Teaching Statement

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Perhaps the most noteworthy aspect of my approach to teaching is that, during the past two years, both my philosophy and methodology have undergone a significant shift along the spectrum between instructor-centered and student-centered models. As a first-year Teaching Postdoc at the University of Arizona, my classroom was a very traditional one: I delivered a carefully-crafted lecture from the front of the room while students dutifully took notes, then tackled problems outside of the classroom. Today, my classroom is quite different. My role is one of a motivator, moderator, guide, and skeptic. My students spend class time active in problem solving and discussion. They are encouraged to question their own understanding and learn to validate their own solutions.

In this statement, I will explain my perspective on the teaching and learning of mathematics by discussing my experience, philosophy, methodology, and ideas for the future. Each of these aspects will be illustrated with examples from my own classroom.

History & Experience

As a graduate student at the University of Texas at Arlington, I began teaching mathematics courses as the instructor of record in Spring 2004. The following is a comprehensive list of courses I have taught since that time. Italics denote courses I have taught more than once.

University of Texas at Arlington	**University of Arizona**
Math for Liberal Arts	*Intro to Statistics*
Trigonometry	Calculus I, *II*, III
College Algebra	*Intro to Linear Algebra*
Business Math	*Math Analysis for Engineers*
Calculus I	Matrix Analysis

While teaching Math for Liberal Arts at UT Arlington, I also had the privilege of serving on the course development team. My duties included **strengthening and field testing course materials**, and providing feedback to the course coordinator. Moreover, I am currently serving on a committee at the University of Arizona whose goal is to **integrate a MATLAB component** into my department's Intro to Linear Algebra course.

In addition to maintaining a 3-3 course load as a teaching postdoc, I also like to **direct reading courses** on subjects which are not typically covered in the undergraduate curriculum. Not only do these courses provide students with a more comprehensive education, but they often give rise to interesting research projects. Such has been the case in my experience — **I am currently supervising a research project** with a computer science major which grew out of a topics course in category theory. The goal of this project is to formulate a diagrammatic proof-without-words of the Yoneda Lemma (an extension of Cayley's Theorem to category theory) and to consider its application to propositional logic. I also recently directed a **WAESO-funded summer research project** with three math majors which investigated the notion of homological algebra, as motivated by a desire to represent arbitrary modules in terms of free modules.

Philosophy & Methodology

My philosophy regarding the teaching and learning of mathematics is centered around the idea that in order to learn (mathematics), one must do (mathematics). This particular idea was the catalyst which inspired me to adopt an **inquiry-based flipped classroom model**, wherein initial knowledge acquisition takes place *out of* the classroom, and problem solving and discussion take place *in* the classroom. In this way, class time is active and students are deeply engaged in the material. What I enjoy most about this student-centered approach is that it promotes an optimal environment for learning: one in which **students are encouraged to discuss, conjecture, gain insight from mistakes and misconceptions, and validate their own reasoning**. Additionally, I feel that this method increases not only the valuable interaction time between students, but also the time that I spend assessing understanding and detecting misconceptions. Under a more traditional teaching model, many of these misconceptions would go unnoticed until the first formal assessment, which is often too late. Moreover, I believe that the flipped classroom approach helps to foster improved mathematical communication skills.

In my experience, most mathematics teachers adhere to the same core philosophy: we want our students to develop deep problem-solving skills while simultaneously mastering the mathematical concepts required by the course. I believe that what often distinguishes one teacher from another is methodology.

Class format. A flipped classroom model demands a certain level of consistency on the part of the instructor, especially during the first few weeks of the course, when roles and expectations are being established and enforced. In order to provide this needed consistency, my current classes adhere to the following format on a daily basis.

- Before each class, students are expected to complete a **warmup activity**[1]. This assignment gives an overview of the day's topic, provides a list of basic and advanced learning objectives, lists various references (e.g. assigned reading or videos), and gives two or three very basic practice problems which students are expected to work on before coming to class.
- I begin each class with a quick **baseline assessment** of the students' mastery of the most basic learning objectives. For example, when beginning a unit on descriptive statistics, I might ask students to give the five-number summary of a small list of data or compute its standard deviation.
- Either I or my (undergrad) preceptor/TA will guide a **class discussion** on the day's topic. During this time, students recall major definitions or points of confusion from the warmup activity. Based on the results of the previous assessment, I might also give a **mini-lecture** which motivates concepts or clarifies misconceptions.
- In groups of three or four, **students work on an activity** related to the daily topic. In a statistics course, I like to plan activities around student-generated data as often as possible. For example, when beginning a unit on inference, I might ask students to compute confidence intervals for a parameter like average height of all students using various sample sizes and confidence levels. These results would then be collected and displayed graphically to the entire class.
- In the last five minutes of class, **students come back together for a wrap-up** of the day's activity. During this time, I ask students to share what they have learned and/or ask questions that may still be lingering. This is also a time when I like to motivate or preview concepts that will be covered in the near future.

In a recent five-week summer course (Matrix Analysis), I also dedicated a portion of in-class time to **student presentations**, which turned out to be very fruitful. For example, one student's presentation of a homework problem spurred a class discussion culminating in a conjecture which (unbeknownst to the class at the time) was essentially the statement of the Rank-Nullity Theorem.

Resources. There are many tools which have become instrumental in my teaching. Aside from my typical wish-list when requesting courses each semester (a technology-equipped classroom with plenty of board space and tables rather than desks, etc.), I rely on several (primarily technological) tools both inside the classroom and out.

- I like to work with (undergraduate) **preceptors and/or TAs** whenever possible. These students not only hold regular office hours and organize review sessions, but they also field questions or guide in-class discussions and demonstrations. In addition to having extensive experience as a mentor to undergraduate preceptors and TAs, I have also co-organized my department's **Undergraduate Teaching Assistant Program**, and I started and currently run a **program for linear algebra preceptors**.
- Much of my in-class assessment is facilitated with a **web-based student response system** called Learning Catalytics [3]. I find this tool to be indispensable not only for on-the-fly assessment during class, but also for prompting discussion or quickly gathering student data (e.g. in a statistics course).
- I frequently utilize **videos by MIT OpenCourseWare** or Khan Academy as supplemental resources for students' out-of-class preparation. To mitigate potential issues stemming from any inaccuracy in the videos, I encourage students to point out (during the class discussion) any flaws they notice. One student recently mentioned that Sal Khan referred to $\mathbf{b}$ as the *solution* to $A\mathbf{x} = \mathbf{b}$, thereby starting a very productive discussion which cleared up several misconceptions.
- For each of my classes, I set up an **online discussion forum** through my university's learning management system (D2L). This forum is designed to be a place for students to ask and answer questions about course material. Aside from the obvious benefit to the students, this tool also helps to keep my email inbox at a manageable size. In order to ensure that the exchange of ideas in the discussion forum is ethical, my preceptor or TA monitors the activity and provides me with feedback.

Assessment. There are two major objectives of any mode of assessment: to **evaluate understanding**, and to provide students with **meaningful feedback**. In order for assessment to be constructive for the purpose of student learning, its feedback must be provided in a very timely manner. By using Learning Catalytics as a daily 'check-up' for understanding, I provide my students with **instant feedback**, thus eliminating many

[1]Adapted from the 'Guided Practice' activities developed by Robert Talbert (Grand Valley State University).

misconceptions early on [6]. This program also offers a sort of **think-pair-share** capability, allowing students to work on problems individually, then pair with other students to tackle the same problems together. As an instructor, I have the ability to see how this collaboration is affecting the students' understanding. Before using Learning Catalytics, my method for delivering frequent feedback was in the form of short daily quizzes. Though these quizzes measured the same thing, they possessed two inherent flaws: (1) both the grading and in-class facilitation were more time-consuming, and (2) the feedback, though quick, was never immediate.

When using assessment for the purpose of evaluation (i.e. grades), there are typically three questions that I want to answer: Does the student have sufficient **procedural knowledge**? (*Find* ∇f *at* P*.*) Can the student make **connections between concepts**? (*How can the contour diagram of* f *be used to approximate* ∇f *at* P*?*) Can the student **effectively communicate mathematics**, both orally and in writing? (*Explain the notion of a gradient to someone with only a knowledge of first-semester calculus.*) I believe that in most cases, the first two questions can be effectively answered with well-designed homework and exams. The third question, however, is a bit harder to answer in this fashion. My attempts to work around this issue come in two flavors: **short essays** and **oral exams**. For example, I once assigned the reading of the novella *Flatland* [1] to my Vector Calculus class, and then asked the students to (1) carefully explain the Sphere's visit to Flatland in terms of mathematics, and (2) write a similar narrative, using mathematics, explaining our perception of a four-dimensional object 'passing through' our universe.

Ideas for the Future

One of my favorite aspects of academia is its very dynamic nature. As the student body evolves, so must the classroom. I embrace this constant need for change and accept it as a challenge. In order to keep up with the trends that occur outside of my department and university, I shamelessly follow a few **education-themed blogs**, my favorites of which are *Math Ed Matters* [2], *Casting Out Nines* [4], and *The IBL Blog* [5]. I also keep up with peer-reviewed literature as part of a current reading group on the **scholarship of teaching and learning** run by my department's Mathematics Instruction Colloquium, which I co-organize. Furthermore, I acquired a laundry-list of ideas during my participation in a recent **workshop on inquiry-based learning**, organized by Stan Yoshinobu (Cal Poly, San Luis Obispo), et al.

To keep track of these ideas (along with the effectiveness of my techniques and of my thoughts during the semester), **I maintain a very thorough teaching journal** which I use as a tool and guideline when prepping for each new semester. The following is a list of long-term goals that I would like to tackle within the next few years.

- I'm very interested in **project-based learning**. To this end, I would like to develop (1) a **sequence of MATLAB projects** to accompany a Vector Calculus course, and (2) a **sequence of Excel projects**, using a single data set, to accompany an Intro to Statistics course.
- I plan to apply for a **small grant through the Academy of Inquiry-Based Learning** for the purpose of developing course materials (notes, problems, etc.) for an Intro to Linear Algebra course taught with inquiry-based methods.
- I would like to gradually **develop videos or webcasts** for use with my flipped classroom model.

References

[1] E. A. Abbott, *Flatland: A romance of many dimensions*, Seeley & Co. United Kingdom, 1884.

[2] D. Ernst and A. Hodge, Math Ed Matters, a weblog hosted by The Mathematical Association of America. Available at: `http://maamathedmatters.blogspot.com`.

[3] J. New, *Pearson acquires Learning Catalytics, a cloud-based assessment system*, Wired Campus, a weblog hosted by the Chronicle of Higher Education, April 2013. Available at: `http://chronicle.com/blogs/wiredcampus/pearson-acquires-learning-catalytics-a-cloud-based-assessment-system`.

[4] R. Talbert, Casting Out Nines, a weblog hosted by The Chronicle of Higher Education. Available at: `http://chronicle.com/blognetwork/castingoutnines`.

[5] S. Yoshinobu, The IBL Blog, a weblog hosted by The Academy of Inquiry Based Learning. Available at: `http://theiblblog.blogspot.com`.

[6] S. A. Yourstone, H. S. Kraye, and G. Albaum, *Classroom questioning with immediate electronic response: Do clickers improve learning?* Decision Sciences Journal of Innovative Education **6** (2008), no. 1.