Teaching Experience

NRU Higher School of Economics (HSE), Moscow, Russia

Instructor, creator, organizer, *Graduate course* August 2017 – present

Together with my colleague Christopher Brav, I created a graduate course *Low-dimensional topology and algebraic geometry*. The course consists of lectures given by myself and by the students. As such, besides teaching, one of my roles is to coordinate student talks. This means supporting each student by suggesting topics, supplying references, and assisting them in preparing their talk. More details of the course may be found at https://math.hse.ru/lowdimtop/.

Organizer, *Research seminar* August 2016 – present

Joint with the Steklov Math. Institute, I organize a research seminar Geometric Topology at the HSE. Students may receive course credit by delivering a (research-level) talk, so besides coordinating researchers, one of my roles is to assist students to prepare seminar talks at the research level. More details of the seminar may be found at http://www.mathnet.ru/php/conference.phtml?confid=192.

Project supervisor, *Reading course* August 2016 – present

At the HSE, undergraduate mathematics students are required to complete a project each year under the supervision of a member of faculty. I have supervised a number of such students. Responsibilities include meeting weekly with the student, addressing questions, and assigning exploratory and directional tasks so as to lead to a cohesive report, produced in Latex.

Project supervisor, *Undergraduate research project (REU)* August 2016 – present

During the summer I offer to supervise undergraduate students in a research project. Responsibilities include formulating research tasks which are catered to a student's strengths and interests, meeting regularly with the student, addressing questions, and assigning exploratory and directional tasks so as to lead to a cohesive report, produced in Latex. More details may be found at https://math.hse.ru/en/reu.

Examiner, *Oral assessment* August 2017 – present

At the HSE, undergraduate students are required to submit their homework solutions in-person (that is, they must explain their written solutions and address any questions the instructor has to ensure they have a complete understanding). Responsibilities involve holding office hours and helping students perform these tasks.

Creator, instructor, *Math circle (available online)* March 2017 – present

Together with Alexander Spivak[1], I created a "math circle" for Russian high-school students. Each week I teach the students in English about topology, with topics ranging from the classification of surfaces to knot theory. The lessons are filmed and produced into an online course to be viewed by Russian students all over the world. These are available at https://www.youtube.com/playlist?list=PL1JJ1jVZ9z5DvlJJG8hveWwiD-6OiXq6q.

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Indiana University, Bloomington, Indiana, USA

Mentor, *Directed Reading Program* August 2015 – December 2015

I mentored a senior mathematics major through a reading course in *Low-dimensional musical pitch and chord spaces*, with an emphasis on topological aspects. Responsibilities included meeting approximately two hours weekly with the student, addressing his questions, suggesting new directions and encouraging progress. This culminated in the student giving a Beamer (projector) presentation to an audience. (Slides may be found at http://www.iu.edu/~mathdrp/).

Co-organizer, *Bloomington Math Circle* January 2015 – May 2016

Meeting weekly, I would take school students (aged 8 to 15) through activities designed to enrich mathematics in a fun, student-directed way. Leaders of the lessons alternated.

Instructor, *Preparation for the Mathematics GRE* August 2014 – December 2014

This course is to prepare senior undergraduates for the (U.S. graduate school-preparatory) GRE mathematics exam. I structured the course to be largely problem-based and student-driven. Responsibilities included: designing the syllabus, lecturing, meeting weekly with the class and with students individually.

Instructor, *Finite Mathematics* ($\sim$ 70 students) (Summer/Fall/Spring 2013, 2014)

This course is a "general education" requirement at Indiana University for students who do not pursue Calculus. As such, it is a very popular course and there is a large diversity of mathematical backgrounds among students — who, moreover, perhaps require extra motivation to study mathematics.

Instructor, *Precalculus with Trigonometry* ($\sim$ 30 students) August 2010 – May 2011

This course is designed for students who wish to pursue a degree that requires Calculus, but who do not have the high school background to enter university mathematics at that level.

Use of online approaches to teaching and learning:

Each of the two previously-listed courses used online tools for student assessment. In *Finite Mathematics*, I created homework assessments using the online environment Webwork. The software allows the instructor to select appropriate exercises from the course textbook; each student has a limited number of opportunities to type in an answer to a randomized version of each exercise, and receives instant feedback. This also enables students to receive help in real-time from online tutors (hired graduate students) in the department. The course *Precalculus with trigonometry* used a similar online homework tool called Webassign.

Instructor, *Public Oral Communication for mathematics students* August 2015 – May 2016

This is a course in which students of mathematics learn to communicate publicly on issues related to science, technology and education. Students attended an online lecture once a week and met as a class with me as the primary instructor twice a week. Responsibilities included: designing each class, which involved creating activities to help students learn the material of the lectures and to prepare for speech presentations; grading exams, essays and speech performances.

Use of online approaches to teaching and learning:

As well as watching lectures online (using the online software Echo360), the class made extensive use of the (new) Indiana University learning management system Canvas. In addition to the standard online learning tools (grade management, announcements, quizzes, etc.), I used this software to annotate and grade student-submitted written essays, thus vastly streamlining an otherwise-tedious task. Such tools could easily be implemented to assess written responses in a mathematics exam.

Departmental tutor Summer 2011, Summer 2012

– The Indiana University mathematics department has a student tutoring facility, the Math Learning Center (MLC), directed by Chris Parks. My role in it was to provide on-the-spot tutoring to students enroled in undergraduate mathematics courses of all levels.

Student Feedback

Student evaluations for many of the courses I have taught at Indiana University may be found at `www.ashlightfoot.com/teaching`.

Awards and Honours in Teaching

• Rothrock Teaching Award, Mathematics, Indiana University, 2014

Referees for Teaching

- Dr. Stephen McKinley, Senior Lecturer, Academic Coordinator & Assistant to the Chair of Mathematics (Indiana University)
- Dr. Andrew Dabrowski, Senior Lecturer of Mathematics (Indiana University)
  - Co-organizer of the *Bloomington Math Circle*.
- Dr. Cynthia Smith, Senior Lecturer of Communication and Culture (Indiana University)
  - Course coordinator of *Public Oral Communication*.
- Chris Parks, Director of the Math Learning Center (Indiana University)

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Statement of Teaching Philosophy

While experimental result drives scientific discovery, new mathematics often arises from connecting what we currently know. This makes mathematics instructors particularly privileged because learning is fundamentally about making connections. It is building connections to stimulate learning which guides me in structuring a course and my teaching.

Establishing a course syllabus that follows a logical sequence is the first opportunity to encourage connectivity. A collection of disjoint topics may be appropriate for an advanced graduate course but in an elementary course we should maximize our ability to motivate new concepts. Of course, this is easier to achieve if an instructor has free reign, but in most large undergraduate courses there is a fixed, sequential syllabus that must be adhered to; it is the instructor who must adapt. For example, in the *Finite Mathematics* course at Indiana University, linear algebra is covered after probability. Thus, when I first introduce matrices and matrix multiplication, I ask students to compute some probabilities using Markov chain theory (in a guided way) so they are immediately exposed to a connection between matrices and their earlier course work, as well as to the utility of these new tools.

On the other hand, given the opportunity to have a more flexible syllabus, I have, for example, used knot theory to motivate and introduce students to certain elementary linear algebra. Indeed, the problem of distinguishing knots (circles in 3-dimensional space) is readily grasped by students, and one simple approach to this problem is called knot coloring. This means that arcs of a picture of a knot are colored so that when two arcs

cross, certain conditions are satisfied. Upon increasing the number of colors to work with and the complexity of the knot it becomes natural to introduce modulo arithmetic, matrices and determinants.

The lecture itself is the central place to stimulate student connections. I do so in my teaching by encouraging students to ask themselves "why?" as often as possible. Although there is no quick fix to turning shy students into hand-raisers, I can at least help students internally answer their questions by emphasizing the logic in a calculation. This is achieved by clearly defining each step and pausing often to face the class and review what has happened. In addition, I frequently ask the audience to predict what step might come next. The latter technique is particularly useful at discouraging students from treating a lecture as an exercise in transcription, copying the instructor verbatim without critically assessing the content. Pausing and putting the onus on students may, for instance, remind them that the blackboard work is using mathematics they were fluent with in high school. By encouraging students to be active participants of a lecture, I may even hope to have more students come up to me after class and say, "I found the answer this way instead. Is it right?".

A less direct mechanism to encourage students to ask questions during a lecture is to ensure that this is their primary source of information — if students can rely on a textbook then they are more likely to devalue the importance of understanding during a lecture, convincing themselves that they can always learn the material later. The lectures must therefore be clear and as self-contained as possible. (Anecdotally, I have noticed a distinct difference in attitude towards lectures in this respect between New Zealand, USA and Russian students; the latter are more inclined to request the instructor elaborate a point until it is well-understood.)

The end of each lecture should include some kind of debriefing: time allocated to summarize the new material and connect it to previous lectures. This may be a continuation of the lecture proper, or, more preferably, some form of student engagement so they can form their own connections. For example, at the end of a lecture in *Precalculus with Trigonometry* in which the basic trigonometric functions were introduced, I would have the class take an open-book quiz with a question such as "Sketch the graph of $e^{\cos x}$." This not only requires students to contrast the behavior of two functions they have recently learned about, but it reviews the earlier concept of function composition.

My role with students is as a facilitator of learning, rather than a transmitter of information. As instructor of *Preparation for the Mathematics GRE* I would have students present their solutions on the blackboard, which spurred lively discussion amongst the (relatively small) class. This exposed students to multiple approaches to problems and to new ways of thinking about mathematics they had previously pigeon-holed as belonging to one particular course of their seemingly distant past. The math circles I have taught (in Moscow, Russia, and in Bloomington, USA) have also given me excellent practise at facilitating learning, for these school students begin with a blank slate, as it were, and lack the credulity that years of drilled instruction is apt to produce. Consequently, mathematics must flow in the direction they think logical, which may differ from that of a standard college course. For example, during a lesson when graph theory was introduced, it was remarked that the complete graph on five vertices could not be embedded in the plane. While a college instructor may choose not to explore the point and promptly move on without apparent objection from the audi-

ence, this particular audience insisted we prove the assertion (and, indeed, this inspired the next week's lesson).

Finally, while its beauty and intrigue is more than sufficient to motivate those of us who study mathematics, we should take every opportunity to connect the subject to the world in which our students live. Now, asking a *Calculus* student to maximize the area of a field to be fenced off by a farmer is hardly a legitimate real-world application of optimization (farmers have more pressing matters than calculus when planning their fences). However, finding the maximum current to arise in an electrical circuit *is* a problem a physics or engineering student will encounter in their future studies.

My approach to teaching mathematics can thus be summarized as a perpetual adaptation to help students see the subject as a connected, cohesive whole, and as something of genuine purpose worth studying. I have demonstrated the ability to do so in a variety of environments, and strive to become more flexible as I continue to teach and expose myself to new settings and student needs.