**What are the challenges, circumstances, program elements that contribute towards impeding student learning about quantitative reasoning and teaching with data in the classroom? What strategies have you found successful?**

I believe that student success in the chemistry classes that I taught was significantly affected by a negative feedback loop of competence and confidence. Lack of competence in basic math skills, notably algebra, resulted in a lack of confidence which then led to a mindset of “I can’t do this because I can’t do this.” They were overwhelmed by new concepts before they allowed themselves to try. Chemistry is often the most mathematically based class that students at both the secondary level and in some college majors are required to take outside of the math curriculum. It is also an introduction to problem solving and analytical thinking using abstract concepts. As such, it can be a predictor of student success later in their classwork.

Unfortunately, students will avoid taking classes that would give them the opportunity to reinforce and improve their math competence and therefore improve their confidence. In college, it is common for young people to choose their majors based solely on the quantity of math classes that they will be required to take thereby ensuring that they will likely never improve their abstract and quantitative reasoning skills.

This provides a significant challenge to instructors. Breaking the cycle of poor competence = poor confidence needs to happen sooner rather than later. Creating experiences where students will feel successful should be part of planning instruction. Chemistry does have one advantage in that instructors can design experiences that are heavily hands on through the laboratory which can accommodate a wide range of learning styles. Creating a direct connection between the concepts taught in the classroom with those taught in the laboratory is critical. It’s also necessary to help students be prepared so that they will feel successful when they work in the laboratory. Such things has having them view instructor-made or YouTube videos to view the color change in a titration, for instance, will help ensure that they are able to complete the lab with a minimum of missteps.

Laboratory experiments by themselves are not adequate for encouraging quantitative reasoning because it is difficult to avoid the mindset of finding the “right” answer. One way to make sure that students are exposed to the errors and challenges that occur in a real world setting is to take the opportunity to explore real world data sets that are available through open data sources. Instructors should look for opportunities to direct students to these sources whenever possible. Looking at how null values are handled or what units the data points are recorded in can be instructive. Take the opportunity to have them visualize the data to look for trends and calculate the slope of a line. Ask them to think about who would collect a certain data type and why. An example might be to look at the data reported for the local municipal supply when learning about solubility chemistry or even polyatomic ions. Compare it to the analysis of a local lake, river or stream and see what is in those sources that are not in drinking water.

Educators must be intentional in order to design experiences that help as many students as possible to improve math competence and expand their ability to apply quantitative reasoning. Open data sources are readily available, free and offer a window into the real world of science.