

STATEMENT OF TEACHING PHILOSOPHY – NATHAN McNEW

I have found that students learn mathematics best by doing mathematics: in particular doing mathematics both from a theoretical perspective and as they will encounter the mathematical concepts they are learning in future applications. While the way these perspectives are implemented certainly changes depending on the level of the students, I have found this remains important whether my students are first-year undergraduates taking introductory statistics who think they don't like math, or advanced undergraduates doing original research at an REU program. In any case, it is critical that the students understand why the problem or project that they have been assigned is in fact relevant, and hopefully even interesting!

I've found it highly effective in my courses to teach students ways of using computational techniques and programming when appropriate. The first course I was assigned to teach at Dartmouth was introductory statistics. In prior iterations of the course computational assignments (if any) were done in Excel and the course text made no mention of statistical software packages. I chose (with department approval) to change the textbook to a new open source text that included weekly labs in R and RStudio where students could implement topics discussed in class to process real data. In previous iterations of the course students only experienced these computations by hand in the weekly homework assignments. These written problems are necessarily limited to very small data sets, very unlike the data they will encounter in real world applications which can realistically be tackled only by a computer. Now they get to practice both: performing the calculations by hand to practice the concepts and doing computations to experience the practical application.

These labs turned out to be so successful that I used the idea again in my probability course the following year, again using R, but using instead its vast library of functions to sample distributions and run simulations. Students could thus get a better intuitive feel for how many of the surprising results they were encountering in class played out in practice. R also made for a convenient way to do in-class demonstrations, the source code for which could then be given to the students for further investigation. In an elementary number theory course I am currently having the students do labs (this time in Sage) which focus more on the algorithmic side of the ideas they are learning in class. In this case, with more advanced students we are able to cover more ground and even get to the point where students can implement real world applications of number theory, like RSA encryption.

One of the other aspects I strongly preferred in the new statistics text I chose was its focus on using real data in every example and problem. I have found that students find examples more engaging when they relate to real problems and stories, and a minute or two of class time is well spent telling an interesting backstory to an example if it means that students can better relate to the problem. Even the homework and exam problems I design come, as much as possible, from real examples.

Nearly every homework I assign includes at least one problem, not from the book, that I design to further explore the theoretical side of the mathematics covered that week. Depending on the level of the students, this may mean extending a proof from in class, relating concepts to a different, related area of math, or introducing a new concept we wouldn't otherwise have time to cover in class. These problems tend to be the most difficult part of the assignment, however students regularly comment that they were the most interesting part of the course and lead to many discussions outside of class on related material.

Another technique that I used in my statistics course was that each time I gave an in-class worksheet I would use mail merge to give each student a unique sample of data points from

the same source. This would further mimic the way they would encounter data in real life, and demonstrate the idea of sampling and of a sample distribution, which students often struggle to understand. Different students would obtain different confidence intervals, and a few would naturally fail to capture the true statistic or would obtain a different result on a hypothesis test from the rest of the class. Students were puzzled by this practice at first, but came to like it, especially since they could check their answers with me after class if they liked. (It's easy to create a master key to everyone's worksheet as part of the process.)

Whenever possible I like to incorporate aspects of my research into my teaching, as examples in class or a problem on the homework. For one thing, this gives more advanced students some insight into what it looks like to do “math research” since it isn't nearly so apparent what this looks like as in their science courses, for example. This often leads to students asking me more about my research or what it is like to be a math major during my office hours. In one case I was able to use the trick from a proof I had just read in a paper as a challenge problem in my probability class: “Show that in a series of coin flips the probability that the first head occurs after a prime number of flips is an irrational number.” Several of the more advanced students, bored by examples about the probability that the first head occurs after an even number of flips etc., visibly perked up with this question and it led to a long, interesting discussion with several of them after class.

Another way that I enjoy relating my research to teaching is by encouraging undergraduate research. This is especially important to me, as this was the way that I first became interested in being a math major and then continuing on to graduate school in math. Luckily, my research leads naturally to several problems that lend themselves well to undergraduate research projects. This past summer I was given the opportunity to work with undergraduates at the Williams College REU to generalize to number fields work that I had done on geometric-progression-free sets. Through this experience I had a chance to learn about how to organize such an undergraduate project and how to get undergraduates up to speed quickly on techniques, which while not difficult, are new to them, in sufficient time for them to make progress on a new problem in a summer. In this case the two elements I like to emphasize in teaching, the further applications of the material and the theoretical underpinnings largely coincide, as the main application of the concepts they are learning to use is to do theoretical math. However, I like to point out as much as possible along the way why concepts were developed the way that they were and how they relate to other important open questions in mathematics.

Finally, I am very interested in using math competitions as a way to encourage advanced students to explore mathematics further and practice their skills outside of the classroom. Having previously served as a MathCounts team coach for junior high school students, I sought out ways to serve a similar role in graduate school and have become the adviser to the school's undergraduate Putnam team. I very much enjoy finding interesting problems for the students to explore in practice sessions and showing them problem solving techniques that they are unlikely to encounter in a traditional classroom setting.

I always work to adjust my techniques and lessons based on the students' feedback during office hours or on midterm evaluations. Students frequently comment about the labs in the course reviews as one of their favorite elements of the class: “Prof McNew is very clear in lectures, labs and examples gave us the opportunities to make the course relevant to each of us.” Another says of the course “Problems are very interesting and the best feature is probably that the instructor is very friendly and approachable.”