

TEACHING STATEMENT

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If there is a golden rule of teaching, it is to make the material interesting to the students: it becomes easier for them to meet the course objectives and the semester runs smoothly. But this can be an uphill battle, especially in math courses, as many students come into our classrooms with a preconception of math as a rarified skill set foisted upon them in order to make them ostensibly more successful in their actual degree. Teaching math as an intellectual supplement only reinforces this bias, so one must make some effort in the classroom to disabuse students of this notion.

One of the ways I do this is by presenting math not as a subject entombed in textbooks, but as a living subject with tantalizing open problems and breakthroughs like any other discipline. It is especially important to work this ethos into introductory-level courses, as the students who enroll in these courses are typically operating under a high-school impression of mathematics as the lifeless pursuit of calculating to get the all-important “right answer”. It is relatively easy to accomplish this in appreciation courses due to their free form, but more challenging in a calculus course with stricter learning objectives. Indeed, one cannot avoid a bit of formulaic calculation while solving a calculus problem, so in these situations it is useful to communicate to the students what the beautiful mathematical nugget of the problem is and what is rote. This gives students some insight into what math is actually about and whether they too find it fascinating. Presenting math in this light becomes easier to accomplish in intermediate and advanced courses as the students begin to engage more in what mathematicians actually do. For instance, a few years ago in a discrete math course that I assisted, the students had enough background to be able to understand the statement of an infamous open problem known as the Hadwiger–Nelson problem and we covered a rough sketch of a breakthrough on the problem made less than a week prior by an amateur mathematician!

Stories like this make math much more accessible, and indeed I find storytelling to be a compelling way to deliver mathematics in lectures. Telling students the story of how mathematicians arrived at a definition or concept covered in class, e.g., limits, helps them realize that these ideas are not handed down from on high and stamped into textbooks, but arrived at after centuries of wild-goose chases and head-scratching. For example, I’ve found that beginning with the contributions of gamblers like Cardano makes for a more lively and historically accurate motivation for basic probability than listing Kolmogorov’s axioms, even though the latter is more mathematically convenient.

Like any other living subject, the math curriculum must also adapt to the times. The scope of automation broadens with each passing year, leaving in its wake an increased demand for creative mathematical skills such as theory-building and problem-solving. Intermediate and advanced students have run the calculus gauntlet, thereby demonstrating a proficiency in manual calculation, so for these students I use the classroom to focus intensely on developing their ability to prove theorems and solve problems, setting aside the more familiar algorithmic and calculation-based material for labs and take-home exercises. For the latter I encourage the use of high-level programming languages, as I am a firm believer that programming literacy should be part of any math education. I have found this division of course material to be successful in advanced computer science courses that I have taught recently. In particular, students benefit from having an ample number of worked examples of a particular algorithm or calculation in video format, as it allows them to pause the process and work at their own pace to understand each step. After seeing enough worked examples, most students are able to carry out the steps of the algorithm or calculation on their own. On the other hand, the more theoretical and abstract elements of the course usually cannot be taught by simply seeing more examples. Here, the questions and confusions that students have are often quite

unique, making it necessary to start a dialogue in lecture or office hours. The emphasis on proofs and problem-solving in the classroom also concentrates on the skills that potential employers are now looking for in their employees, recognizing that the technical skills learned in, say, a tech degree, can be obtained more easily on the job than the intangible theory-building and problem-solving skills that one hones in a math degree.

The foregoing gives some idea of the methods I use to get students excited about mathematics in order to help them succeed in the course and beyond, but there are also concrete and perhaps more procedural ways to help students meet course objectives. I conclude by describing some of my expectations of math students at varying levels and the actions I take to help students achieve them.

For math-appreciation students I expect them to finish the semester knowing what a mathematical statement is and what is not. Through propositional logic, they are also expected to have some idea of what a proof of a mathematical statement entails, along with some first-hand experience of the difficulty of showing that a proposition is true. This leaves them with an appreciation for mathematical truth. Many of these students are looking forward to putting math behind them, so I consider it a success if they finish the semester thinking that math is cooler than they thought.

For science majors in the calculus sequence there is less freedom as to what material gets covered, as this is carefully orchestrated by the calculus coordinator(s). In my experience leading calculus recitations, the primary goal is to get the students to digest the prepared material and not fall behind. To this end, I typically spend the first ten minutes of the lecture or recitation reviewing what we learned last time and then I show how today's lesson builds off what we learned last time. Many of these students are also fresh out of high school and unable to keep up with a fifty-minute lecture format, so periodically breaking them up into groups to work on problems that we then discuss as a class helps keep them engaged. A regrettably cliché mistake that I have made with students at this level was to assume a working knowledge of the prerequisites that they don't have. I have since learned from this and achieved some success fixing these sorts of issues in my online courses by assigning ungraded, open-book, take-home proficiency exams that students must complete in order to access the course materials. Student backgrounds vary dramatically, especially in online courses, so this early feedback also gives me an idea of what the strengths and weaknesses of the class are as a whole and which individuals might need more attention. Getting feedback throughout the semester is important, so I give weekly quizzes to monitor whether the students are absorbing the material, and I format the exams to be like the quizzes so that students feel more comfortable taking exams.

Aside from obtaining some general understanding of the major areas of mathematics, my goal for advanced math students is to equip them with the skills needed to do math in the wild. Too often are students asked to prove statements that are already known to be true, and in practice this is almost never the case. In my experience both assisting and taking advanced math courses, I find the "prove or disprove" exercises to be an effective way to address this. Such exercises require students to explore and play around with mathematical objects rather than rush into the problem already knowing the verdict. Along these lines, the problem sets that I find the most rewarding are those designed as a sequence of exercises that lead students to state a conjecture and then prove it. Indeed, finding the correct statement to prove can be as challenging as its proof, and this more accurately models the scientific process of mathematicians. Finding the correct statement to prove can also involve formulating the "right" definition for some object or property. For developing such theory-building intuition, it's a useful exercise to have students start from several concrete examples and then discover for themselves the abstract mathematical properties that unite the examples. This allows students to independently arrive at definitions for mathematical objects which prepares them for making their own mathematical discoveries in the future.