Quantitative reasoning and visualizing data across the sciences

Anne Marie Ryan, Gillian Gass, Susan Gass, Kerrianne Ryan & **Jennifer Van Dommelen**
Dalhousie University, Canada
amryan@dal.ca

In classes across the scientific disciplines of the life, earth, and environmental sciences, students struggle with the essentials of quantitative reasoning and visual representations of data -- and their instructors struggle to help them, and indeed struggle to understand the reasons why students find these concepts so troublesome. In the context of a math class, students may have effectively learned such basics as ratio, proportion, and percentage; trigonometry and geometry; using algebra and solving for an unknown; working with logarithms and exponents; estimating errors; and representing data graphically and interpreting graphical representations of data. But in the context of another scientific discipline, these quantitative concepts can present a new challenge as a part of the varied disciplinary content and ways of thinking that students strive to incorporate into their understanding as they begin the journey along the spectrum from novice to expert within that discipline.

We propose that a change in perspective is required if we are to provide scaffolding for our students as they undertake this difficult passage. Instead of understanding quantitative reasoning and the possibly related data visualization as skills learned elsewhere that must now be applied to the scientific discipline in question, we need to understand these concepts as part of the content of our own disciplines. Students will bring prior mathematical understanding with them into our classes, as they will bring prior understanding of other aspects of the natural world, and as instructors we must draw on this prior understanding as we help students learn. Our role becomes one of helping students connect and change this prior knowledge in light of what they are now learning about the concepts and modes of thought characteristic of science and of the particular discipline they are studying. This means we need to be moving away from assumptions that students should "already have the math", and towards an understanding of ourselves as teachers of how this math looks and works as it is embedded within the disciplines we practice. We are expecting that students' understanding of quantitative reasoning and the associated data visualization become transformed through their learning within and across the scientific disciplines, and we should not expect this process to be easy or quickly accomplished.

In this presentation, we explore some examples of quantitative difficulties, particularly those with associated visual components, that students encounter within the range of scientific disciplines that we teach. We propose that a change in our approach to these troublesome concepts might better support our students as well as transforming how we understand our disciplines as we teach them. In particular, we will examine the potential role of three possible approaches to helping students acquire the quantitative and related data-visualization content of our disciplines: frequent opportunities for practice, discovery learning, and modelling of reasoning by instructors. Finally, we will consider whether this discipline-situated approach to quantitative skills might help students struggle less as they learn across the range of scientific disciplines.