TEACHING PHILOSOPHY STATEMENT

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Much of my teaching philosophy has grown out of my experiences as an undergraduate at Rose-Hulman Institute of Technology. Rose-Hulman is an extremely small [1] science and engineering school in rural Indiana which focuses on Bachelors level education. Because of the resulting small [2] and relatively homogeneous (in terms of major) classes the professors were able to tailor their instruction to each individual class and continually challenge the entire class to understand and appreciate the material on a higher level. My teaching philosophy centers around replicating this experience by challenging my students to engage with the material on a higher level than rote memorization of formulae and algorithms. However, since the majority of classes are not as homogeneous or as small as the classes at Rose-Hulman, there are some obstacles to applying this philosophy. Broadly, I think of these challenges as lying in three categories; student engagement, scaffolding, and assessment.

As is the case with many instructors, when attempting to engage the students in the material I use a carrot and stick method. The stick is assessing on a deeper level than formula recall and memorization, while the carrot is a more subtle and spread throughout the course. Unfortunately, before enticing student's intellectual curiosity about mathematics, I often have to break mathematics out of the box of mindless formula application that many students have put it in. I start this process on the first day of class, when I challenge the students to tell me why they are taking this course and what they expect to get out of it. After the expected answers of a "good grade" and "because it is required," I push them to think harder about why it is required, especially in light of the fact that computers can do most of the computations faster and more accurately than any of them. Through the course of this discussion, my goal is to lead them to the realization that mathematics is way of thinking logically about the world and that this viewpoint is what they should be trying to learn. Then the computational aspects of the class will flow naturally from this greater understanding. Throughout the semester I reinforce this idea by having a running dialogue about why certain problems were considered, how they relate to previous methods, and what are their limitations. For example, while teaching *Calculus III*, I repeatedly challenged to students to predict methods and formulae for multi-variable calculus via analogy with the single-variable case. This process emphasized to them that there are no essential differences between the two, just difference in detail. I have found that, in contrast to a running theme, sometimes a one-off "optional" lecture is more effective in raising students' engagement. In light of this, I have at various times lectured on the importance of number theory for e-commerce or on the existence continuous nowhere differentiable functions as a means of exciting students intellectual curiosity and spurring engagement in the course.

Although I have some success in guiding the students to a deeper understanding of mathematics through classroom discussions, I think I have been most effective in achieving this goal through out of class activities. For example, when I most recently taught *Linear and Discrete Mathematics*,[3] I required the students to complete several writing assignments designed to force them to think deeper about the material and how it applied to the major. Additionally, these assignments gave them a much needed opportunity to practice communicating technical material in a clear manner to a non-technical audience. Although initially the quality of the writing assignments were somewhat lacking, over the course of the semester they improved substantially. More importantly, several students communicated to me that the writing assignments helped them understand the material better and that through them they had gained a greater appreciation for the material. In fact, several of the final written group projects[4] showed a grasp of the material that surpassed my initial expectations.

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[1] At the time I attended Rose it was approximately 1600 students, it has since grown to approximately 1900 students.

[2] The average size for classes I was in was the low teens.

[3] This is a sophomore-level course for industrial and computer engineers covering a variety of combinatorial and optimization topics.

[4] They were to choose a real world problem which was amenable to the tools learned in the course and create a "pitch document" to convince a non-technical audience that they had the ability to create an appropriate solution.

Asking the students to develop a deeper understanding of the material creates a delicate balance when attempting to assess students' learning. On one hand, challenging the students in the classroom creates an implied level of competence in order to succeed on the major assessments, such as exams. However, if the entire exam is requires too deep of an understanding of the material, then it does not serve as an accurate assessment of the students' learning and it disengages the students from the class. One way to handle this is to carefully create out of class assessments, such as the writing assignments discussed above, which allow the students to showcase their understanding in a low pressure environment. However, such assessments do not mitigate the need to design exams which assesses both deep understanding and computational competence. In order to manage students' expectations for exams, I explicitly tell students that the exams are going to be spit roughly half and half between computational questions and conceptual questions, and further, one of the conceptual questions will require a deeper understanding of the material. For instance, when teaching *Calculus III*, one of my exams included a question where the students were asked to determine the directions a Martian rover could travel, given a function describing the local topography and a range of slopes the rover could successfully navigate. In order to successfully complete the problem not only do they have to be able to calculate the gradient, but they have to understand the geometric interpretation of the directional derivative and how it relates to the gradient.

Although Superman may have been able to leap tall buildings in a single bound on his first attempt, most mere mortals need some scaffolding to build up to the top of the tall buildings. In a similar manner, students need to be built up to tackling new and challenging problems. Depending on the size of the class, I have found two methods to be particularly effective in building up to more challenging problems. In medium to small classes, I have used supervised small group activities combined with classroom discussion very effectively. For instance, when teaching linear programming to a class of approximately 30 students, I broke the class into small groups and asked them to write linear programs to model a series of scaled down real world problems. I was then able to roam the class and guide individual groups over the difficulties and guide them into addressing all the complications. Then, during the examination, the students were able to formulate a small linear programming for ensuring good nutrition while minimizing cost.

I have found that in a large class environment it is much harder to effectively interact with many small groups. However, by modeling problem solving behaviours over the course of several lectures I can achieve a similar effect. While teaching an *Introduction to Differential Equations* to a class of about 160 students, starting from the very first lecture, whenever a new topic or idea was introduced I led the students through the thought process that resulted in the idea. For instance, when discussing salt tank problems, rather than give a generic formula for the differential equation, I walked them through the cyclic modelling process using a "real world" salt talk problem. This incremental development of the governing differential equation gave them the tools to handle a tank problem with sinusoidal flow rates on the exam.

As as an extension of my philosophy of challenging my students, I also feel it is my obligation to challenge myself to continually improve as a teacher. For me, other than experience within the classroom, the single greatest factor in improving my instruction has been discussing the challenges and successes of teaching with my peers. Of particular note, were my experiences while receiving a research assistantship during the 2007-2008 school year. In the spring of 2007, I noticed that although there was a cadre of graduate students who discussed teaching matters, it was not a focused discussion including the full spectrum of graduate students. In response to this, I proposed to the School of Mathematics at Georgia Tech that there was a need to have a non-judgemental environment where graduate students who were lead instructors or who were interested in becoming lead instructors would be able to discuss their experiences and ideas regarding teaching. Since the school approved (and funded) this proposal, we had regular enlightening and successful meetings. In fact, the school believes that this endeavor is worthwhile enough to have made it a feature of the teaching development program. Beginning in Fall 2008 they gave teaching load reduction to the graduate student who organizes these meetings and performs other teaching developmental duties. Additionally, because of my efforts in this direction, I was recognized as one of the Outstanding Teaching Assistants in 2007-2008.

If I had to summarize my teaching philosophy briefly, it would be a play on the old saying:

If you teach a man to calculate,
you solve his problems for today.
If you teach a man to think,
you solve his problems for life.