What challenges do you face in assessing student computational skills and learning? Have you had success in overcoming these challenges? If you have had success, what strategies did you use to overcome them?

Never Too Late: Developing Quantitative Thinking Skills in an Upper-Division Biology Course

"I am not a math person" is a common refrain from students in my upper-division Systemic Physiology course. This course draws students from a wide variety of majors, including Biology, Kinesiology, Psychology and Dietetics. Because of the wide swath of students interested in my course, I encounter a high level of variability in terms of the extent of their quantitative backgrounds and the amount of time separating them from their last quantitative experiences. When I present a concept involving quantitative thinking, most of my students will put forth a genuine effort. Unfortunately, past experiences (typically unpleasant ones) and/or lack of basic quantitative training occlude their ability to keep the problem in perspective. My students often focus not on what they "can do," but instead focusing on what they "can't", feeling as if they will never be able to "get it," and thus remaining unproductively stuck on the problem.

Therefore, in order to develop these quantitative thinking skills and move students out of that unproductively-stuck position, I begin by focusing not on the math, but the concept the math is supposed to explain. Take the Nernst Equation, which describes how two forces (chemical and electrical) acting on an ion balance each other. It is given by (in simplified form at standard conditions):

$E=(58/z)*(\log [o]/[i])$

Where E = the potential difference in charge where the electrical and chemical forces balance, z is the charge on the ion and [o] and [i] represent the concentrations of the ion both outside [o] and inside [i] the cell, respectively. My discussion starts not with the equation, but with a more basic understanding of how the two forces (electrical and chemical) work, either together, in opposition, or when they are balanced. Now the equation becomes a means to determine something about the forces, shifting the focus away from the math itself.

With that foundation, I then delve into the equation, dissecting out how the two forces relate to the two terms on the right-hand side of the equation. For this part, I use a basic description of how logarithms work. I simplify this discussion and do not describe the function as a whole, but rather the output of the function. When would the log of a number be positive? Negative? Zero? At this point, the students learn that the ratio of [o]/[i] determines what the output of the logarithm will be. I conclude by discussing the first term and the sign of the variable z. Taken together, students can then predict, without knowing any specific values or performing any calculations, the sign of E.

The final step then, is assessment. On an exam, I have students predict and/or explain why a value of E is negative, positive, or zero. Each of these scenarios involves either a biological explanation (which focuses on the forces acting on the ions) or a quantitative one, using the

reasoning outlined above. Given the choice, I have seen students who were “not math people” opt for the more quantitative explanation, suggesting they were more confident in their ability to explain the biological concept using quantitative thinking rather than biological thinking.

In conclusion, I try to incorporate quantitative thinking in my class by starting with an intuition, invoking the math, then asking my students to lead with that foundation as they solve problems related to the concept. I use this for several different concepts presented throughout the semester. Perhaps the best indication of this method’s success is when I have observed my students dissecting equations on their own, trying to see how the math relates to the concept at hand. Until now, I haven’t used Matlab for this endeavor; but I look forward to finding ways to incorporate Matlab in this process.