UTMOST: A JOURNEY THROUGH OPEN SOURCE TEXTBOOKS

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SOME BACKGROUND

Abstract Algebra: Theory and Applications (AATA) was first published by PWS in 1994.

There was a second printing but no second edition.

After PWS merged with Brooks/Cole, AATA went out of print.

I assumed ownership of the copyright in 1997.

AATA sat idle until 2008.

ABSTRACT ALGEBRA
theory and applications

Thomas W. Judson

2023 edition

orthogonal publishing l3c
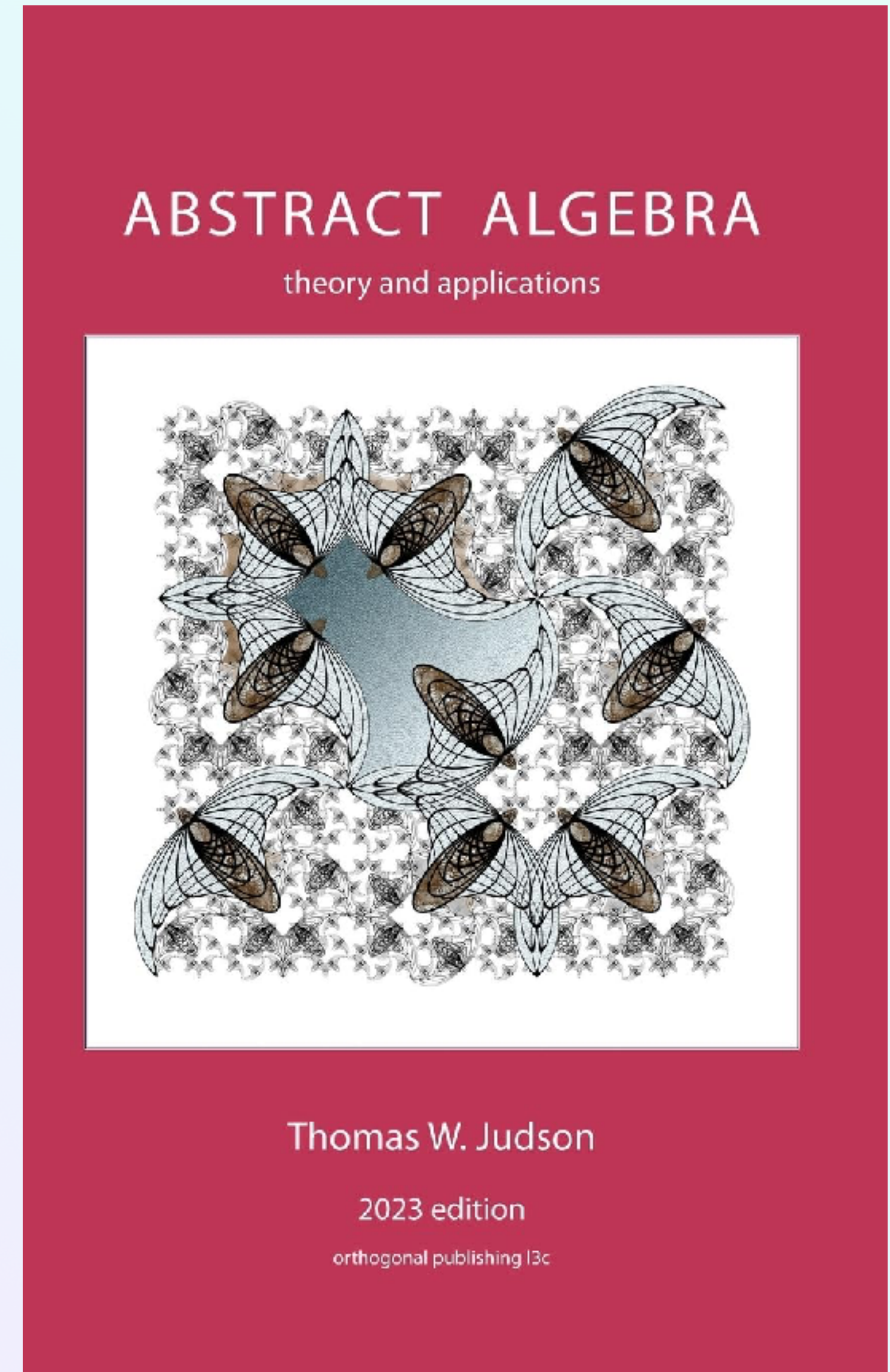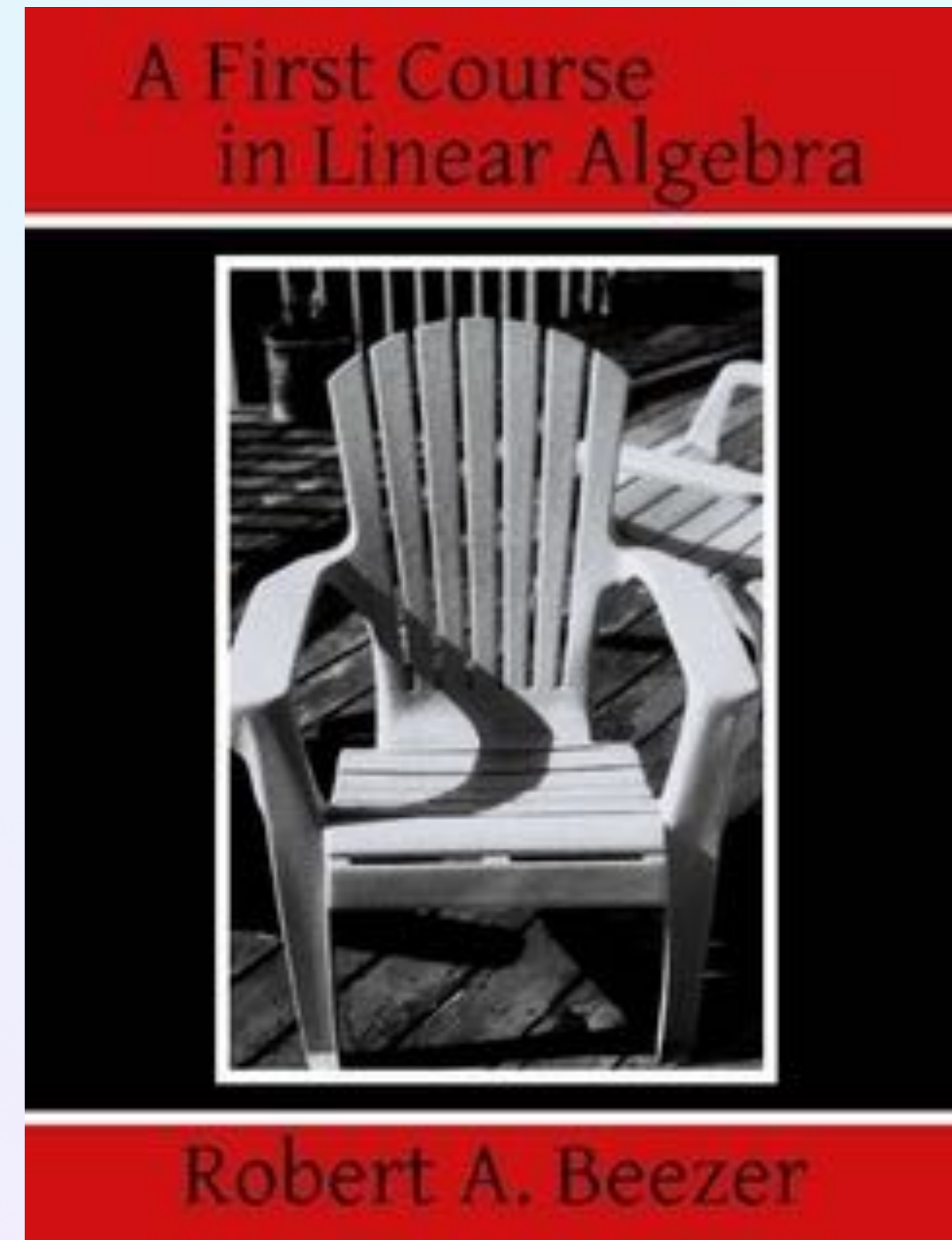
FIRST COURSE IN LINEAR ALGEBRA (FCLA)

FCLA began as an experiment almost 20 years ago.

FLCA was open source (GDFL) from Day 1.

Version 1.0 was released Summer 2004.

An online version was released Summer 2008.

At Rob Beezer's urging, AATA became open source in 2008 with a full text version released in early 2009.

A First Course in Linear Algebra

Robert A. Beezer

WHAT IS UTMOST?

- **UTMOST = Undergraduate Teaching of Mathematics with Open Software and Textbooks**

- **The focus of the UTMOST Project, funded by the National Science Foundation, is to understand how students and faculty actually use textbooks in undergraduate mathematics courses and to use that understanding to produce textbooks that are more effective in promoting student learning. The major components of the project involve education research, resource development, dissemination, and evaluation.**

UTMOST PRODUCTS

- **CoCalc**

- **PreTeXt**

- **Sage Cell Server**

- **Educational Research on How Students and Faculty Use Textbooks**

- **American Institute of Mathematics (AIM) Open Textbook Initiative (https://aimath.org/textbooks/)**

BEGINNINGS OF UTMOST

- **UTMOST is a byproduct of Sage (an open source computer algebra system). Sage was founded by William Stein in 2005. There have been periodic "Sage Days," workshops to develop and maintain Sage.**

- **Sage Days 18 was in Cambridge, MA (December 1–5, 2009) included a Sage Education Day on December 5.**

UTMOST I: UNDERGRADUATE TEACHING OF MATHEMATICS WITH OPEN SOFTWARE AND TEXTBOOKS (DUE-1022574)

- 2010–2014: $525,000 collaborative grant from National Science Foundation with American Institute of Mathematics, Drake University, Stephen F. Austin State University, University of Colorado, and University of Washington

- William Stein (UW): Sage, SageMathCloud

- Jason Grout + Students (Drake University): Sage Cell

- Tom Judson (Stephen F. Austin University): Abstract Algebra textbook (first book written in PreTeXt)

- David Farmer (AIM): Knowls, FCLA CSS

- Kent Morrison (AIM): AIM Open Textbook Initiative

- Kiran Kedlaya (UC-San Diego)

- Rob Beezer: (University of Puget Sound) Mathbook XML (now PreTeXt)

UTMOST II: UNDERGRADUATE TEACHING OF MATHEMATICS WITH OPEN SOFTWARE AND TEXTBOOKS (DUE-1022574)

- 2016–2018: $700,000 collaborative grant from National Science Foundation with American Institute of Mathematics, Stephen F. Austin State University University of Colorado, and University of Michigan, an University of Puget Sound

- Vilma Mesa (University of Michigan): Educational Research

- Tom Judson (Stephen F. Austin University): Abstract Algebra and ODE Textbooks, Sage Cells, Educational Research

- David Farmer (AIM): Knowls, CSS for PreTeXt

- Kent Morrison (AIM): AIM Open Textbook Initiative

- Kiran Kedlaya (UC-San Diego)

- Rob Beezer: PreTeXt

UTMOST III: UNDERGRADUATE TEACHING OF MATHEMATICS WITH OPEN SOFTWARE AND TEXTBOOKS (DUE-1022574)

- 2018–2022: $2,000,000 collaborative grant from National Science Foundation with American Institute of Mathematics, Stephen F. Austin State University University of Colorado, and University of Michigan

- Vilma Mesa (University of Michigan)

- Tom Judson (Stephen F. Austin University)

- David Farmer (AIM)

- Kent Morrison (AIM)

- Kiran Kedlaya (UC-San Diego)

- Rob Beezer

WHY OPEN SOURCE?

- **Definition: A textbook is *open* if the copyright holder explicitly allows unlimited copying, and the distribution of modified versions.**

- **Gnu Free Document License (GFDL) and Creative Commons (CC) are the main open source licenses.**

- **Free from market forces and available at zero or low cost**

- **Availability—Every student has a book on the first day of class.**

- **Interactive versions**

- **Ease of maintenance**

ZERO OR LOW COST

Commercially published textbooks are expensive

- **J. Gallian. *Contemporary Abstract Algebra*, 10th Edition—$79.96**

- **T. Hungerford. *Abstract Algebra: An Introduction*, 3rd Edition—$164.95**

- **James Stewart. Calculus, 8th Edition—$329.95**

- **Matt Boelkins, David Austin, & Steven Schlicker. *Active Calculus*—Free ($20.05 for a print copy)**

- **Thomas W. Judson. *Abstract Algebra: Theory and Applications (AATA)*—Free ($16 and $23 for a print copy)**

AVAILABILITY

Open source books are universally available via the Internet.

Open source textbooks can be made available in a variety of formats: print, PDF, HTML, ePub, Jupyter Notebooks, and braille.

Open source textbooks can be read on a variety of devices: paper, desktop, laptop, tablet, smartphone, Kindle.

Commercial publishers have difficulty duplicating the access that open source textbooks can provide.

OTHER ADVANTAGES

- **Interactive Features: GeoGebra (geometry demonstrations), JSXGraph (interactive graphs), WeBWorK (homework system), Skulpt (in-browser Python), Sage Cells (open source Mathematica, Maple, Matlab), Audio and Video players, MathJax (typesetting math).**

- **Maintenance: Every reader is a copy-editor (students are the best), typos and errors can be fixed easily and quickly.**

- **Freed From Market Sources: The best book for the course that you are teaching is the one that you wrote and others may find your book useful.**

- **Open source textbooks written in PreTeXt are accessible.**

DIGITAL TEXTBOOKS

- Some digital textbooks are simply <u>PDF files</u>. Maybe the PDF will include hyperlinks.

- Many publishers now offer their text in a digital format in addition to the hardbound version.

- PreTeXt

  - PreTeXt is a set of XML tags and is structured in a manner very similar to LaTeX. Extensible Markup Language (XML) is a markup language that defines a set of rules for encoding documents in a format which is both human-readable and machine-readable (<u>https://pretextbook.org/</u>).

  - PreTeXt source is processed by XSLT (Extensible Stylesheet Language Transformations) into the target format—print, HTML, PDF, ePuB, and braille.

  - Books created with PreTeXt can be hosted on the Runestone Academy (<u>https://landing.runestone.academy/</u>)

  - PROSE (<u>https://prose.runestone.academy/</u>)

A SIMPLE PRETEX EXAMPLE

```xml
<?xml version="1.0" encoding="UTF-8"?>
<pretext>
  <book>
    <title>Hello World!</title>
    <chapter>
      <title>My Great Chapter</title>
      <p>This is a PreTeXt document.</p>
    </chapter>
  </book>
</pretext>
```

WHAT ABOUT THE MATH?

```
<me>
  \frac{d}{dx} \int_1^x \frac{1}{t}\, dt
</me>
```

produces

$$\frac{d}{dx} \int_1^x \frac{1}{t}\, dt$$

WHAT IS POSSIBLE IN PRETEXT

- Check out the showcase (https://pretextbook.org/examples/showcase/html/frontmatter.html) and sample articles (https://pretextbook.org/examples/sample-article/html/derivatives.html).

- The PreTeXt catalogue (https://pretextbook.org/catalog.html) now lists 80 projects.

- PreTeXt is now the authoring language for Runestone (https://runestone.academy).

EDUCATIONAL RESEARCH

- The education research concentrates on the use of textbooks in calculus, linear algebra, and abstract algebra, which are courses that are taught in every mathematics department.

- The experimental course sections use highly interactive online textbooks, while the control sections use more traditional textbooks.

- The online versions work with a tracking system to provide data about the time and duration of individual student attention—suitably anonymized—to the various parts of the textbook at a detailed level.
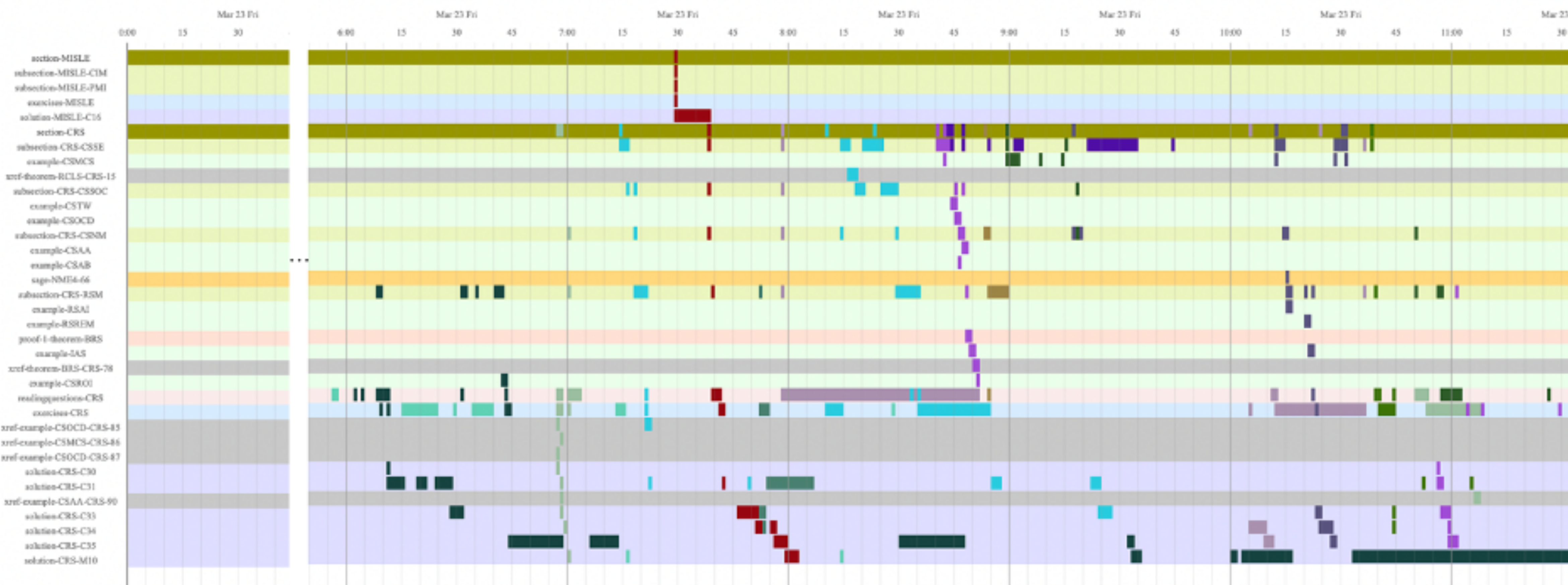
COLLECTING DATA

USING PRETEXT, WE CAN COLLECT DATA AT ONE SECOND INTERVALS

Class summary of viewing FCLA by 411008

Total count in each section, each day (5+139)
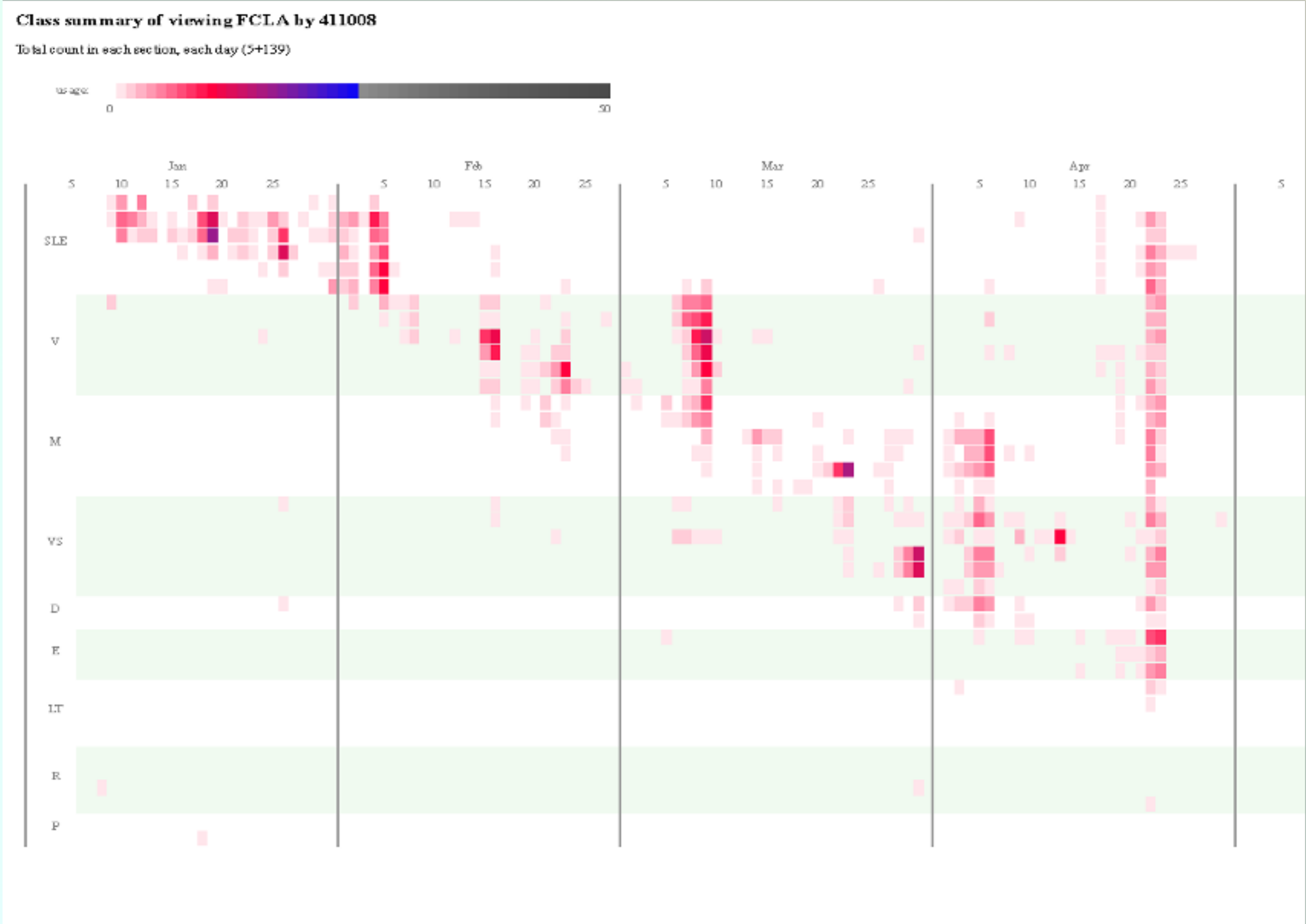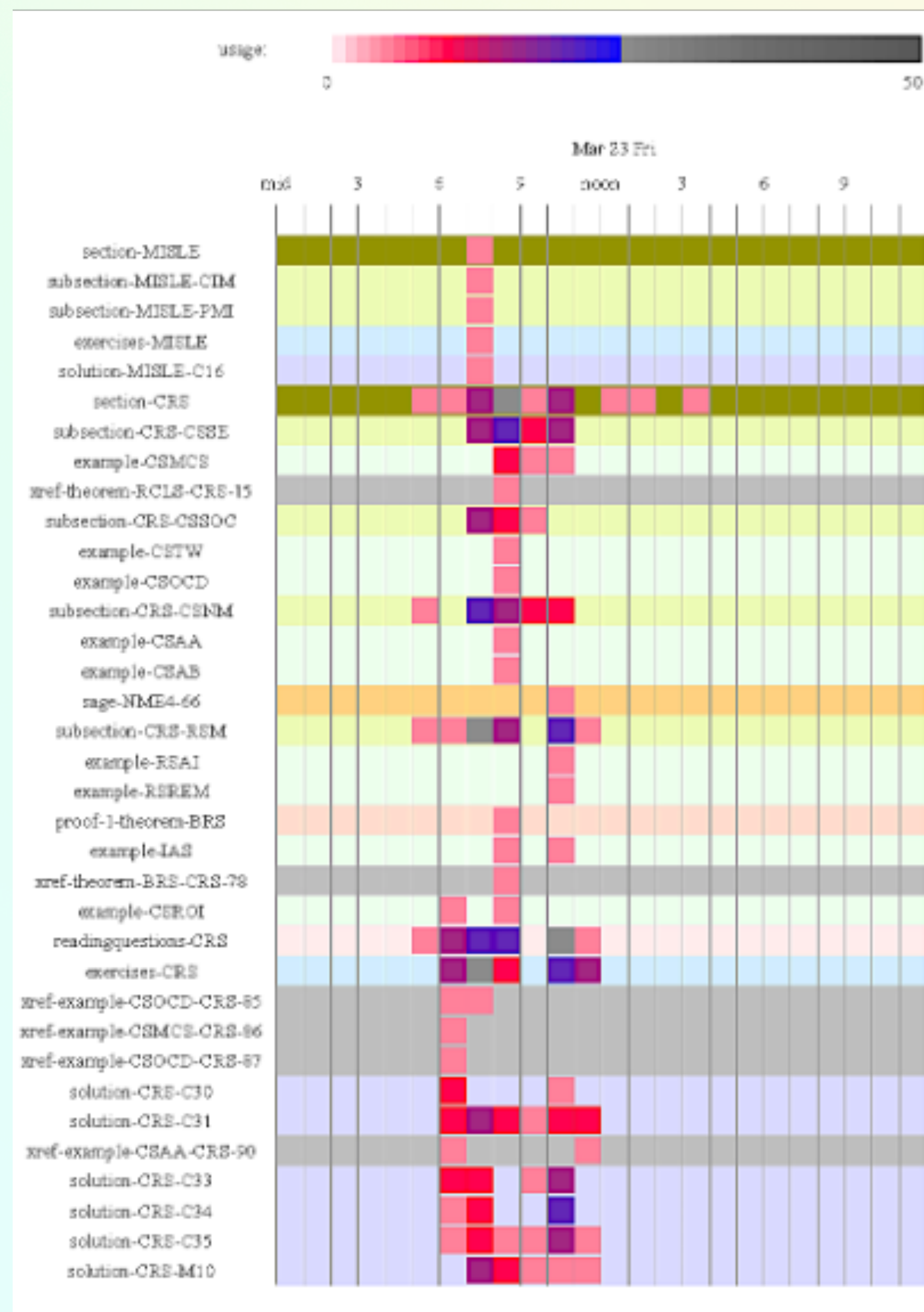
Class summary of viewing FCLA by 411008

Usage within Chapter M, on one day, per minute(82+1)

QUESTIONING DEVICES

- A questioning device is simply a set of questions each followed by a box in which students type their answers directly into the textbook. They are called Reading Questions in *FCLA* and *AATA* and Preview Activities in the *Active Calculus*.

- Questioning devices ask students to think about the material before class and give faculty a chance to reflect on their plans for the day and respond to students' productions as they read material before class.

WILA Reading Questions ¶

1. Is the equation $x^2 + xy + \tan(y^3) = 0$ linear or not? Why or why not?

Reload responses

A1104401	24 Jan 11:22

It is linear. It contains at least two variables and has addition and it is equal to a constant.

A1104403	19 Jan 11:28

This is not linear because there is an x that is squared and a y that is cubed

A1104404	19 Jan 20:54

This equation is not linear. This is because linear equations only typically involve multiplication and addition. This equation also contains a trig function, which is not a linear function.

A1104405	23 Jan 18:47

no because when I plugged the equation in desmos it was not linear. I think it is because of the tan(y^3)

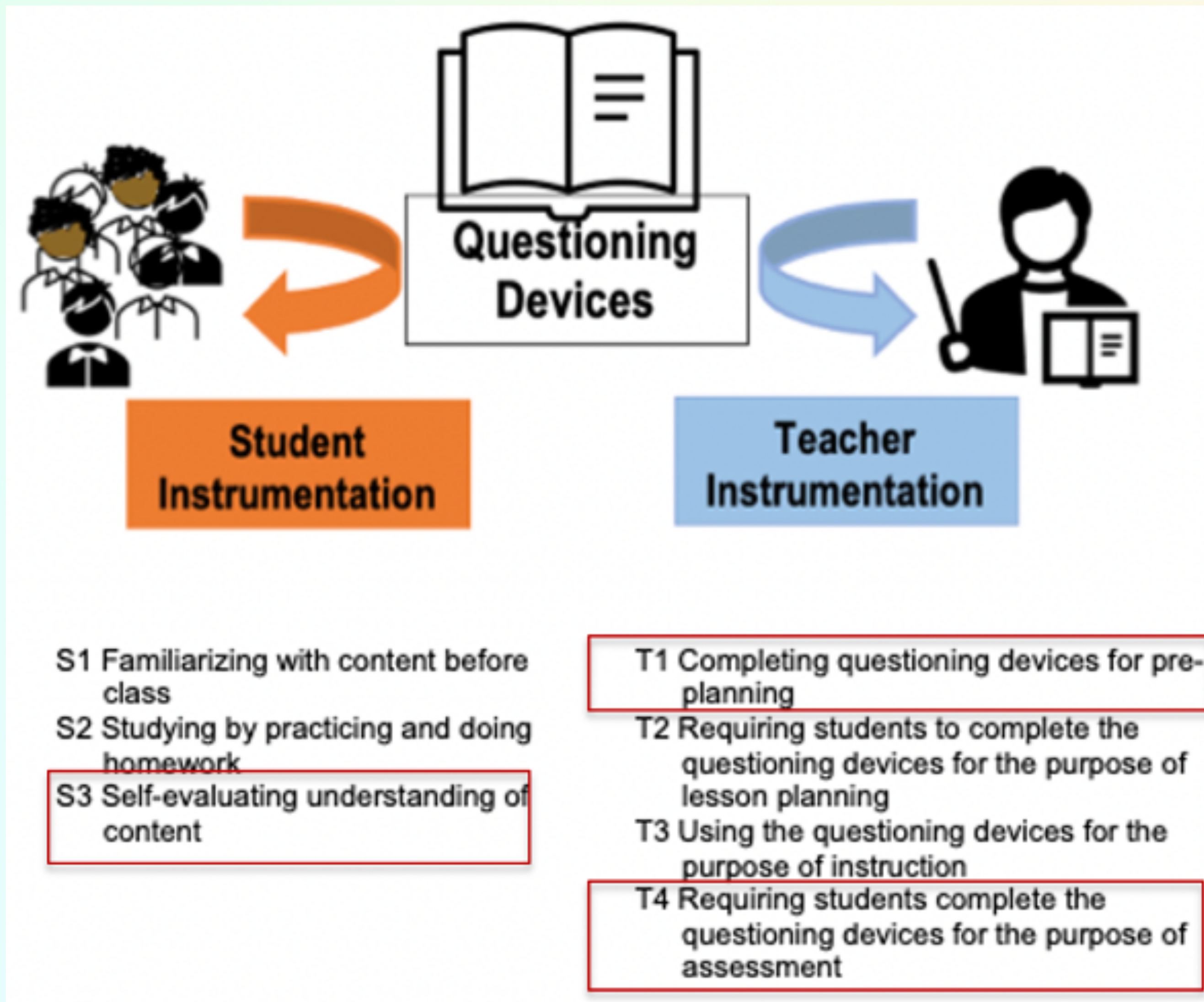|	
A1104406	20 Jan 15:39

No, it does not take on the characteristics of a straight line.

A1104408	23 Jan 18:47

HOW STUDENTS AND TEACHERS USE QUESTIONING DEVICES

PROTEUS: PRETEXT-RUNESTONE: OPEN TEXTBOOKS ENGAGING UNDERGRADUATES IN STEM

- **July 2022: We submitted a $2 million proposal to National Science Foundation to investigate how students and faculty use interactive textbooks on Runestone.**

- **Vilma Mesa (University of Michigan)**

- **Tom Judson (Stephen F. Austin University)**

- **David Farmer (AIM)**

- **Kiran Kedlaya (UC-San Diego)**

- **Rob Beezer (University of Puget Sound)**

- **David Austin (Grand Valley State)**

- **Brad Miller (Runestone Academy)**

- **West Ed**

GOALS OF PROTEUS

- Two educational research questions:

    1. How do instructors and students use textbooks?

    2. How can we develop textbooks that lead to better teaching and learning?

- Using PreTeXt textbooks hosted in Runestone, PROTEUS interactive textbooks, we explore the potential of building and mining banks of student responses to various types of interactive questions that can be added and managed through Runestone on selected topics.

    1. Understand student thinking about complex mathematical ideas

    2. Understand how departments organize their teaching to capitalize on information about student thinking gathered through those questions

    3. Propose models that could analyze student responses efficiently

    4. Explore the impact of systematic use of this information on department orientations towards inquiry and student learning.

- We will create learning communities of faculty who teach in three departments with large subscription students at three different institutions, a mid-size state university, a large community college, and a large research university.

THANK YOU FOR LISTENING

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