I have always loved the "Ah-Ha" moment when something comes together for one of my students. It hooked me when I tutored in high school. Now, after three years as a full time visiting assistant professor at Swarthmore College, I have learned how much work and care is required to lay the foundation that facilitates the "Ah-Ha". I have learned to love this foundation-laying part of teaching. I have invested a lot of thought and effort into my technique; I'd like to tell you a little about it.

For each new idea, I try to help my students understand four things: what it is, why we know it is true, how we use it, and where it fits into the big picture. First, I'll briefly discuss some ways I try to achieve these four things for one particular topic. Then I'll discuss some broader topics at the level of an entire course.

1 What it is

Understanding a mathematical definition is tough for most students. For example, take the Riemann sum definition of the definite integral $\int_a^b f \, dx := \lim_{n\to\infty} \sum_{i=1}^{n} f(c_i^*)\Delta x$. It can look like an imposing jumble of symbols. I am often tempted to gloss over it. However, I have come to believe that students who don't really grasp such a definition are less likely to recognize and apply that idea later in other contexts. Thus, they don't fully benefit from their education. I saw this disconnect in my work with advanced undergraduates, graduate students, and engineers in established careers.

I have developed a technique to help. We develop a slogan, like "Cut into rectangles, add areas, shrink". I draw arrows with colored chalk to connect a part of the slogan to the symbols in the definition that "encode" it. We start each lecture by quickly rewriting the annotated definition and its slogan on the board. The repeated exposure to this same item tells my students that the definition is important, shows them that it is natural, and gives them many chances to really learn it.

2 Why we know it is true

I once believed, given limited time and attention from students, I should skip proofs and derivations in lieu of the other three "things to understand." However, my students have taught me that I was wrong. Many of them ask for proofs, even in lower level courses. They want to know why things work, not just how to use them. Naturally, this appetite varies between students, over time, and across topics; I try to constantly gauge and adjust. But I have now learned to view my math course in the context of the larger educational mission to produce skilled and knowledgeable thinkers. When students learn to reason in a new way about a mathematical idea or proof, they become better thinkers overall.

I am proud that my students actively engage with the proofs, even in lower courses. I take care to explain the motivation for each step in simple language and they respond with enthusiasm that they can actually "do a proof." In my linear algebra class, I assign at least one proof per weekly homework set and exam. These are not hard, but they provide practice thinking systematically and symbolically.

3 How we use it

With definitions and theorems in hand, we can use the new idea to solve problems. I pick a sequence of examples, progressing from simple to complex. For the simple ones, I try to get the class to do all the work, ideally acting only as the "chalk operator." For the final 1-2 examples, I try to choose real world problems that show the payoff from all the prior effort. This may be error correcting codes in Linear Algebra, heat flow on a disk in Multivariable Calculus, encoding music into your computer with Fourier series in Differential Equations, etc. The most popular such topic was Markov Chain Monte Carlo methods for decoding a prisoner's encrypted letter, drawn from Persi Diaconis's paper here. I cover this on the last day of Linear Algebra.

When I team taught Discrete Math, we dedicated the last 45 minutes of each week to group work on such problems. In order to build writing skills and ensure equal engagement, we asked each student to submit individual expositions of their group's method. These were more like essays than "math homework," with discussions of the overall strategy and of how each step fit into it.

4 Where it fits into the big picture

I want my courses to be cohesive.

When I plan a course, I try to find a set of stories that tie everything together. Here's one - the story of Linear Algebra as told by a lilac bush growing in my backyard (credit to Otto Bretscher for this example). Thinking in discrete time steps, a "new" branch is born, then becomes "mature", then spawns k new branches every step after. It's a simple, 2 state system. Students can easily draw it and understand how it works. They also quickly see that it gets quite complicated if you do the naive thing. But, if we define matrix multiplication in the right way (though it may look strange at first), you see that it's easy to get the lilac bush's future n steps later - just multiply by $A = \begin{bmatrix} 0 & k \\ 1 & 1 \end{bmatrix}$ n times. So, let's ask the computer to do that. Plot the result. You see that the lilac bush's looks "the same" no matter what its state is today (almost). That's an eigenvector. So, much of our course revolve around the hunt for eigenvectors. It'll take a while to get there and we'll need to develop ideas like determinants, kernels, bases, coordinates, etc. But, we'll frequently return to the lilac bush story in lecture, homework, and exams so that we remember where each new piece fits.

I put a lot of effort into making my courses cohesive because I usually didn't see the big picture when I was student. I saw lectures and homework as a patchwork of individual calculations. As long as I could perform the "mechanics" on the exam, I would get an A. I finished with high grades, but didn't understand what it really meant. In the long run, that hurt me. I want my students to walk out of my course with a cohesive view of the big picture.

5 Course level topics

I want my courses to be collaborative.

My classes are very interactive. Though I do primarily use traditional blackboard lectures (more below), my students talk. A lot. I know every student's name. At least half of them say something every week. To try to encourage the rest to collaborate, I have begun to integrate clickers into the classroom. (I am the first to use them at Swarthmore).

Here are some things I say on day 1 of a course to establish this collaborative atmosphere.

"Learning math is hard. You declared that you want this challenge when you signed up for this class. I want to help you meet that challenge. It is all of us against the material; we are working toward the same goal. The more you talk during class, visit me in office hours, and send me emails, the better I can help."

"Find a group to work with. It'll make everything better. But always cite them on your homework. If you struggle to find a group, come to office hours and help clinic. There is usually a group there to join."

"I'll write a lot of stuff on the board. My goal is for your notes to be really complete and helpful when you study them later. (Students often specifically cite this in course evaluations). But it means that I am probably going to make mistakes during lecture. You can help me and everyone else in class by spotting them so we can all get it correct."

Office hours are my single favorite part of the job. They are my chance to help and get to know my students personally; they are well attended. One of my proudest moments as a professor came when over 40 students attended day 1 of Real Analysis (M63) (this is huge by historical comparison). I asked my grader if I have a reputation for being easy. He laughed and said, "NO! But you are known for being accessible."

Real Analysis had 3 weekly "problem sessions" where students presented their own work on exercises. I was proud to see the collaborative spirit that developed among these students. It was a very rewarding experience.

6 Innovation and Technology

The more I teach, the more I learn.

I find these stories, slogans, applications, etc. as I teach the course for the first time. That is one reason why I have intentionally asked to teach as many distinct courses as possible. I now feel prepared to teach a wide array of courses, including all of the low and mid level math courses and introductory statistics.

I also learn a lot from my colleagues. I am grateful for all the ideas, both big and small, that my colleagues at Swarthmore have given me over the last few years. I am looking for a collaborative department with colleagues that will help me continue to improve.

I'd like to highlight some other innovations from the last few years.

1. **Clickers** - I began using clickers in my classroom in Fall 2013. I believe they give less talkative students a nonthreatening way to engage with lecture. The clickers also ensure that students genuinely "take a stand" on questions in class. This improves their chance to identify and correct misconceptions before it hurts them. Clickers also help me better use time where it will help the most.
2. **LaTeX online** - I require all major level courses to use LaTeX and encourage middle level courses to do so. To lower the setup barrier, I encourage students to use one of the online LaTeX sites. Students start TeX-ing immediately. They have access to their document from any machine and can collaborate. It has been very successful. For example, I told Multivariable Calculus they could have a formula sheet for exam 2. But they had to make it themselves (collaboratively) using an online LaTeX document (that I "controlled"). They made a beautiful two page document. Two students said, "I was scared of LaTeX before, but now I like it."
3. **WeBWorK** - I use a combination of WeBWorK and written problems in lower and mid level math courses. I love that students get immediate feedback and the chance to fix their mistakes. It is great for computational problems and allows me to focus written problems on more conceptual/visual/expository exercises.
4. **Posting student solutions** - I post exemplary student solutions (anonymized) as models for other student to learn from. I believe this gives that student extra encouragement and sets a bar of excellence for others to aim for.
5. **Introductory Statistics** - I have been fortunate to teach parallel sections of the Introductory Statistics course (S11) alongside Prof. Kelly McConville this semester. With her leadership, we implemented several changes: we adopted the Lock5 textbook, helped our students learn and use R for nearly all coursework, and, on election day, sent 100 students to conduct exit polls about the voter experience. I believe these changes greatly enhanced the course and gave our students the experience of actually doing statistics.
6. **Stochastic Modeling** - A new "topics" course in Spring 2015. This course builds on the computer simulation aspect of my research. It is designed to help students to learn to turn computers and randomness into allies for doing math and for modeling real world systems. We will use Python with NumPy and SciPy.
7. **Research with students** - I plan to do research with students. My research draws from several areas of mathematics and physics and involves computer based simulations. So, it appeals to a broad range of students. As an undergraduate, I was fortunate to do 3 REU's; I greatly matured during these summers. I learned some amazing science. I also learned how science works - that it takes patience and tenacity in the face of frustration and confusion. These lessons helped me succeed; I want to share them with my students.
8. **Flipped classroom** - I love lecturing. But I am not convinced that it is best for my students. From the experiments of colleagues, there seems to be some resistance among students to the idea, so I have not yet moved in this direction. But I could see doing so in the future.
9. **Other tech** - Here is a partial list of other software that I regularly use in the classroom that I haven't mentioned yet: Moodle, Mathematica, Geogebra, R, Sage (esp. sage.cloudmath.com), Dfield/Pplane.

7 Conclusion

I love teaching. I love my students. They choose to trust me to help them learn. They put enormous time, effort, and money into my courses. I will do everything in my power to help them find that "Ah-ha" moment. And I am always looking for ways to improve.

If this is the sort of colleague you are searching for, I will be available at the Joint Meetings in San Antonio or through phone, Skype, etc. I look forward to talking with you. Thank you for your consideration.