Mar 4th, 9:30 AM - 10:15 AM

Cultivating a Community of STEM Polymaths at UNG

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Cultivating a Community of STEM Polymaths at UNG

Sarah Formica, Royce Dansby-Sparks, Margaret Smith, Gregg Velatini

Departments of Physics, Chemistry, Biology, & Mathematics

University of North Georgia, Dahlonega
“What is a polymath?!”
We Need More Polymaths in Georgia

- Kauffman Foundation: GA excels in fast-growing companies, fares poorly in producing knowledge-workers

- Needed to compete in major national economic trends that require science-based innovation

- New Economy Index: GA does well in growing firms, middle of the road in IT professionals, scientists, and engineers, lowest in educating and importing the much-needed technical and scientific workforce

(Atkinson and Andes 2010)
The X-Laboratory Project provides a two-semester, inquiry-based laboratory curriculum focused on major themes and concepts in biology, chemistry and physics with an emphasis on their integrated applications in modern, quantitative scientific research.
An Integration of Chemistry, Biology, and Physics: The Interdisciplinary Laboratory

Gerald R. Van Hecke* and Kerry K. Karukstis
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Richard C. Haskell
Department of Physics, Harvey Mudd College, Claremont, CA 91711

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F. Sheldon Wettack
Vice President/Dean of Faculty, Harvey Mudd College, Claremont, CA 91711
**Disciplinary**
- Of or relating to a particular field of study (Merriam-Webster)

**Interdisciplinary**
- Transferring knowledge from one discipline to another. Allows researchers to inform each other’s work and compare individual findings. (Washington Univ. School of Medicine)

**Transdisciplinary**
- Collaboration in which exchanging information, altering discipline-specific approaches, sharing resources and integrating disciplines achieves a common scientific goal (Rosenfield 1992)
The Specs

- **STEM 1002L**

- Catalog Description: Transdisciplinary, inquiry-based laboratory curriculum focusing on major themes and concepts in biology, chemistry and physics with an emphasis on their integrated applications in modern, quantitative research.

- Satisfies course requirements for BIOL 1108L, CHEM 1212L, and PHYS 1112L or PHYS 2212L

- 3 credit hours
Course Objectives and Learning Outcomes

- Develop **quantitative**, transdisciplinary reasoning skills
- Gain experience with cutting edge techniques spanning Biology, Chemistry, Physics and Mathematics
- Foster creativity through oral and written communication appropriate for technical STEM fields
- Advance fluency in the scientific method
Towards Developing a Quantitative Literacy/Reasoning Assessment Instrument

Eric C. Gaze  
Bowdoin College, egaze@bowdoin.edu

Aaron Montgomery  
Central Washington University

Semra Kilic-Bahi  
Colby-Sawyer College

Deann Leoni  
Edmonds Community College

Linda Misener  
Southern Maine Community College
Number sense, reading and interpreting graphs, basic probability and statistics, and reasoning.

Instead of procedural, algorithmic questions; more involved reasoning, critical thinking questions.

Tests quantitative literacy, using numbers in meaningful sentences rather than just computation.

Postulate possible explanations for statistics rather than use traditional logic games.
It’s About Big Ideas

- **Harnessing Light’s Energy**
  - Optical Spectroscopy, Absorption Spectroscopy, Photovoltaics

- **DNA Analysis**
  - Gel Electrophoresis: Electric and Drag Forces, Buffers, PCR

- **Efficiency of Biofuels**
  - Paper => Glucose, Glucose => Ethanol, Distillation, Combustion
Language and environment for statistical computing and graphics

Open source statistical language

Scientists use R to solve problems in fields ranging from computational biology to quantitative marketing
title: 'Why Are Some Scales Logarithmic?'
author: 'Sarah Formica'
output: html_document

---

result_table

<table>
<thead>
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<th>x</th>
<th>y</th>
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<tbody>
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<td>2</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>8</td>
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</tbody>
</table>

---

require(plyr)
require(dplyr)
require(reshape2)
require(scales)

vec[x]_{avg} = \frac{\Delta v}{\Delta t}

labs(title = "1/H Activity vs. Added Solution", y = "1/H")
Why Are Some Scales Logarithmic?

Sarah Formica
December 2015

Introduction

Logarithmic scales are used extensively in math and science when viewing and analyzing certain types of data. For example, log scales are used when studying earthquakes, hydrogen ion activity, sound pressure levels, antennas, and many more. Why are logarithmic scales used for many types of analysis, and not for others?

Hydrogen Ion Activity

The hydrogen ion activity of solution determines whether the solution is acid, neutral, or basic. In solution there is activity of positive hydrogen ions (H+), and negative hydrogen ions(H+). Either may be used to determine whether a solution is acidic or basic. From this point on, this paper will use H+ for all calculations and graphs.

<table>
<thead>
<tr>
<th>Quality</th>
<th>HPlus</th>
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</thead>
<tbody>
<tr>
<td>1</td>
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<tr>
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<tr>
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</tr>
<tr>
<td>15</td>
<td>1e-14</td>
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</tbody>
</table>
First Attempt at Graphical Analysis

If the data is plotted, it would be reasonable to assume that quantities of added solution and H+ activity could simply be read from the graph.

For Example:
1. How much solution must be added in order for $H^+ = 10^{-10}$?
2. How much solution must be added in order for $H^+ = 10^{-7}$?
3. How much solution must be added in order for $H^+ = 10^{-3}$?

If we graph $1/H^+$ instead of H+, all of the exponents will become positive.

The above questions then become
1. How much solution must be added in order for $\frac{1}{H^+} = 10^{10}$?
2. How much solution must be added in order for $\frac{1}{H^+} = 10^{7}$?
3. How much solution must be added in order for $\frac{1}{H^+} = 10^{3}$?
Second Attempt at Graphical Analysis

Since the hydrogen ion activity spans such a huge range, it may be best to “compress” it using a log function.

A column containing the log(1/H+) can be added to the original data frame “hplusdata” with the following code in R.

```r
hPlusdata$logHplus <- log10(1/(hPlusdata$hplus))
```

Once again, the first several rows can be viewed using `head()`

```r
head(hPlusdata)
```

```
##     ml hplus logHplus
## 1    0.00 3.467369e-13  12.46
## 2    1.00 3.990295e-13  12.51
## 3    2.05 3.235937e-13  12.49
## 4    8.80 3.890451e-13  12.41
## 5   14.35 4.365158e-13  12.36
## 6   28.04 5.623413e-13  12.25
```

Now there is a new column in the data frame containing the log of the hydrogen ion activity. The plot of the new data is below.

![Graph of log(1/H+) vs. Added Solution](image)
Build Your Own Spectrometer

- Single-Slit and Double-Slit Diffraction, Diffraction Gratings
  \[ d \sin \theta = m \lambda \]
- Box Spectrometer Kit
- Wavelength measurements from a variety of light sources
- Hydrogen, Helium, Neon, LEDs, White Light with Colored Filters, etc...

http://labman.phy.utk.edu/phys222core/modules/m9/interference.htm
Beers Law
Beers Law
Chromatography and Chlorophyll Absorption
Chromatography and Chlorophyll Absorption

- Spinach Chromatography
- Iceburg Lettuce - Absorbance vs. Wavelength
- Kale Chromatography
- Romain Lettuce - Absorbance vs. Wavelength
Photovoltaics and Hydrogen Fuel Cells
Photovoltaics and Hydrogen Fuel Cells
Paper Titles for Paper 1

- Biomimicry of Solar Cells to Plant Leaves in Their Absorbance of Sunlight
  - Sarah Adams, Staci Young, Tyler Kostun, Nicholas Ehmann
- Examining Light as a Sustainable Source of Energy
  - Campbell Baldwin, Caroline Brown, Wes Robinson, Preston Weeks
- The Absorbance of Light in Edible Plants and how it affects Caloric Potential
  - Alex Diodati, Seth Shirley, Lauren Staniewicz, Renee VanHorn
2nd Big Idea: Gel Electrophoresis
Gel Electrophoresis
What’s To Come…

- 2nd Paper on DNA Analysis or related topic
- 3rd Big Idea: Efficiency of Biofuels
  - Paper => Sugar => Refractometry => Fermentation => Distillation => Combustion
- 3rd Paper
- Oral Presentation and Poster on one big idea (one of their papers)
In the Future …

- Break down discipline silos
- Transdisciplinary learning from the start
- Need to design STEM 1001L (BIOL 1107L, CHEM 1211L, PHYS 2211L)
- Transdisciplinary lecture courses, STEM Living-Learning Communities, …
- Inspire more students to pursue careers in STEM, contribute to GA’s technical and scientific workforce