as such, we will spend a significant amount of time looking at applications drawn from linear systems of equations, discrete dynamical systems, Markov chains, computer graphics, and least-squares approximation.

2. University of Chicago

Besides my liberal arts teaching experience, I was also fortunate to have the opportunity of teaching as a graduate student and after my PhD at the University of Chicago.

2.1. **Proof-Based Methods.** After finishing my PhD in summer 2018, I had the unique experience of teaching an *Introduction to Proof* style class to a group of academically talented incoming first-year students at UChicago through the *Chicago Academic Achievement Program* Summer academy, conducted by the *Center for College Student Success*. This class was designed to expose the students to the academic rigor expected of them as they enroll into introductory Math courses at the college, as well as provide a support framework to help them navigate through the new social and cultural norms.

The classes met for four one-and-a-half hour meetings every week for six weeks. As a class essentially to develop Math reasoning, we covered ideas and problem solving strategies from a broad area of topics such as Number Theory, Combinatorics, Graph Theory, Sequences, and limit Calculus. Besides the final exam, the students also were required to give a presentation in front of their peers which I believe helped them with their Mathematical writing and interaction skills. I tried to keep the atmosphere of the class as casual as possible so that they do not get overloaded with too much expectation. The syllabus for this class as well as the list of sample projects that I provided to the students in class is available in my website.

2.2. **Math 195, Mathematical Methods for Social Science.** In Autumn 2017 and Fall 2018, I taught semester long course titled Mathematical Methods for Social Science. The course consists of topics that are important for students who are planning to become majors in Economics, Political Science, Mathematical Linguistics etc. As such we covered vectors and multivariable calculus up to optimization, but instead of talking about Green's theorem, we covered linear programming next and finally sequences and series with the goal of learning Taylor approximations. Besides the class, I also worked with some of the interested talented students in an independent study session on Game Theory and a project on *Least Unique Bid Auction*.

2.3. **Math 150's, Standard Calculus Sequence.** As a graduate student college instructor, I taught independent section of courses in 2014-2017, usually with 15-30 students each, for an average 3 hours a week. The yearlong rigorous one-variable and multi-variable *standard Calculus* sequence (taught thrice) is designed for science, economics and Math majors. As the instructor of record, I was responsible for designing my own course curriculum, planning lectures, designing and grading exams, holding office hours, and assigning homework. I also mentored teaching assistants, and coordinated junior tutors.

2.4. **Math 196, Linear Algebra.** In summer of 2017, I taught an intensive five week long computational *Linear algebra* course that met for six hours a week. It was offered through the *Graham School of Continuing Liberal and Professional Studies* for computational linear algebra, intended primarily for students in the social sciences who have completed single and multivariable calculus sequence. However, the students weren't expected to have much experience with writing proofs and as such, we spent a lot of time working on examples from many disciplines, in particular ones that relate to their primary fields of interest.

2.5. **Math 133, Elementary Functions and Calculus.** I taught a quarter long course on Vector calculus titled 'Elementary Functions and Calculus' to non-science (mostly History, English, and Theater) majors. Teaching students with very little technical background was an unparalleled learning experience.

2.6. **Other Responsibilities.**

2.6.1. *Undergraduate Mentoring - DRP and REU.* At the University of Chicago, I mentored eight undergraduate students (during 2014-2017) through the *Directed Reading Program* (DRP) and the summer *Research Experience for Undergraduates* (REU) on a wide array of topics from geometry, linear algebra, topology, dynamics of group action etc. We usually met twice a week for about 10 weeks, where the students would

discuss a paper they have read and any original work they have done, followed by me outlining the next possible direction of approach and available useful literature. In both cases, I also helped them learn mathematical writing and coached them for an end-of-quarter presentation or written paper. The list of students and their papers are available via my CV.

2.6.2. *As a Teaching Assistant and Grader.* In 2013-2014 academic year, I worked with professor Eugenia Cheng as a teaching assistant for a year-long *Honors Calculus* sequence, and later worked as a grader for graduate courses on Algebraic Topology, Differential Topology, Differential Geometry, and Riemannian Geometry. Details on these are listed in my CV.