MP Meeting – Biology notes 2-4-15

Biology Group Participants

Wynn Cudmore	Chemeketa
Bert Pooth	Lane
Michael Bartlett	PSU
Kendra Cawley	PCC
Karen Sprague	UO
Noella Grady	Linn-Benton (MATH)
John Knudson-Martin	EOU (MATH)
Michael Milhausen	Chemeketa
Jaimie Powell	PCC

KEY IDEAS

Students really need basic skills:

- graphing (especially, taking a data set and creating a graph that has the right axes and reasonable scale
- dimensional analysis; inter-conversion of units (e.g. nano to micro; English to metric)
- scientific notation and exponents
- simple algebra – especially linear relationships and simple exponential relationships
- basic number sense – including the ability to estimate and to know whether a numerical answer makes sense.
- Understanding rate and acceleration – but rates can be expressed as Δs rather than dx/dt s (calculus)
- Statistics, with emphasis on the reasoning behind selection of appropriate methods and interpretation of results. The pure math theory behind statistical methods isn't needed and has the potential to distract students from the principles that should guide their use of statistics.
- If students had a good grasp of the material in Math 60 and 65, they'd be fine. They need more practice applying this simple math in settings other than math class. This is more important than being able to work with very complicated expressions in the abstract (the emphasis of Math 95 and 111).

Is calculus important? Yes, for some parts of biology (*e.g*. population dynamics in upper-level ecology), but not for many others. *E.g*., not for molecular biology; maybe for biochemistry -- but mostly because it's required for chemistry. Calculus is not required for all parts of chemistry, though. For example, the parts most important for Biology students (General Chemistry and Organic chemistry) don't require calculus, or even advanced algebra. We (Biologists) start students down the calculus track (via Math 111) because Math 111 is a pre-req for Gen Chem. That is, the math pre-req for our beginning Biology courses (typically, Math 111) is motivated by what's required as a pre-req for General Chemistry, not by our appreciation of the math students need in our Biology courses. In fact, the rationale for our math pre-req is even more indirect – because it turns out that the chemists don't think Math 111 is useful for Gen Chem! it's just a pre-req for the calculus they want their majors to get to eventually. The chemists think the math that would help students in Gen Chem is actually Math 60 or 65. They were very surprised to discover the content of these remedial math courses. One motivator for keeping calculus in the Bio major is that some medical schools require it. Is this a sufficient reason? We also need to think about the math that might be needed for informatics – an area that's sure to grow in importance for all biologists, including doctors.

Is statistics important? Yes, very – and for nearly all of biology. PSU allows their Bio majors to choose calculus or statistics. Would it be better to require statistics instead of calculus? If so, could students ignore math 111? Why is Math 111 needed? It gives students technical facility with the complex algebraic manipulations needed for actually doing calculus. Doesn't really help with the concepts of calculus – instantaneous rates of change and what the area under a curve means.

Big discovery: Logarithms aren't taught until Math 111!! After the riot subsided, we realized that we think of logs as something simple that's taught along with exponents back in Math 60, or earlier. That's not what happens, though. Students don't get logs until <u>after</u> they've waded through all of the quadratics in Math 95. As biologists, we've been assuming that that students come to us as freshmen with a good grasp of logs, which show up right away in freshman courses. Apparently, that's not true, and could explain the great difficulty that logs cause for many students.

Math 95: It was clear from comments by Mike Price and several others, independently, that Math 95 is a terrible course. Not sure how it came to be that way. Bert Pooth (LCC) found that making Math 95 a pre-req for his beginning Bio majors course made a big difference in the ability of the students to handle quantitative material. It wasn't clear that it was the Math 95 content that achieved this, or simply that the students had acquired maturity and increased math fluency in general.

Math 98 (at LBCC): This may well be a much more useful course than Math 95

> **Principal topics** are logic, statistics, and financial math, logic. There is a lot of algebra embedded.
>
> **Pedagogy is non-traditional:** There's very little lecture. Instead, students work together on activities and use ALEKS (Assessment and Learning in Knowledge Spaces), a "just in time" tutorial for algebra and other things, on the side. Students come up with important concepts (*e.g.* linear relationships, rates of change) *via* their own thinking — not just by plugging into a formula. Figuring these things out helps students to become able to think on their own.

Insight from math faculty (Noella Grady): The parts of math (esp algebra) that we biologists think is important is taught – but isn't emphasized and tends to get pushed to the periphery of math courses. This could change.

Insights from the sample problems people had brought: There's significant math embedded in bio courses – much of it in the lab exercises. Examples are:

- Exponential growth curves
- Other kinds of graphs
- Semi-log plots (semi-log paper, as used for growth curves or migration of DNA fragments in electrophoresis): students are completely baffled by the scale
- Logarithmic relationship between absorbance and transmittance of light
- Scale (microscopic magnification) and metric unit conversion
- Chi –square test of Mendelian ratios of progeny from a di-hybrid cross.
- Simple geometry: approximating the volume of a log with a cylinder
- Density measurements

Our concerns about students' ability to use math are not new. Why hasn't there been more progress?

- **Attitudes about math are part of the problem**
    - Our culture encourages the "I'm not a math person" descriptor.

    - Students need to be able to persist through initial confusion and failure when trying to solve problems. That's a critical habit of mind, but one that's hard to teach.

    - We need to convince students that making mistakes is OK. Their lack of confidence inhibits them from trying things where mistakes are possible, even likely. This is a barrier to real learning and we need to change this culture.

- The school system seems to speed through middle school math. It's clear that this math is essential –not only because the concepts and skills will be used directly in later quantitative work of all kinds, but also because they are foundational for higher level mathematics. Maybe we're not giving students enough time and enough different kinds of encounters with this vital material. We were surprised and concerned to learn that the Common Core Standards, instead of slowing things down at this crucial step, are accelerating them – for example, by introducing algebra in Grade 6.

- If poorly used (that is, used as crutches rather than tools), calculators can erode students' willingness to think about what they're calculating.
- We're not very skillful at remediation. We keep adding remedial courses of various kinds, but don't seem to get at the fundamental problem.

- Maybe we're emphasizing the wrong math. We need to identify the places where the math requirement makes sense, and distinguish them from the places where it is simply an un-examined custom.