**Incorporating engineering-based problem solving into water and environmental geology classes**

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As a civil engineer teaching in a geology program for more than ten years, I integrate engineering into my geosciences classes regularly whether subconsciously or consciously. I find that as I’m developing my course material I ask myself how can I make this material relevant to my students and the answer is often to help them see how what they’re learning about can be applied to solve technological, environmental and societal problems. In my classes I tend to focus on material and activities that are more quantitative, shorter-term process oriented, applied, problem-solving oriented and sustainability oriented.

The focus of my teaching is in water, environmental geology and environmental science, so incorporating engineering and problem-solving into my classes comes very naturally. Environmental geology is already what I call “anthropocentric geology”, which makes the “how is it relevant to me” question very easy to answer and presents endless opportunities to demonstrate how basic scientific understanding can be applied to solve environmental and resource-related problems. In my water classes, since I was trained as an engineer, I tend to have a strong focus on problem-solving activities and exercises. I think that students obtain a deeper grasp and understanding of basic concepts when they successfully apply those concepts to solve problems.

One of my biggest challenges in teaching in a geology program is the lack of math preparedness of our students. Many struggle with basic algebra and I cannot assume that they’ve all had calculus by the time they take my classes. As a result, I have had to dramatically change the types of problems I assign, and to spend a lot more time on basic problem-solving skills. At the beginning of the semester in both ground water and hydrology I spend some time just talking about problem-solving and the steps to take when approaching a problem. I am very specific in my expectations for their homework assignments and work hard with many examples to help them understand that good problem solving takes practice and that taking their time and following some standard steps (e.g., writing the knowns and unknowns and drawing a picture before starting on the problem) can greatly increase their chances of success.

Along with the lack of math preparedness, I’ve also struggled with the students’ lack of comfort with using quantitative tools like Excel. Over the years I have incorporated more exercises that teach basic quantitative skills. I schedule some class sessions in a computer lab and give them applied exercises to solve in Excel. I received a letter from a student after graduation thanking me for my classes and in particular thanking me for all of the Excel workshops because he felt that those skills helped him more in his job advancement than many of the other things he learned.

Another challenge is that I occasionally do get engineering students taking my hydrology class along with the geology and environmental science majors. Most of the engineering students have strong quantitative and problem-solving skills, but have had little, if any, exposure to the geosciences, sustainability and environmental issues. And, on the other hand, the geology and environmental sciences students often struggle with the quantitative problem-solving activities, but have a good understanding of earth-surface and environmental processes, landforms and issues. I do my best through the semester to help them feel good about their strengths and about learning in new ways that might push them in ways they haven’t thought about before. In the future, I hope to incorporate group assignments and intentionally mix up the engineering students with the science majors.

I include engineering-oriented activities and perspectives in the following classes:

**Basic Hydrology** – In this class, I present the basic science of the major hydrologic processes, but then go a step further and cover some basic methods of estimating and modeling each process. For each process, I present examples and problems that illustrate how our understanding of the process contributes to our ability to model the process. Then I try to give examples of how those results are applied. For example, Colorado agricultural water rights are based on the evapotranspiration (ET) rates of the crop that’s being irrigated. So, after learning how ET works, they learn to apply the actual method that engineers use to calculate ET for agricultural water rights.

**River Dynamics** – I teach this class more like an applied fluvial geomorphology class. I present the basic forms and processes of fluvial geomorphology, and then explore how those processes result in modern natural and human-induced channel changes and adjustments. I use a lot of local examples, but also take advantage of the opportunity to expose students to rivers and human impacts on rivers all over the world. In looking at human-induced changes we cover the impact of engineering on the natural environment, ensuing restoration efforts and how we can sustainably manage our resources. The students are required to do a small HEC-RAS modeling project on a stream reach that they survey in which they estimate the magnitude of a recent flash flood, and they also have to present a case study on a river that has undergone recent channel change.

**Introduction to Ground Water** – I have two focuses in this class beyond conveying the usual course material. The first is to develop the students’ problem solving and math skills. I’ve had students tell me after this class that they understand calculus better from this class than from their semester-long calculus classes. The second is to help them learn to write better technical reports. I require complete technical reports for three of their labs and spend a lot of time discussing the difference between technical writing and creative writing and why being able to clearly and logically communicate one’s work is so important.

One of the things that I would like to try in all of my classes is to incorporate more student-centered active learning activities. I have attended teaching workshops offered at my university, but they have been more general and lacking in applications to the sciences or engineering. I’ve struggled with how to incorporate the things I saw at these workshops into my classes, for example, how to adopt a flipped classroom approach. In this workshop, I hope to learn new techniques for encouraging deeper-learning in my classes via more student-centric learning. Another goal that I have for this workshop is develop opportunities to engage engineering students in the geosciences.