

CALCCONF23 BERGEN, NORWAY

STEM as Culture

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Exploring
exclusion and
inclusion in
mathematics
and biology

“

“Like all people, we perceive the version of reality that our culture communicates. Like others having or living in more than one culture, we get multiple, often opposing messages. The coming together of two self-consistent but habitually incomparable frames of reference causes un choque, a cultural collision.”

Gloria E. Anzaldúa, Borderlands/La Frontera: The New Mestiza

Positionality



- Complex Adaptive Systems
 - started in computational neuroscience
 - theoretical evolutionary ecologist at heart
- Mathematician by PhD, appointed in biology and computational departments
- Researcher of quantitative interdisciplinary education
- Latinx, mother, activist
- Two worlds training - “*conocimientos*” as Anzaldua coined
 - resilient networks · boundary spanning · community building*



Theoretical perspectives in feminist Latinx studies

- **Nepantla** - The place of in between where something new is created
- **In Lak'ech** - Seeing commonalities in each other
- **Reciprocity** - Taking care of each other as an obligation

e.g Rochelle Gutiérrez (2017), Gloria Anzaldúa (1987)

Perspectives from a community builder & community ecologist

- **Brokerage** - Living between many words helps us translate ideas, builds sustainable diverse ecosystems
- **Collaboration** - Unifying frameworks and language, mutualism
- **Care** - Humanizing approach, to relationship building in research and teaching, obligate

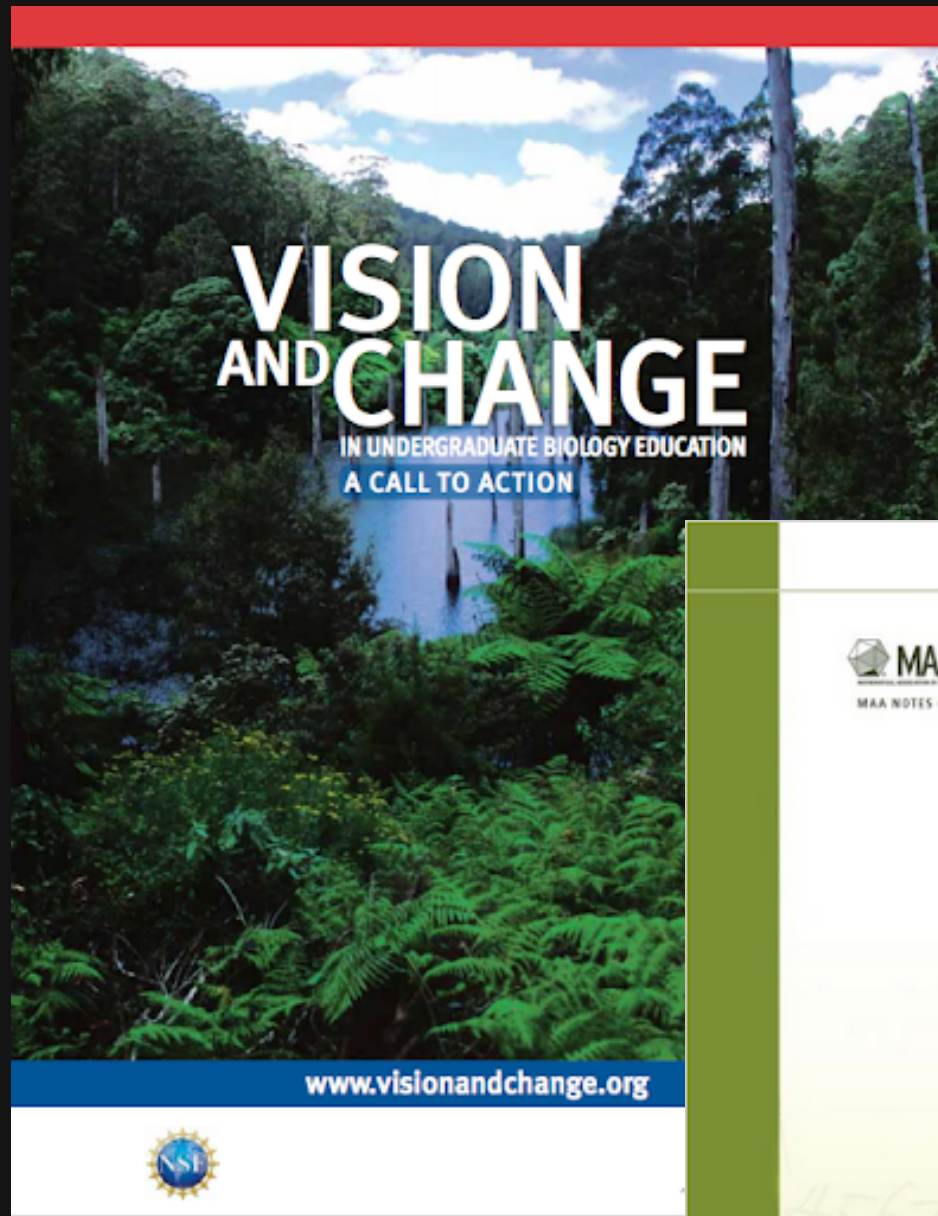
MI TESTIMONIO*

STEM as culture

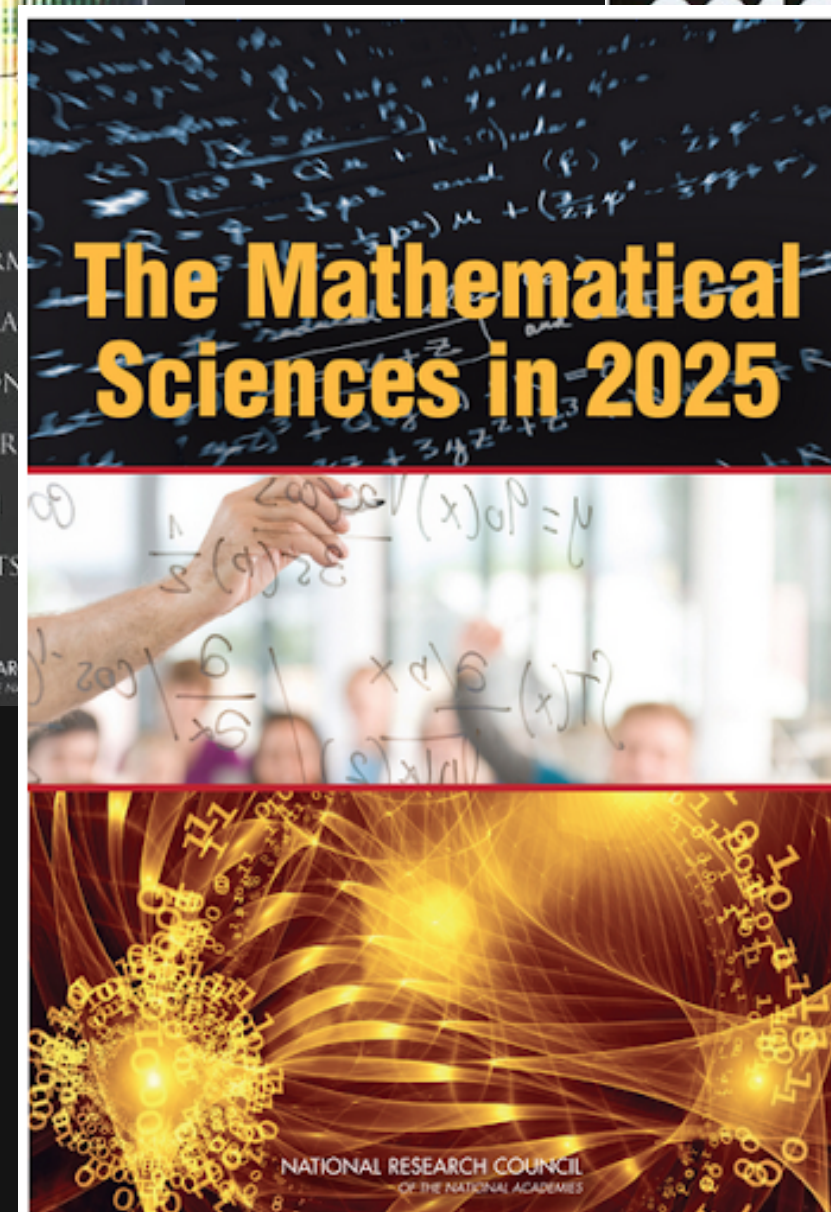
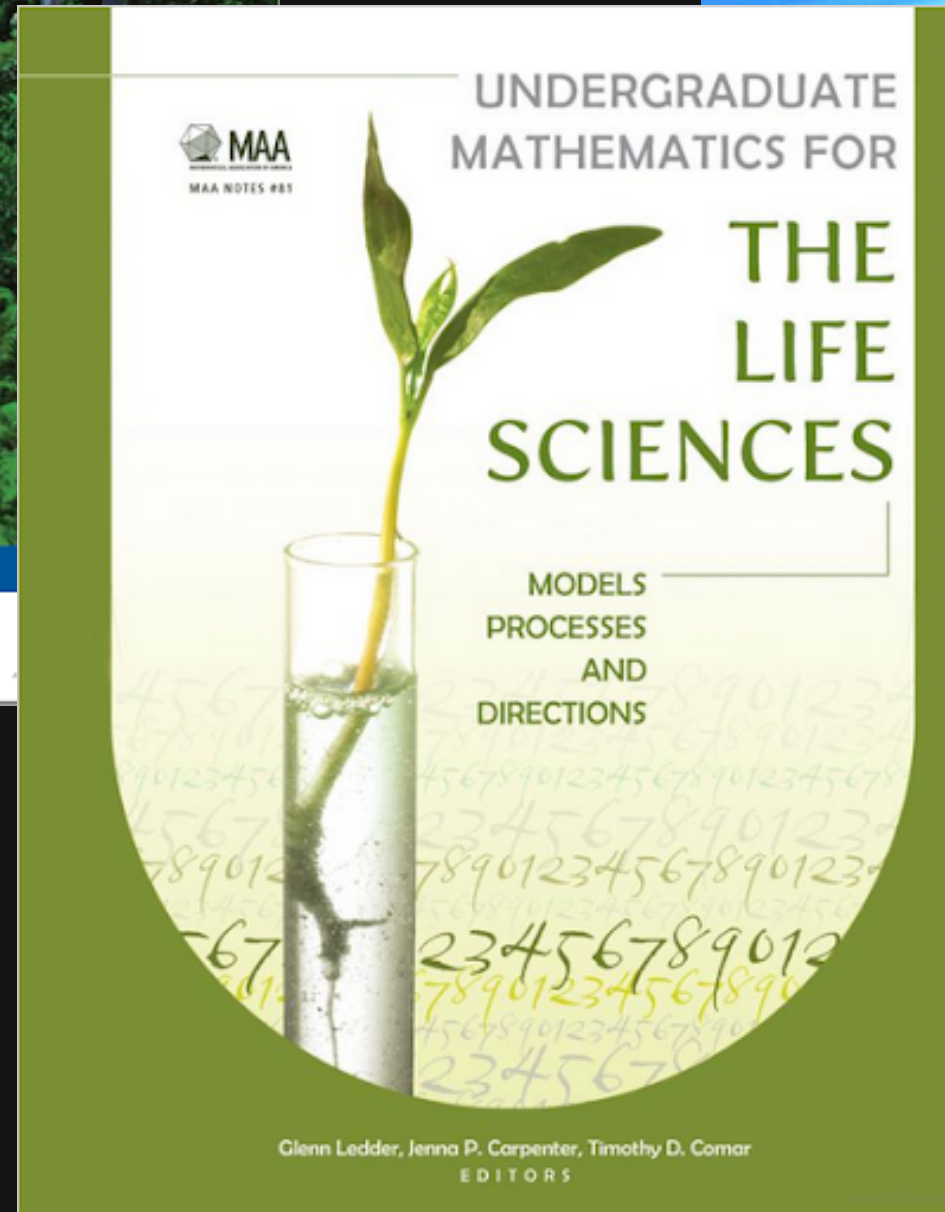
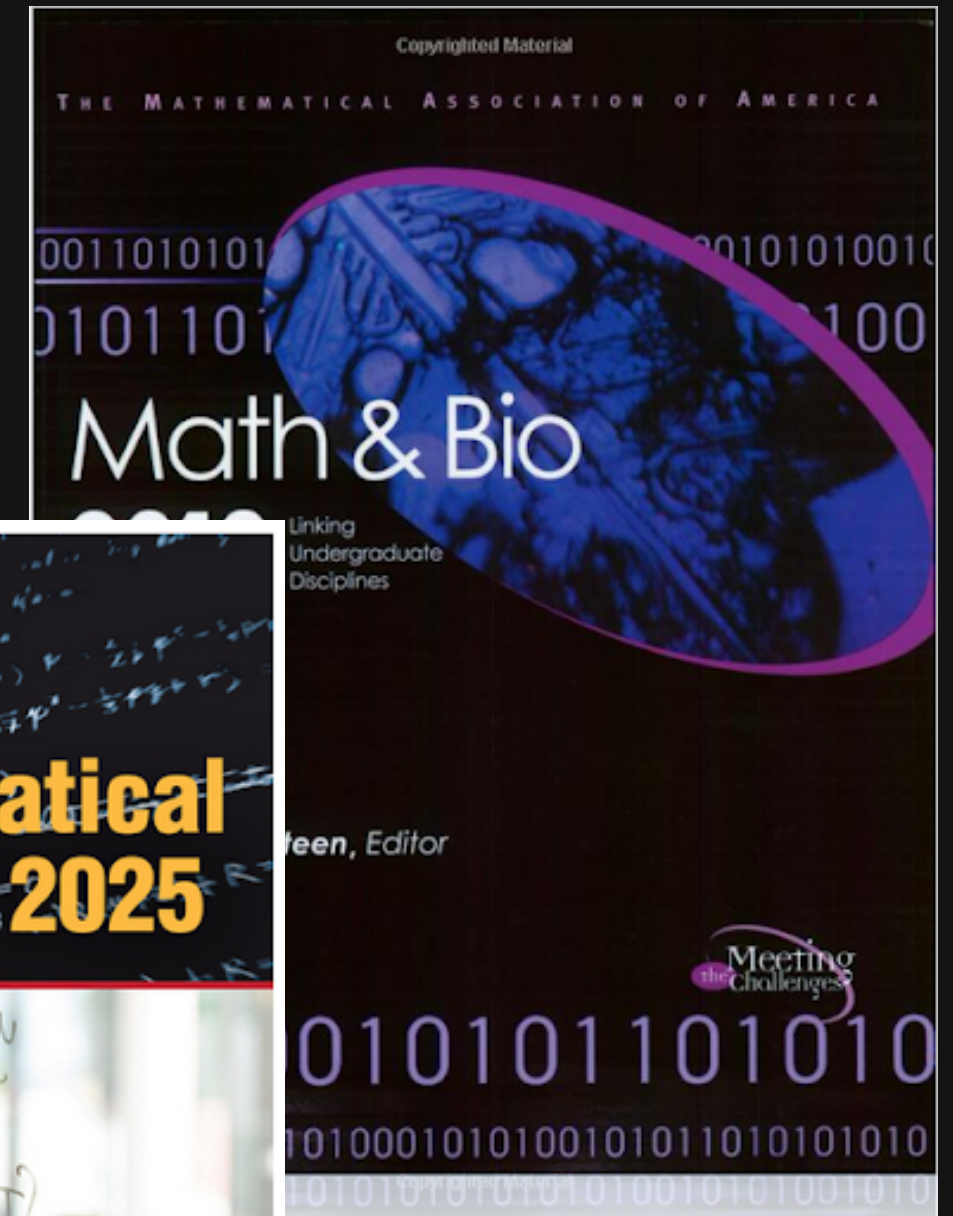
**"testimonio positions itself as an urgent and political voicing that rejects notions of objectivity and neutrality. Instead, it posits that there exist multiple truths of which each contributes to producing our understanding of a collective reality"*

Rodriguez-Campo, M. (2021)

- **Context** - landscape of calculus for biology in the US
- **Value and language** - translating the dialects of mathematics
- **Models and microaggressions** - the quest for unifying epistemological bridges & the issue of non-neutrality
- **Relationships and care** - interdisciplinary work requires relationship building
- **Humanizing and contextualizing** - humans do science and mathematics
- Conversations ahead



BIO
2010



Re-imagining a calculus for biology

TRANSLATING THE DIALECTS OF MATHEMATICS

Value and language



Context

Several departments at
Unity might cut calculus
But every report is saying
we need it even more



Value proposition

1. Grad school
2. Content
3. Proxy for "rigor"



Content survey

Asked with math dialect -
no value.
Asked with biology dialect -
lots of value!!!



translating the
"dialects" of math

JOE REDISH

Average Rank	Calculus Topic	Translation
1.3	Exponential function	Feedback loops
1.4	Fitting data to a model	
1.5	Computer skills	Excel, some logical thinking for programming
1.5	Derivative	Concept, not computation
1.5	Population growth models	Logistic growth, Excel
1.8	Equilibrium analysis	Equilibria, stability, climate change, and population management
1.8	Limits	Carrying capacity

Made changes

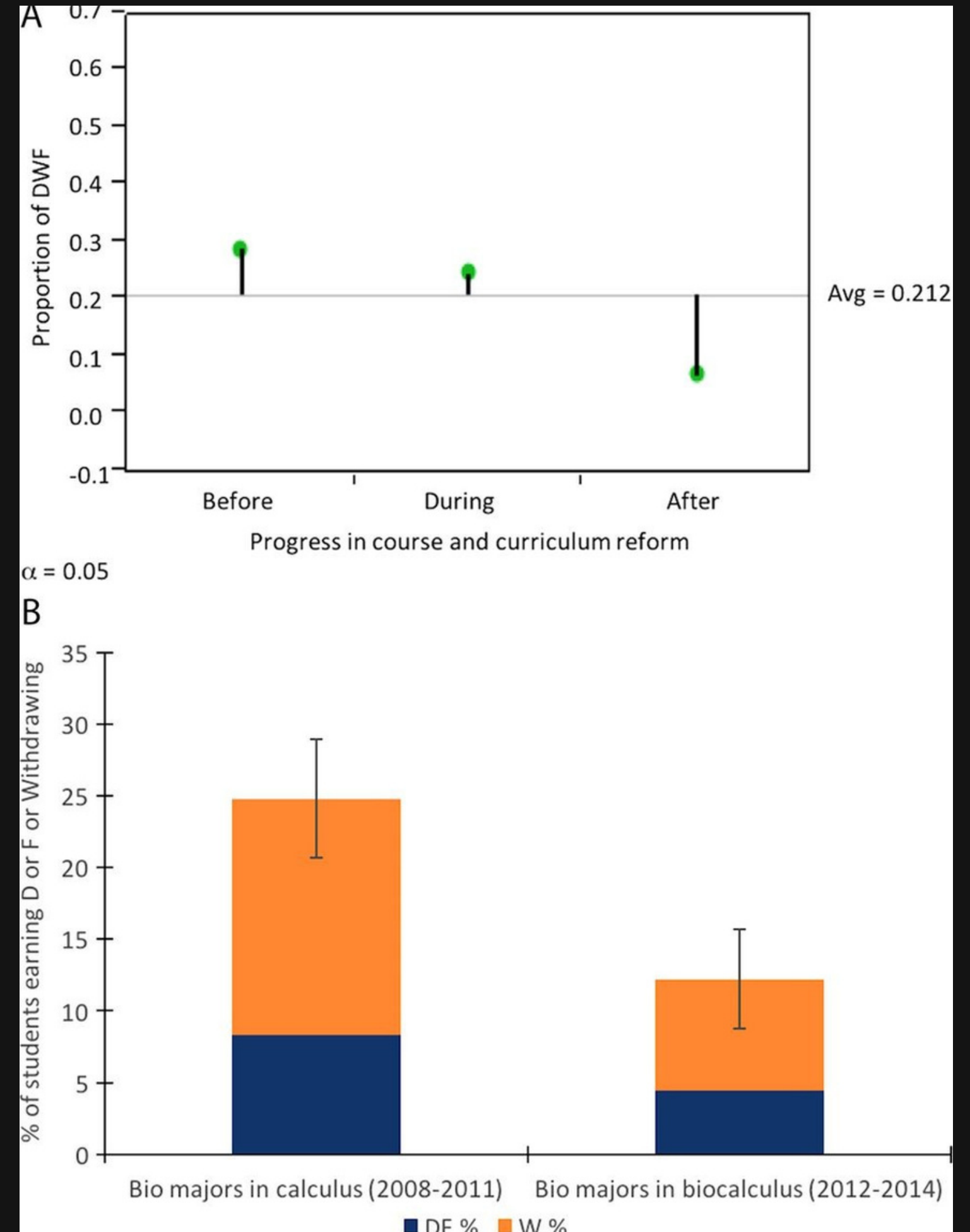
BLEW UP THE CURRICULUM A BIT

- Adopted a new book & developed POGIL-like exercises and later group projects with lab reports
- Added discrete models (first) and with geometric sequence and harvesting management project
- Added exponential functions
- Spent time teaching their importance as a feedback loop
- New project analyzing rate of change to confirm proportional to size with an exponential tail indicating an "environmental indicator"

Results

Collab w/Highlander Callender

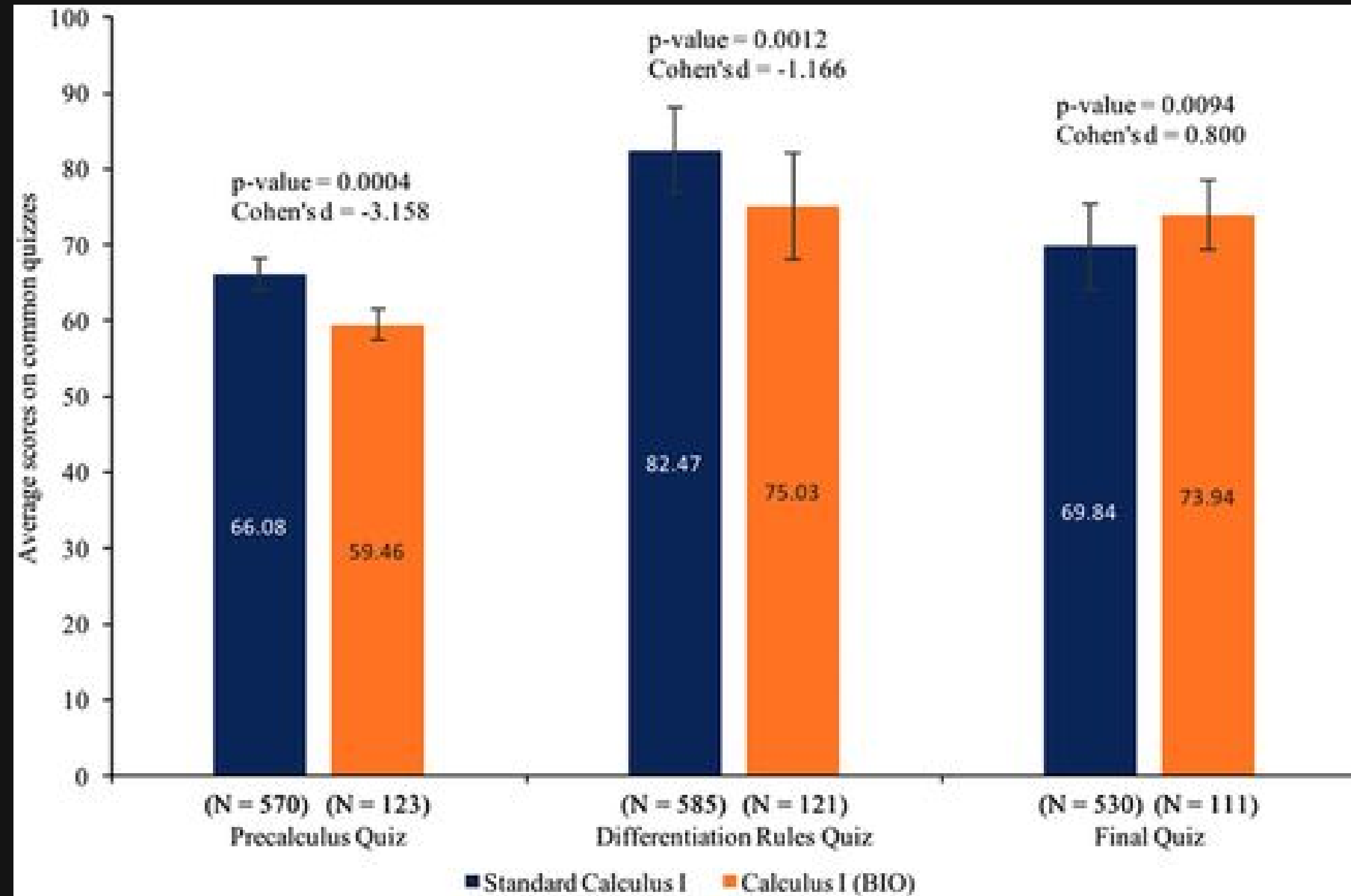
Improved student performance
- reduced "filtering", dropping
DWF rates by half



Results

Collab w/Highlander Callender

Improved student
performance and "rigor" –
counternarrative of
biocalc



Models and microaggressions

QUBES/BioQUEST & NIMBioS - HOW TO TEACH MODELING FOR BIOLOGISTS



Interdisciplinary:
math, math ed,
physics ed,
biology, science
ed, bio ed

Cultural Issues as key

MODELS AND MICROAGGRESSIONS

SAME WORD, DIFFERENT MEANING

Mathematicians required equations

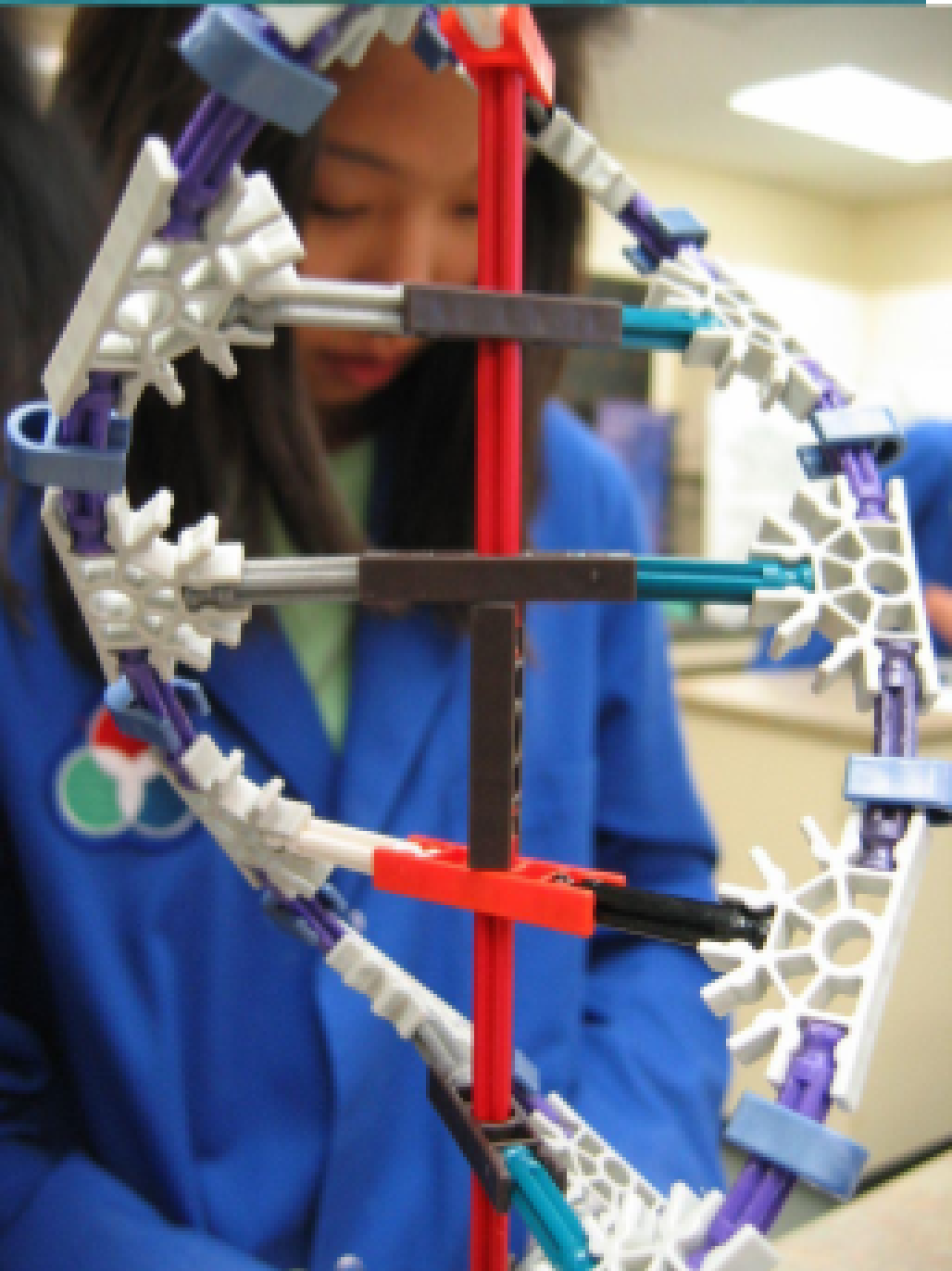
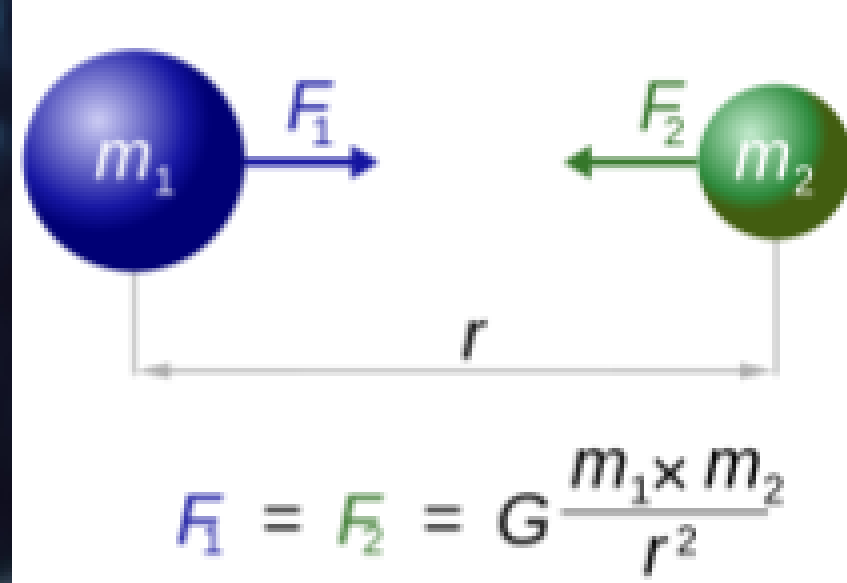
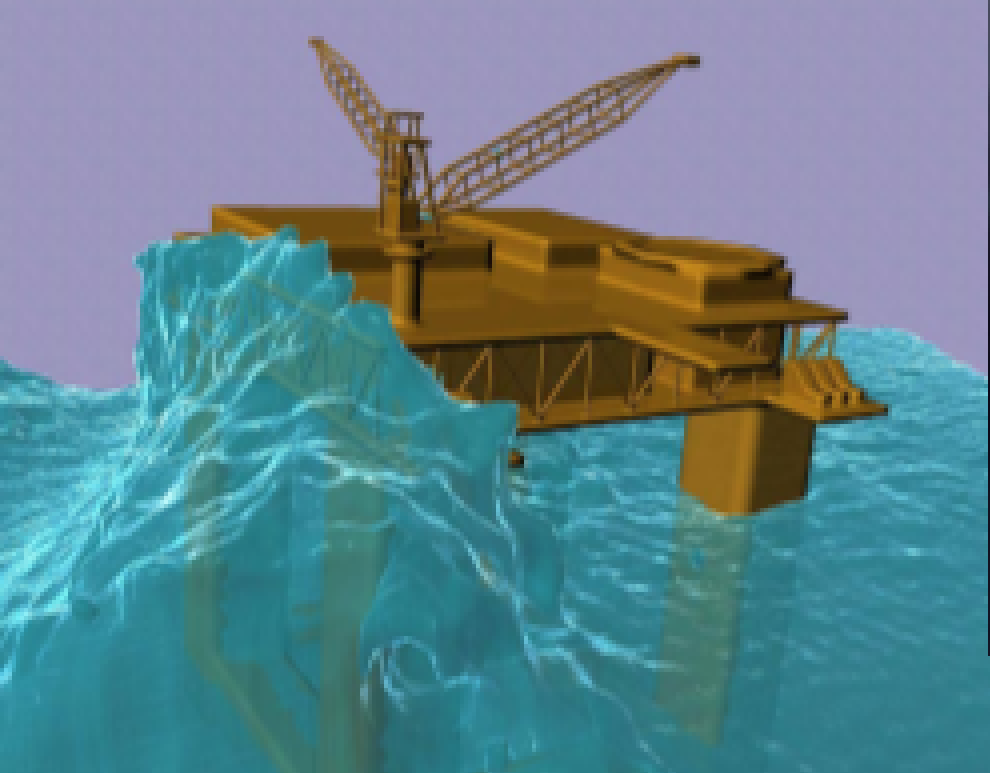
Biologists required data

EPISTEMOLOGICAL BELIEFS WEAPONIZED

Dug up feelings of “not belonging” and
“disciplinary microaggression”

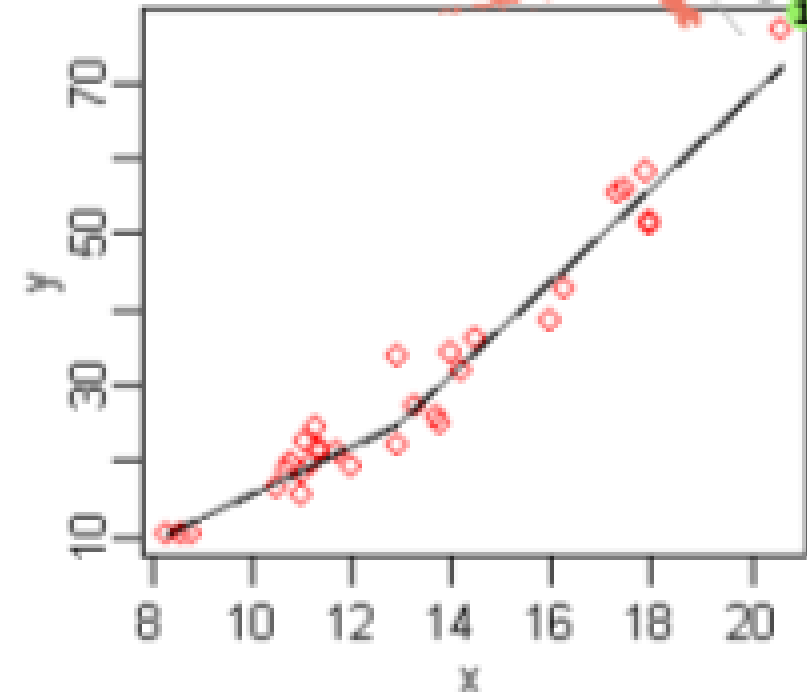
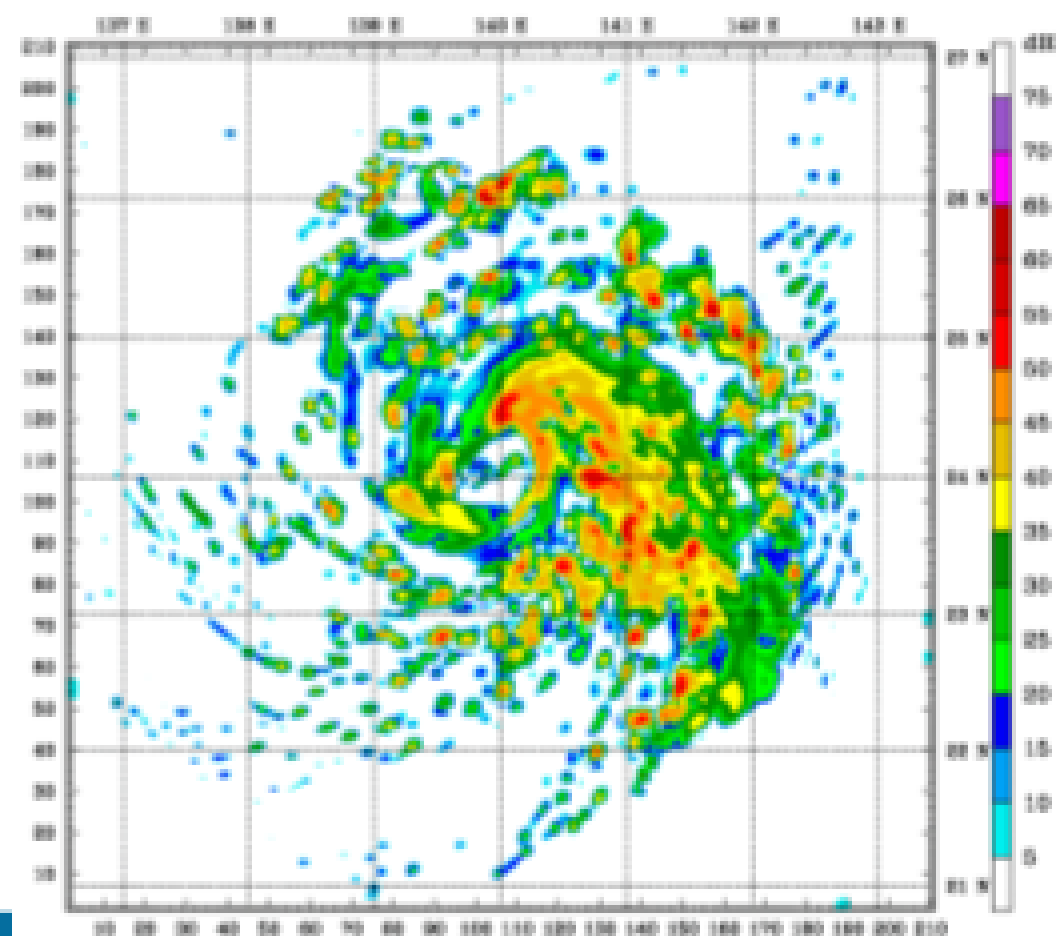
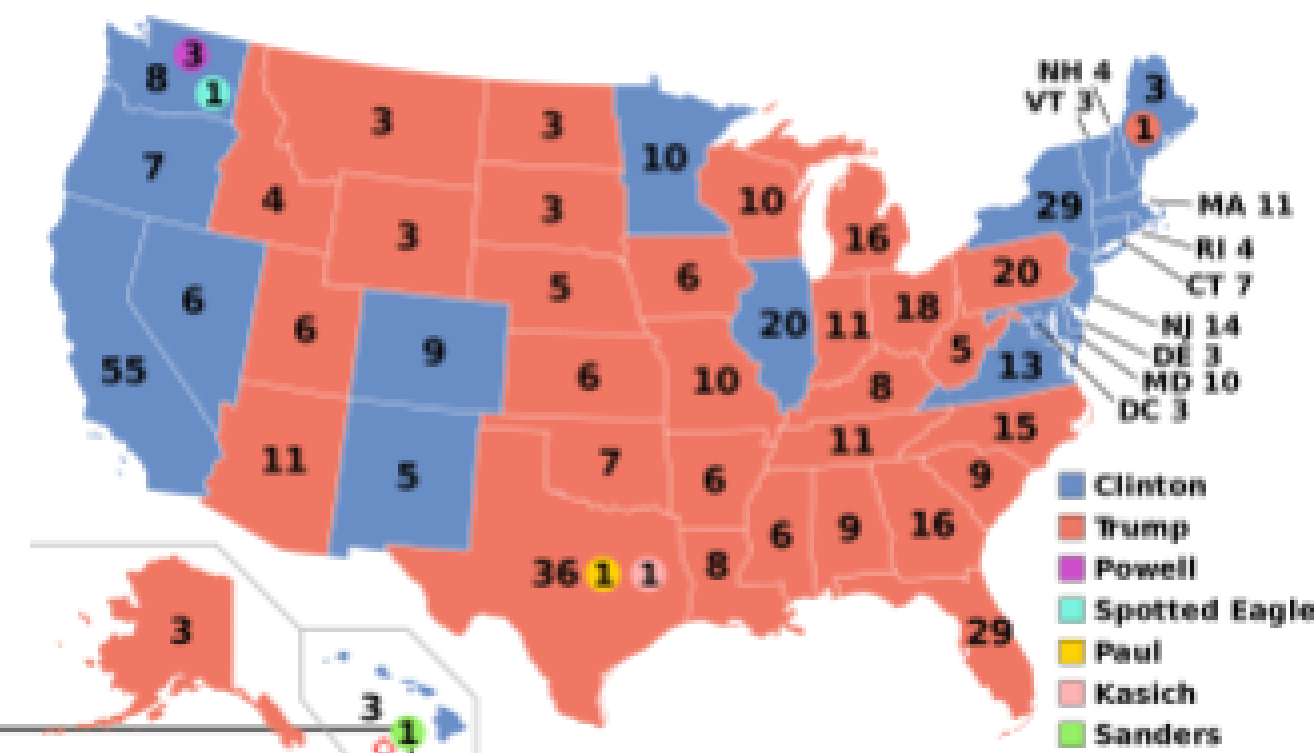
THIS WORK IS NOT NEUTRAL

Our scientific constructs are not necessarily
independent of our social constructs, need
inclusive language/frameworks for innovation



t	p
0	1
1	1
2	2

They Are All Models





Models and microagressions

UPDATING OUR MODEL

"A model is a simplified, abstract or concrete representation of relationships and/or processes in the real world, constructed for some purpose"



Verbal

“The rate of population growth is proportional to its size.”

Numerical

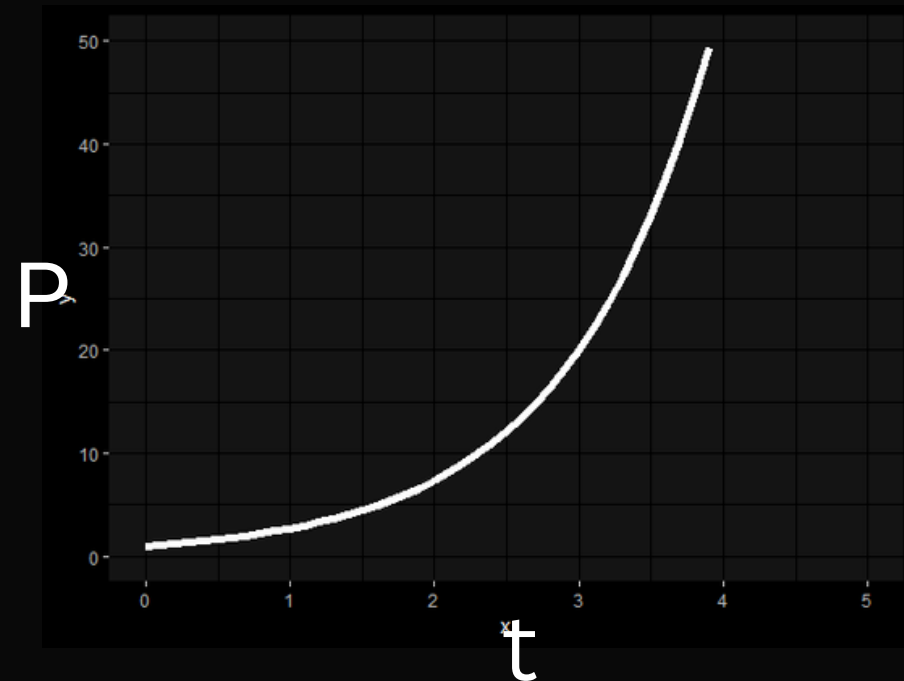
t (year)	P (per hectare)
0	56.1
1	63.2

They are all Models

Experiential

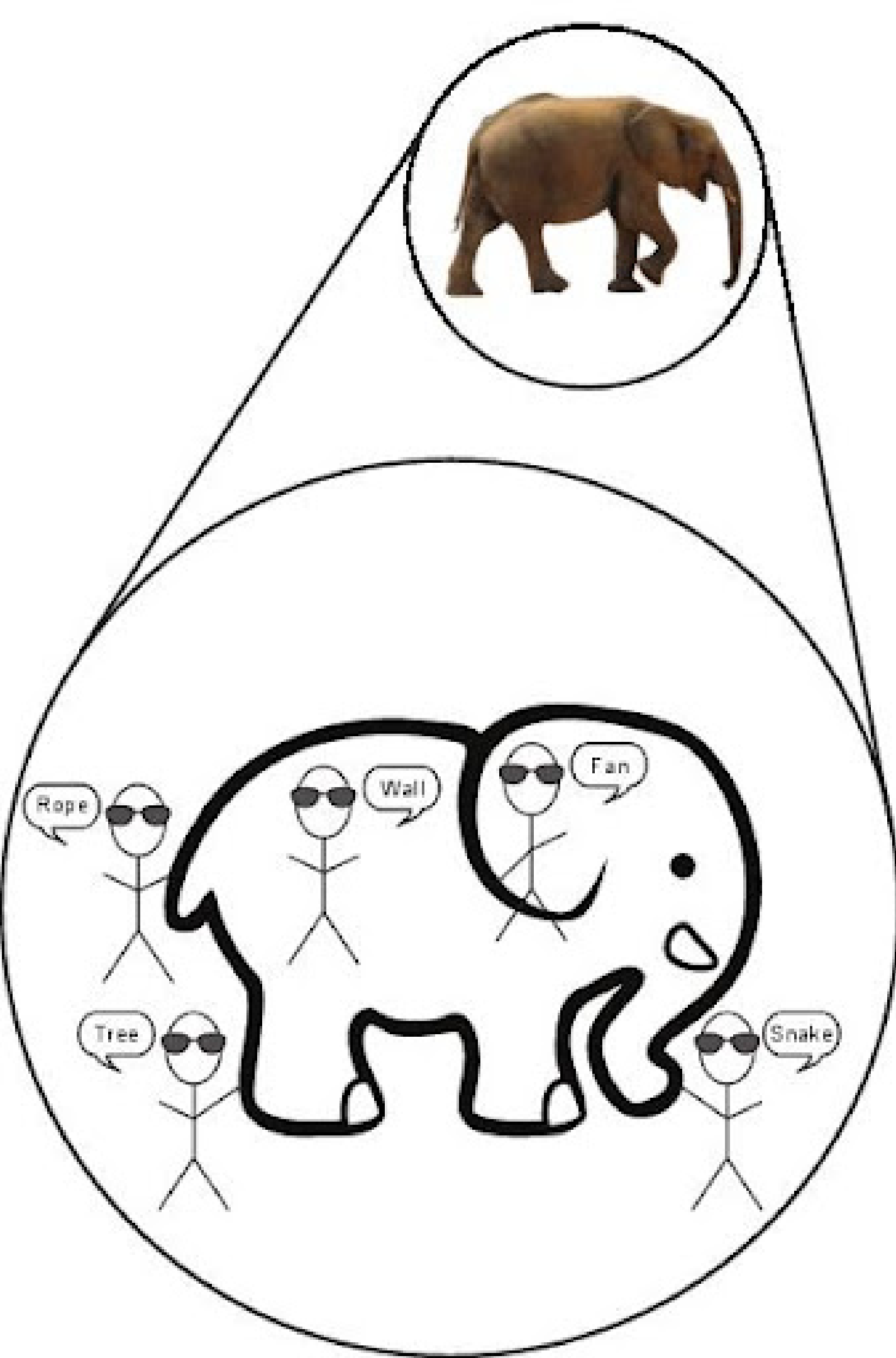


Visual



Symbolic

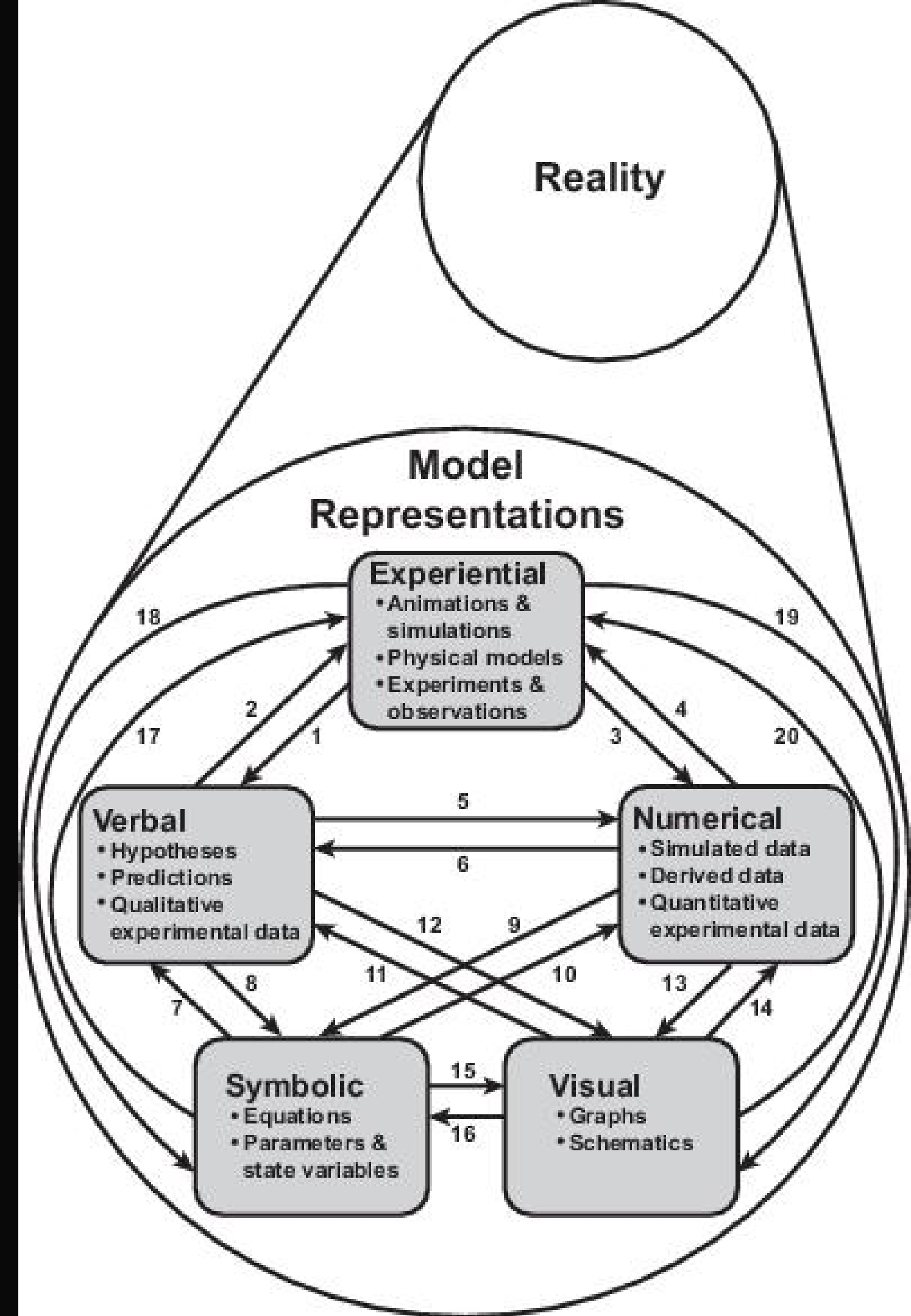
$$\frac{dP}{dt} = rP$$



Unifying framework
allows for students
(and all of us?) to
bring strengths/
*cultural wealth
into learning &
research

saber vs conocer

*YOSSO 2005



Intersectional approach

DISCIPLINARY IDENTITIES INTERACT WITH SOCIAL IDENTITIES

Intersectionality is a framework to discuss how race, gender and class identities introduce multiple, intersecting, and potentially multiplicative axes of oppression (Crenshaw, 1991).

Revising my model

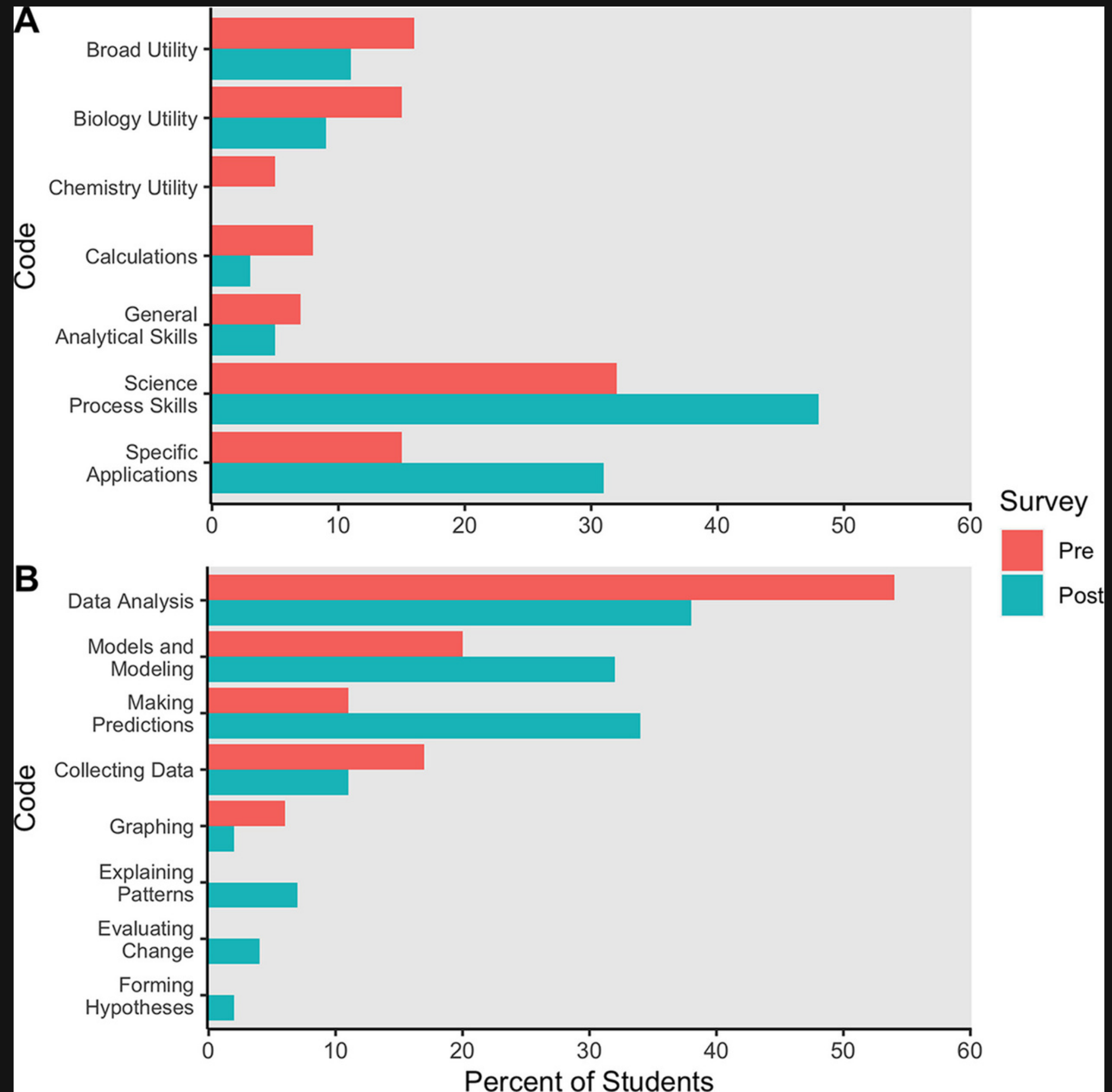
Emphasizing models and data

- Explained the Rule-of-Five framework in class and positioned where statistics is useful and where calculus and modeling are useful
- Referenced the framework repeatedly and encouraged students to explore concepts using the representation they feel most comfortable with - especially on exams
- Showed videos of exponentially growing bacteria (with Jaws sound effects)
- Used Mauna Loa long term CO₂ data set to connect with climate change concerns
- Added exponential data fitting - including log transformation

Results

Collab w/Aikens & Highlander Callender

Improved understanding of science process and Modeling & with specificity

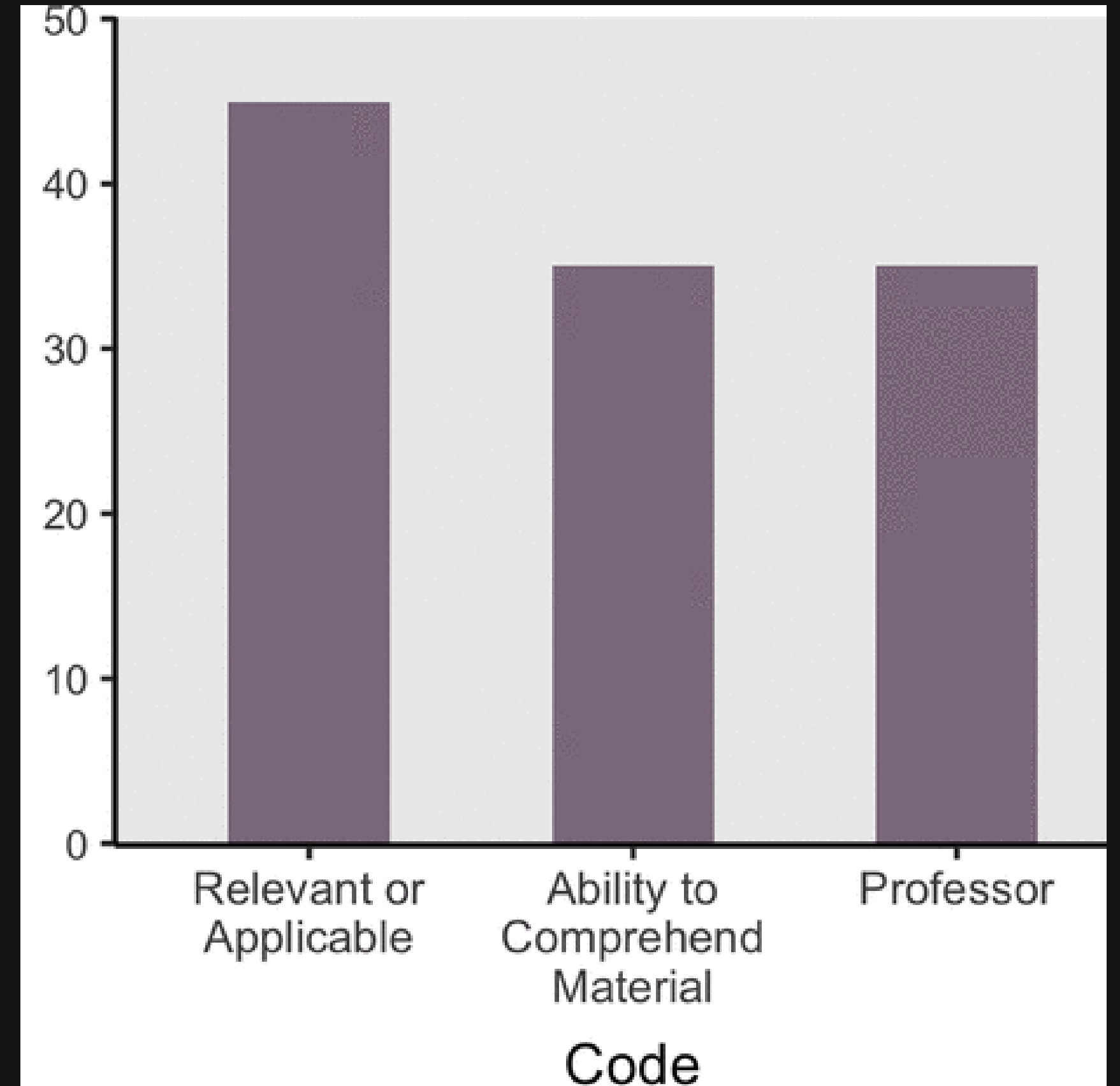


Relationships and Care

Intertwining and intersection of Interdisciplinarity and inclusiveness

Quant: Learning outcome drop

Qual: Why did interest increase?



Relationships and Collaboration

SUMMIT-P: CORaL Lab at Unity College
MARINE BIOLOGY





Results

Experiential



Revising my model

Emphasizing experiential, emphasizing context

- Sat in each other's classes (and took data on where calculus appeared in intro bio)
- Involved students as co-authors of educational research
- Built on Mauna Loa CO₂ project to connect climate change with coral reefs and bleaching
- Added field work drawing transactions of an outside location
- Added reading contour maps of Acadia National Park when introducing partial derivatives
- Flipped unit project's introduction to the beginning of the course w/motivating question

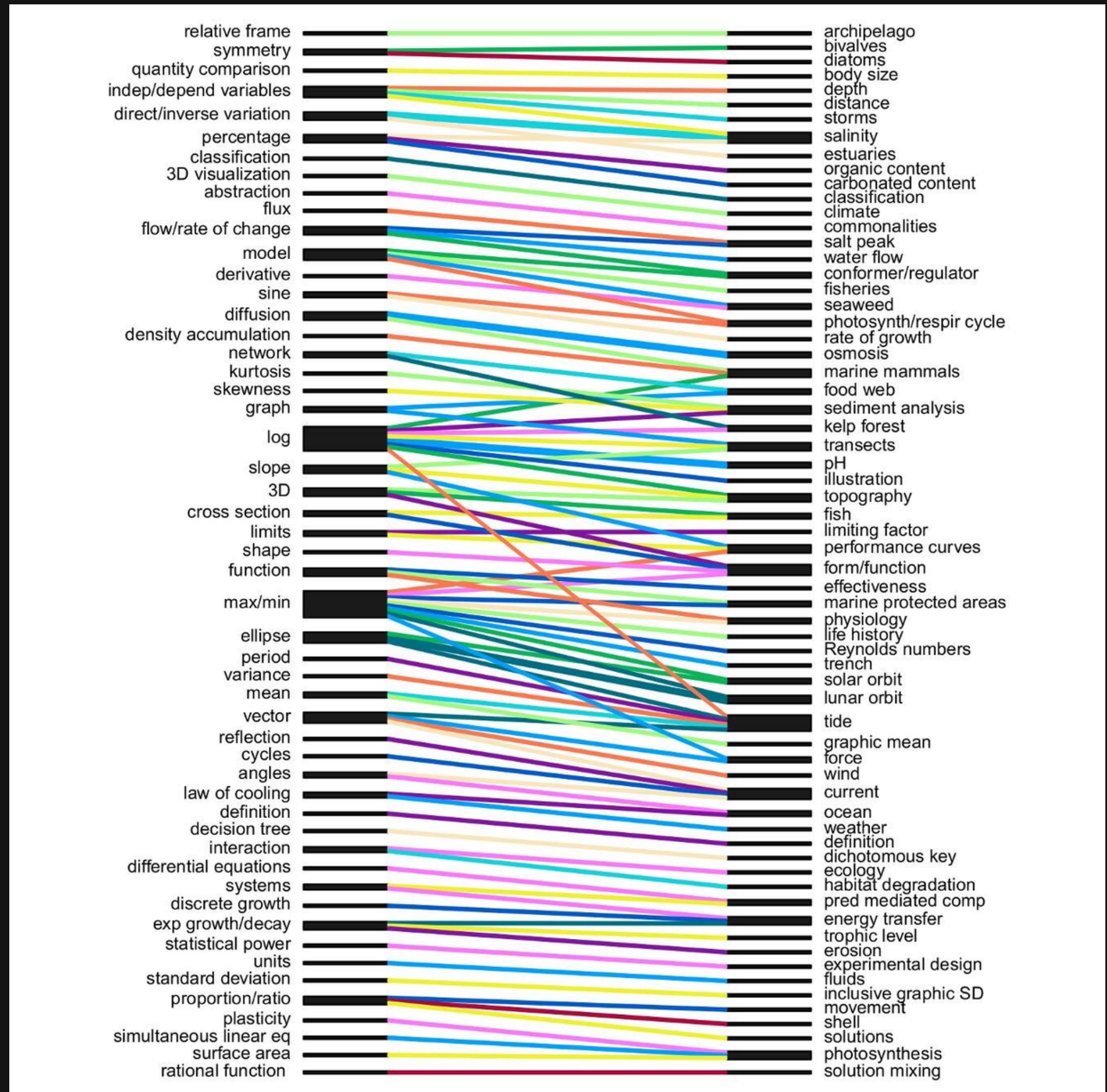
More Results

Collab w/ students
Nietzel and Zhao

Marine Biology and
Calculus as Coevolving

Appreciated for how
much and different
algebra and calculus
were in Intro Marine Bio

Neitzel et al in review



Humanizing and Contextualized

MORE THAN JUST CORAL

DON'T SAVE THE BEST FOR LAST

Anecdotal increase of engagement. Translates early why we are going to set up these new math concepts.

COMPELLING NARRATIVE

New and genuine marine biology narrative and language (co-authored with Emma) vaulted this project into top 2 favorites mentioned by students

STILL CONTENT...WHAT ABOUT HUMANS?

Next revision involved contextualizing whose data...Ingenious Data Sovereignty and Colonization and the fight over Mauna Kea

“

**"I don't teach math, I teach people
about math"**

Mr. Adams quoted in *The Power of Middle School*, Babbage (and others)



Changing priorities



- Communities of care & radical grace*
- Universal Design for Learning
- Agency for activism

Price and Savić (2022)

Revising our Model: mathematics teaching is not neutral



IF WE TEACH PEOPLE,

We need to understand how we historically oppress and disempower people - and then how we can intentionally support and empower instead.

Let's discuss!

Thank you so much for the invitation!

Work supported in part by the NSF, Hewlett Foundation



To get involved in leading an open and inclusive STEM see riosinstitute.org

