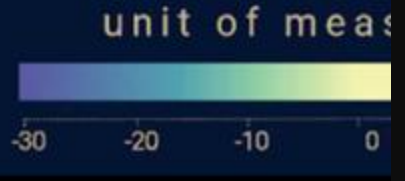
How can the progressive education pedagogy make math and AI education more efficient for atmospheric sciences?





Sam Shen, San Diego State University (SDSU)

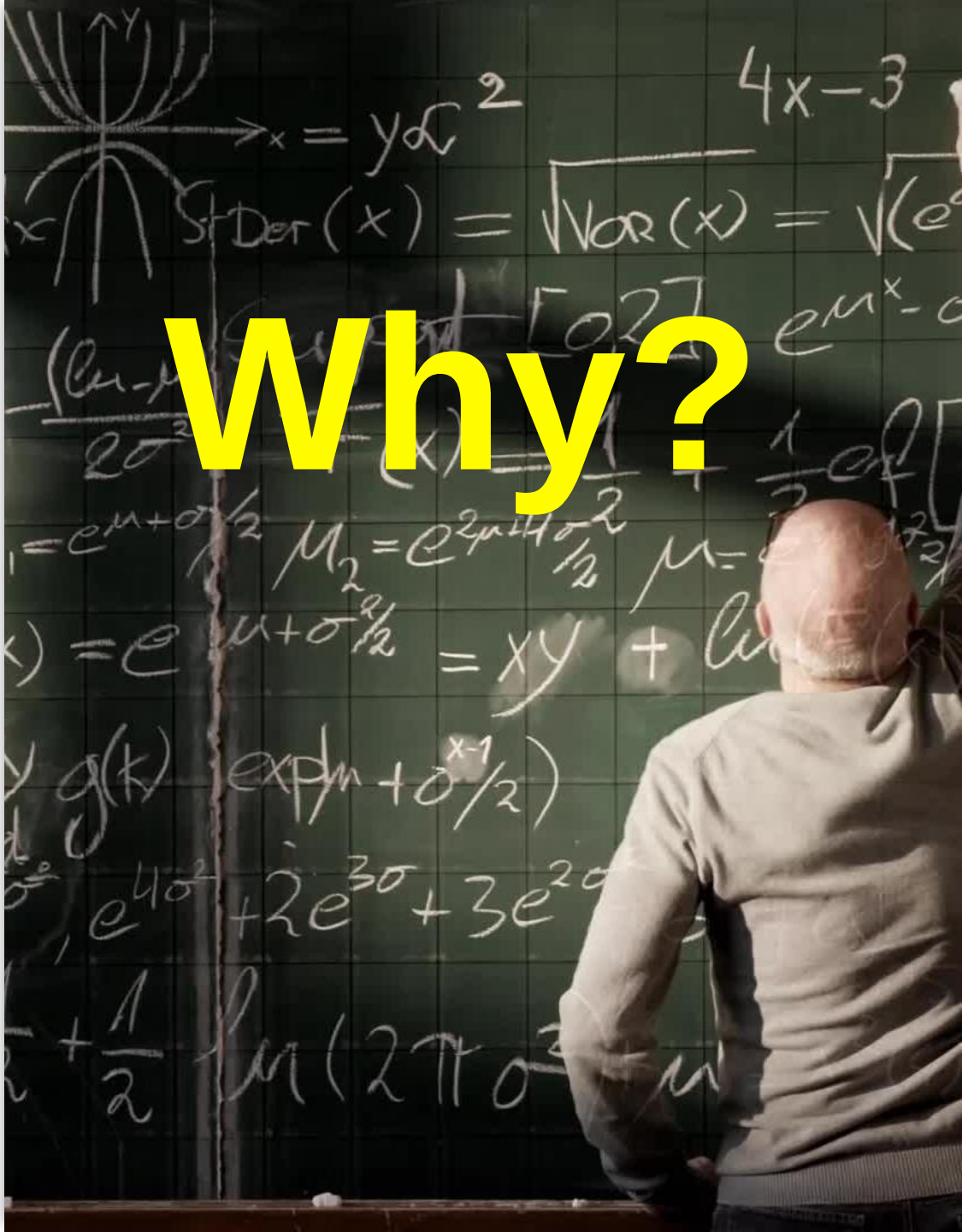
Elizabeth Mulvihill, University Corporation for Atmospheric Research (UCAR)

Richard Somerville, Scripps Institution of Oceanography, UCSD

The conclusion from a 2019 UCAR survey

- Mathematics is by far the greatest challenge faced by undergraduate university students when they enter a meteorology program

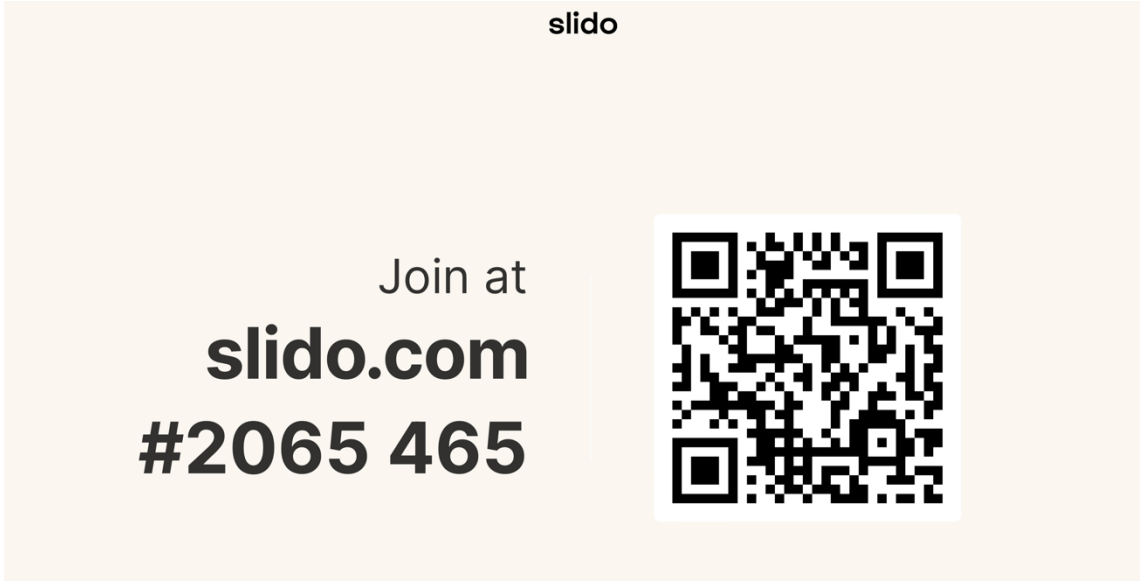
- Page, E., S.S.P. Shen, and R.C.J. Somerville, 2024: Can we do better at teaching mathematics to undergraduate atmospheric science students? *Bulletin of the American Meteorological Society*. DOI:https://doi.org/10.1175/BAMS-D-22-0245.1



A Slido Audience Q&A

- **The failure rate of College Calculus I and II is more than 30. Why are college calculus courses so difficult and scary?**

- **Instruction: Please use your phone or computer to scan the QR code or enter the Slido number # to enter your answer to why.**
- **Audience Q&A**



slido

Please download and install the Slido app on all computers you use

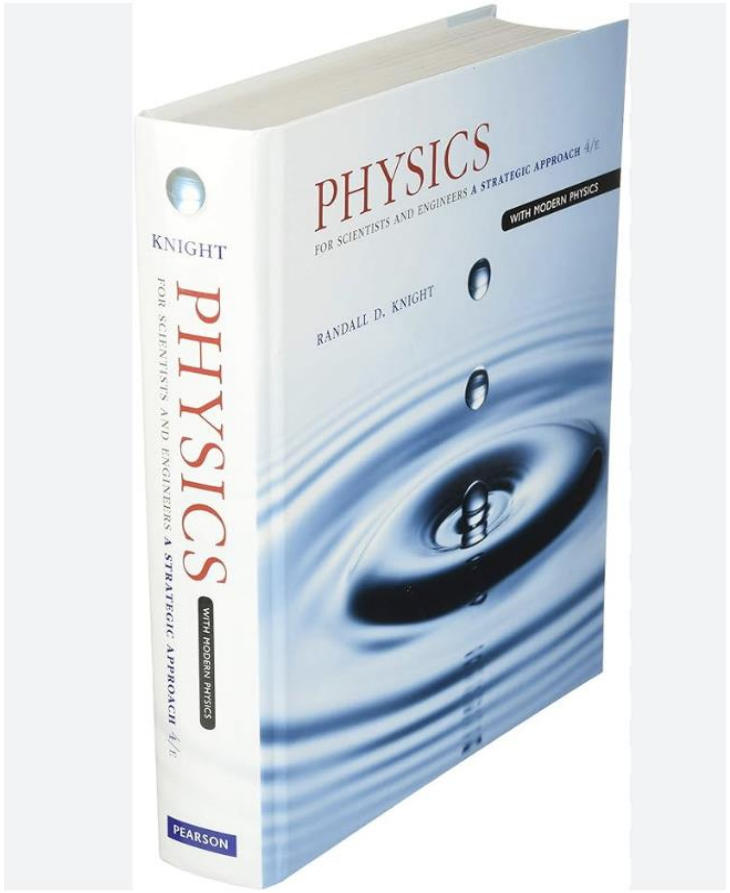


The failure rate of College Calculus I and II is more than 30. Why are college calculus courses so difficult and scary?

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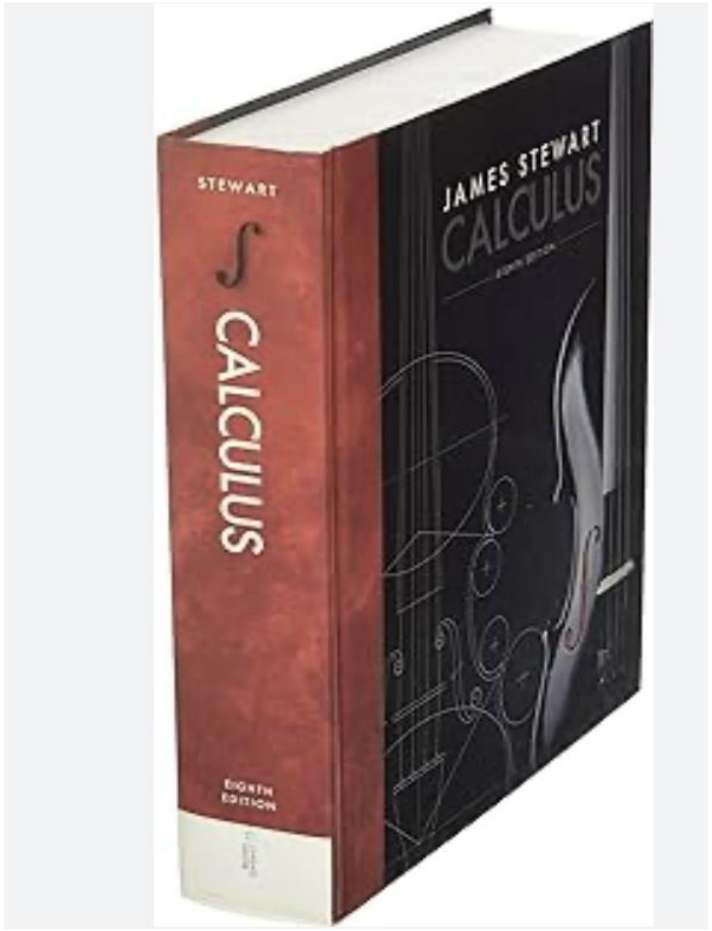
ⓘ Start presenting to display the audience questions on this slide.

This is why!



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- **A discriminative system of many obsolete and useless materials, such as the 1300 pages of calculus and physics books, is set to fail many students.**
- ***"We may not be discriminative, but many of us are protecting a discriminative system."***
- **A modernized curriculum is needed to help students learn modern and useful materials relevant to students' majors.**

What must today's students learn?

- Computer languages like Python or R
- CSV, netCDF or JSON data analysis and visualization
- Empirical orthogonal functions (EOFs) computed by singular value decomposition (SVD)
- Calculus concepts with meteorology and oceanography examples
- Model assumptions, statistical assumptions, and storytelling

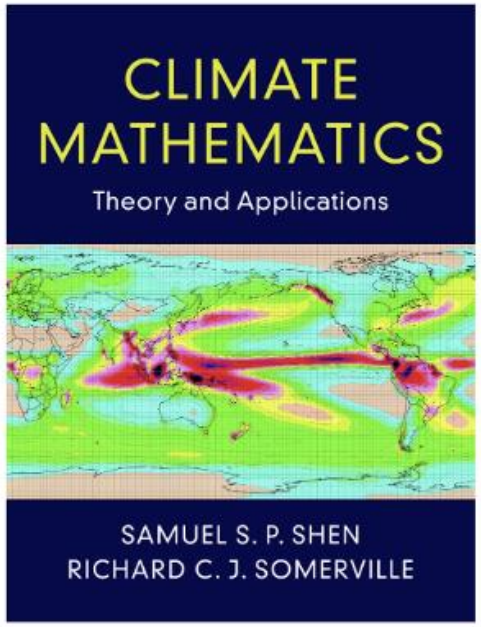
However, these methods were NOT included in the current undergraduate math courses for meteorology and oceanography students in many universities even five years ago.

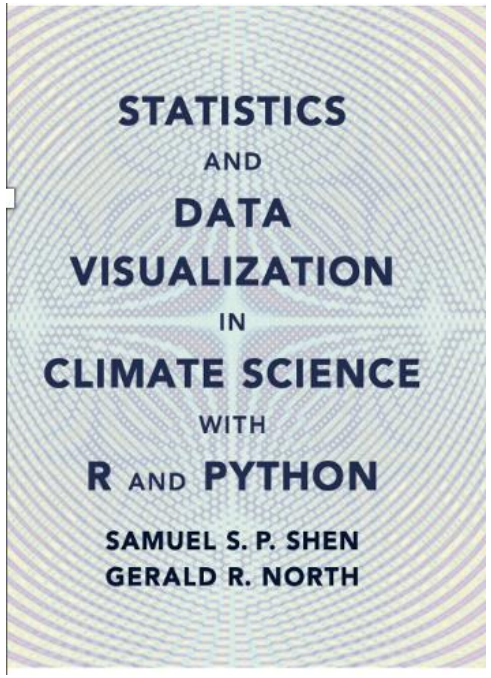
Principles of progressive education for the modernization of math and AI instructions

- Learning-by-doing vs the traditional learning-by-memorizing
- Students' needs vs the traditional instructors' interest
- RUM principle: Relevant, Useful, and Modern materials vs obsolete text
- GUT actions: Go to daily life motivations, Use modern computers, and Tell calculus stories, vs the traditional pen-on-papers

How?

- **Modernize textbooks: Examples with Cambridge University Press**





Modernize instructors: Example skills

- Use ChatGPT and other AI tools
- Good at Python or other modern computer languages
- Use Slido, big data, and other interaction tools
- Ready to help students find internships and jobs

Example: How to measure the area of a lake?

Ans: Use Green's theorem, ChaptGPT/DALL.E, and a phone

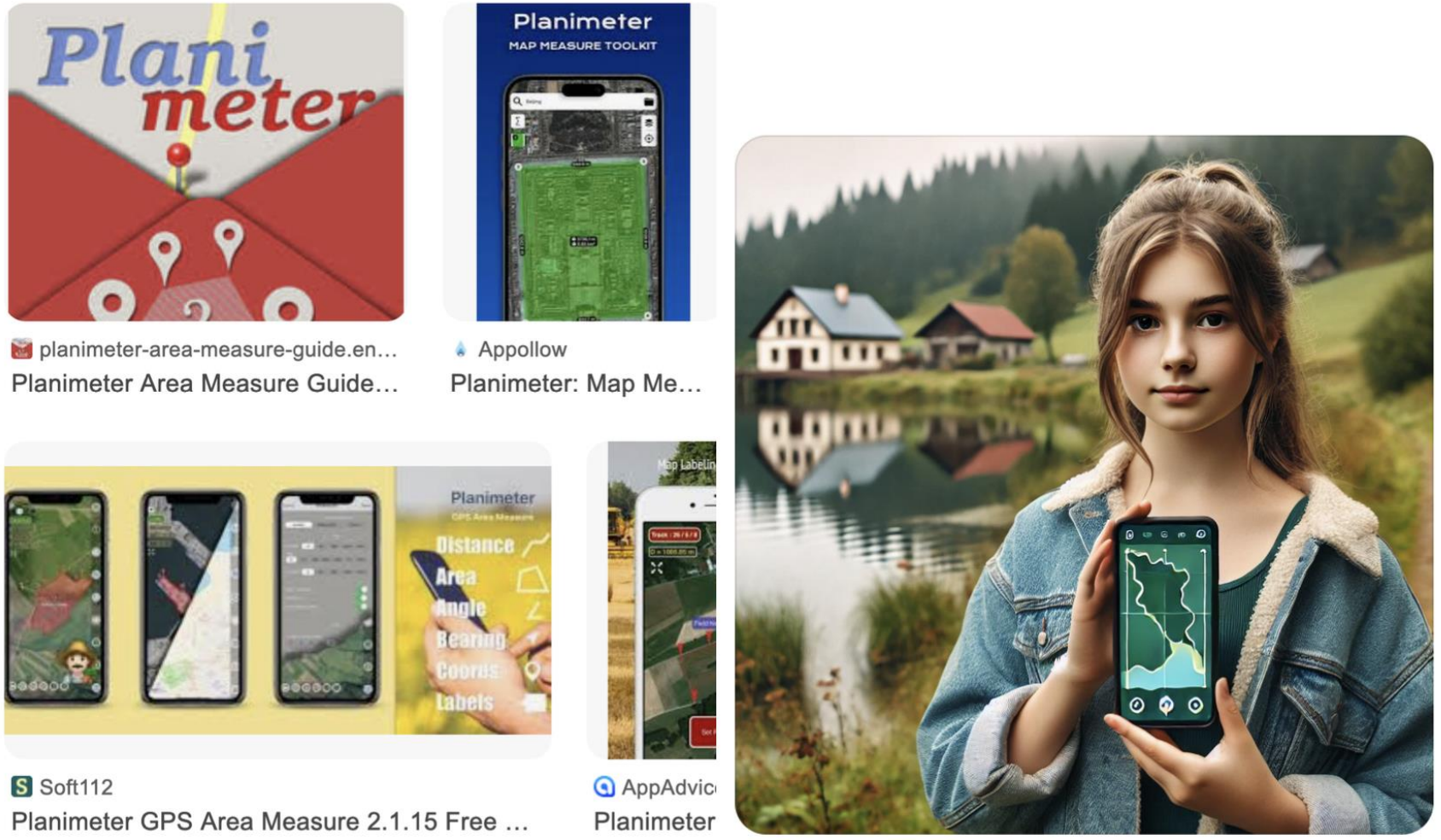


Fig. 1.9 Left: Planimeter apps. Right: A college student tries to measure a lake using a planimeter on her phone.

What is the purpose of Calculus ?

Isaac Newton 1671

56. I. *The Length of the Space described being continually (that is, at all Times) given; to find the Velocity of the Motion at any Time proposed.*

57. II. *The Velocity of the Motion being continually given; to find the Length of the Space described at any Time proposed.*

Elie Cartan 1945

Modern calculus concepts based on the generalized Stokes' theorem by Elie Cartan 1945: Use boundary data to predict inside

A thread: A line segment's boundary
Is two points, i.e., red points
[Fundamental theorem
Of calculus]



A hat: An open surface's boundary
Is a closed contour, i.e., red rim
[Stokes' theorem and
Green's theorem]



A potato: A solid body's boundary
Is a closed surface: i.e., potato skin
[Divergence theorem]

Integrate [Derivative of the physics] with the dimension of the domain

$$\int_{Domain} dP$$

Integrate [Original physics] with the dimension of the domain boundary.

$$\int_{Boundary} P$$

Conclusions on "*How can the progressive education pedagogy make math and AI education more efficient for atmospheric sciences?*"

- **Learning-by-doing pedagogy in progressive education**
- **RUM principle: Relevant, Useful, and Modern materials**
- **GUT actions: Go to daily life motivations, Use modern computers, and Tell calculus stories, vs the traditional pen-on-papers**
- **Modernized textbooks and modernized instructors**
- **Modernized education systems, e.g., AI-based curricula**

YouTube by Samuel Shen and Richard Somerville

- Part 1: https://www.youtube.com/watch?v=bCQVLvomHYg
- Part 2: https://youtu.be/ARVHl6-xyhw
- English with subtitles
- Part 1: https://www.youtube.com/watch?v=jrITwXeIjJU
- Part 2: https://www.youtube.com/watch?v=nra4eCXlyko
- Spanish subtitles
- Part 1: https://www.youtube.com/watch?v=wNBXQ2WptUg
- Part 2: https://www.youtube.com/watch?v=wnkgTZeoP_g
- Chinese subtitles
- Part 1: 如何将大气海洋科学中的数学教育现代化：上集
- https://www.youtube.com/watch?v=YexzaWwlicw
- Part 2: 如何将大气海洋科学中的数学教育现代化：下集
- https://www.youtube.com/watch?v=S5cVKapjjEM
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