Authoring Online Open Textbooks with MathBook XML

II International Conference on Mathematics Textbooks

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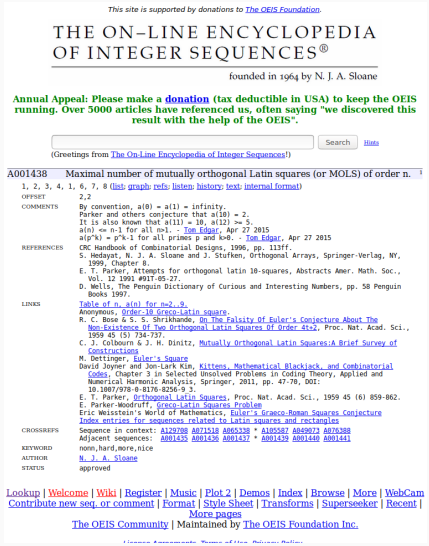
Open Source Publishing

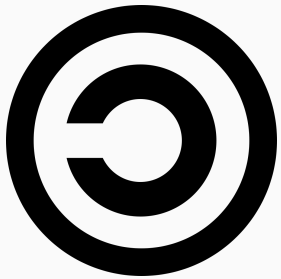
Mathematics on the Web

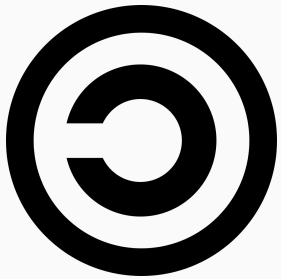
- The Internet is an amazing thing
- Online Encyclopedia of Integer Sequences
- Also: kitten videos
- Your own:
  - printing press
  - shipping and distribution network
  - marketing (e.g., Google Page Rank)
- If you want to be read,
  you want your writing on the Internet
- "Any good book is available on the Internet
  (but maybe not legally)"

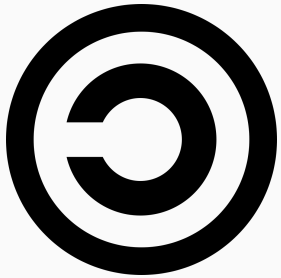


Legal

- Copyright is a government-granted monopoly
- An open license provides additional freedoms
  - Unlimited copying
  - In perpetuity
  - Modifications for personal use
  - Possibly: the right to distribute modifications
  - “Copyleft”





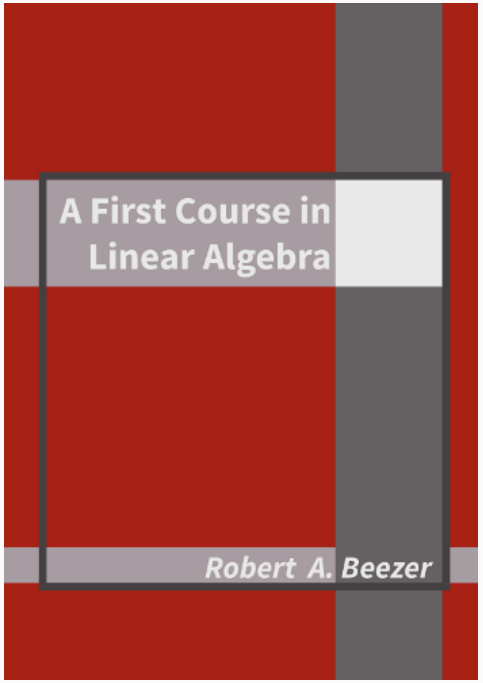


Web Versions of Open Textbooks

- Portable: 64 GB is
  - 64 Encyclopedia Britannica (text)
  - 1 English Wikipedia (text)
  - 10,000 400-page math textbooks
- Ubiquitous: laptop, tablet, or phone
- Up-to-Date: correct, and refresh at will
- Accurate: crowd-sourced proof-reading
- Open: never out-of-print
- Intellectually Honest:
  no pressure to satisfy market segments
- **FREE!!!!!**

Sandbox: Open Source Linear Algebra

- A First Course in Linear Algebra
- 2004: Highly structured, semantic LaTeX
- Distributed as PDF output
- 2006–2008: Rough conversions to HTML
- 2012: Converted source to experimental XML
- 2013: Initiated MathBook XML project
- Today: 500,000 annual unique visits

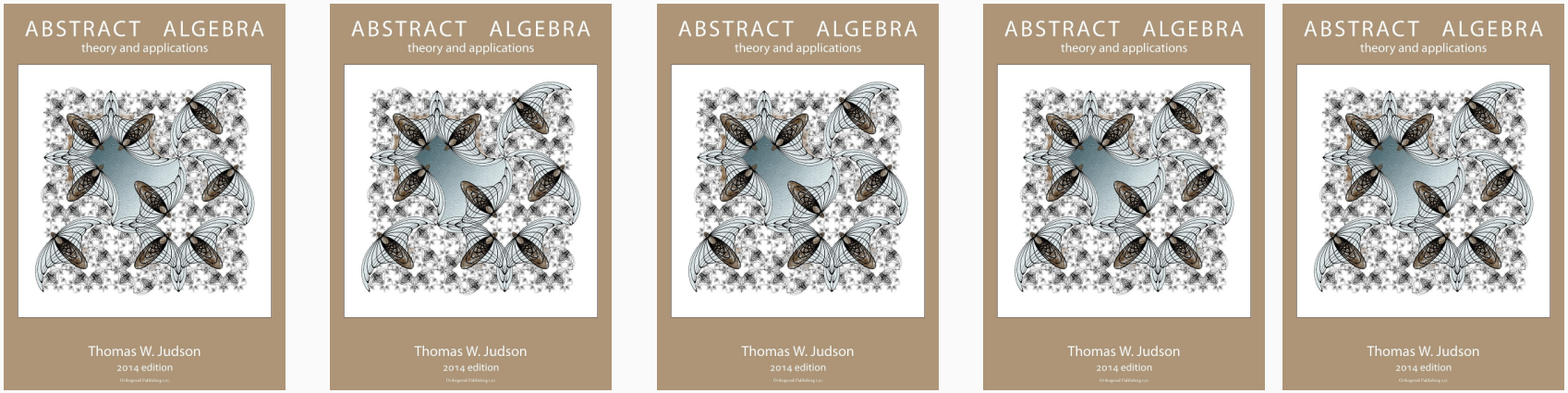


An Open Textbook, Online

Abstract Algebra: Theory and Applications, by Tom Judson

- #2 in Google "`abstract algebra`"
- Free! (since it has an open license)
- Hardcopy: $25

ABSTRACT ALGEBRA DEMONSTRATION



MathBook XML

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- An authoring system for all scholarly documents
- Philosophy: **rigorously** separate
  - structure and content
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  - XML: eXtensible Markup Language – perfect
  - math content: still LaTeX (AMS Math)
- Payoff: multiple outputs from a single source
  - powerful navigation, organization
  - author with your favorite text editor
  - cross-platform open-source toolchain
  - powerful processing with XSL (eXtensible Stylesheet Language)

MathBook XML Technical Example

```
<theorem xml:id="power-rule">
    <title>Power Rule</title>
    <index>power rule</index>

    <statement>
        <p>The derivative of <m>f(x)=x^n</m>
        is <m>f'(x)=nx^{n-1}</m>.</p>
    </statement>

    <proof>
        <p>Apply induction to the product
        <me>f(x)=x^n=x\cdot x^{n-1}</me>
        using <xref ref="product-rule"/>.</p>
    </proof>
</theorem>
```

Theorem 4.4 (Power Rule)**.** *The derivative of* $f(x) = x^n$ *is* $f'(x) = nx^{n-1}$.

Proof. Apply induction to the product

$$f(x) = x^n = x \cdot x^{n-1}$$

using Theorem 4.1. □

Theorem 4.4 (Power Rule). *The derivative of* $f(x) = x^n$ *is* $f'(x) = nx^{n-1}$.

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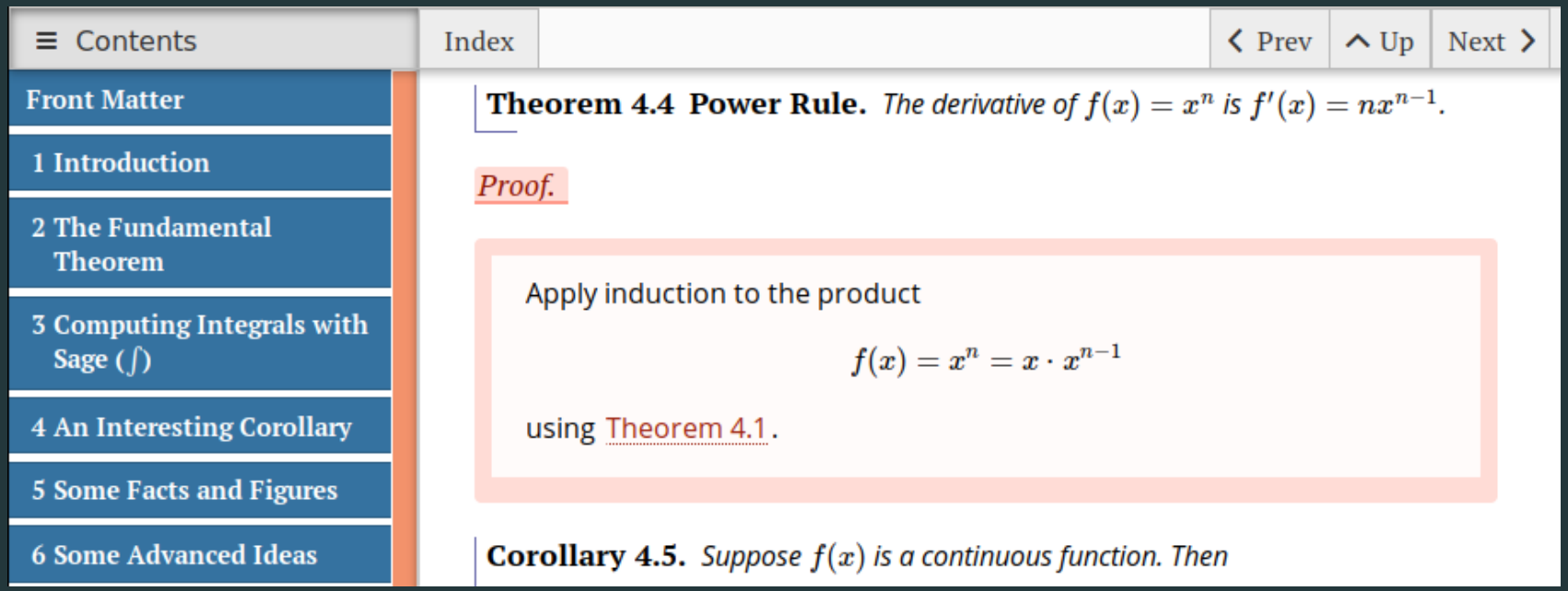


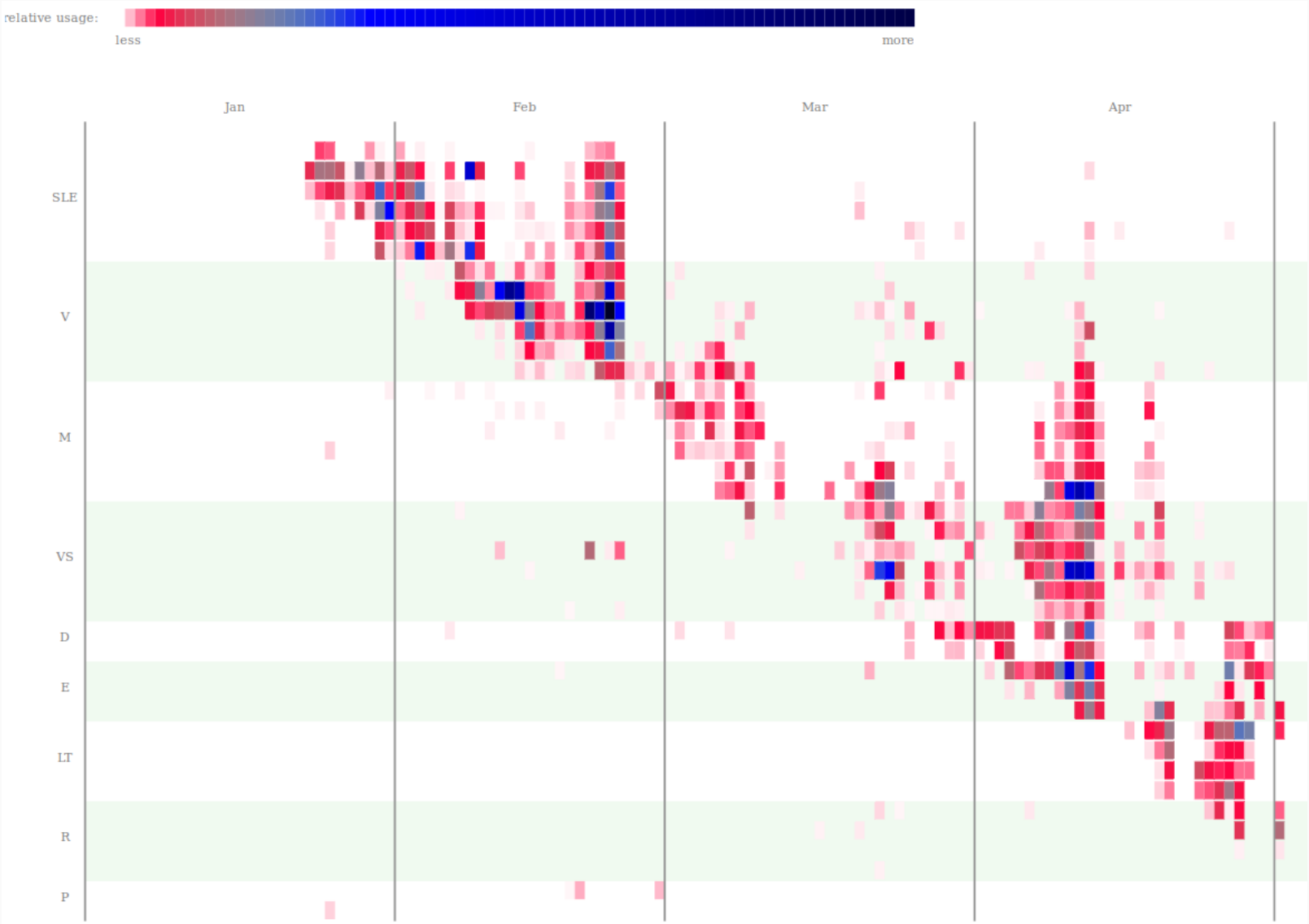
Analyzing Reader Behavior

Analyzing Reader Behavior

- MathBook XML source is highly **structured**
- Chapter, section, subsection, subsubsection
- Some components require a mouse click to read or use
  - Theorems, plus proof
  - Exercises, plus hints, answers, solutions
  - Cross-references
  - Sage Cells, which are editable
- Which makes it possible to structure the output
- And then we can collect **very fine-grained data**

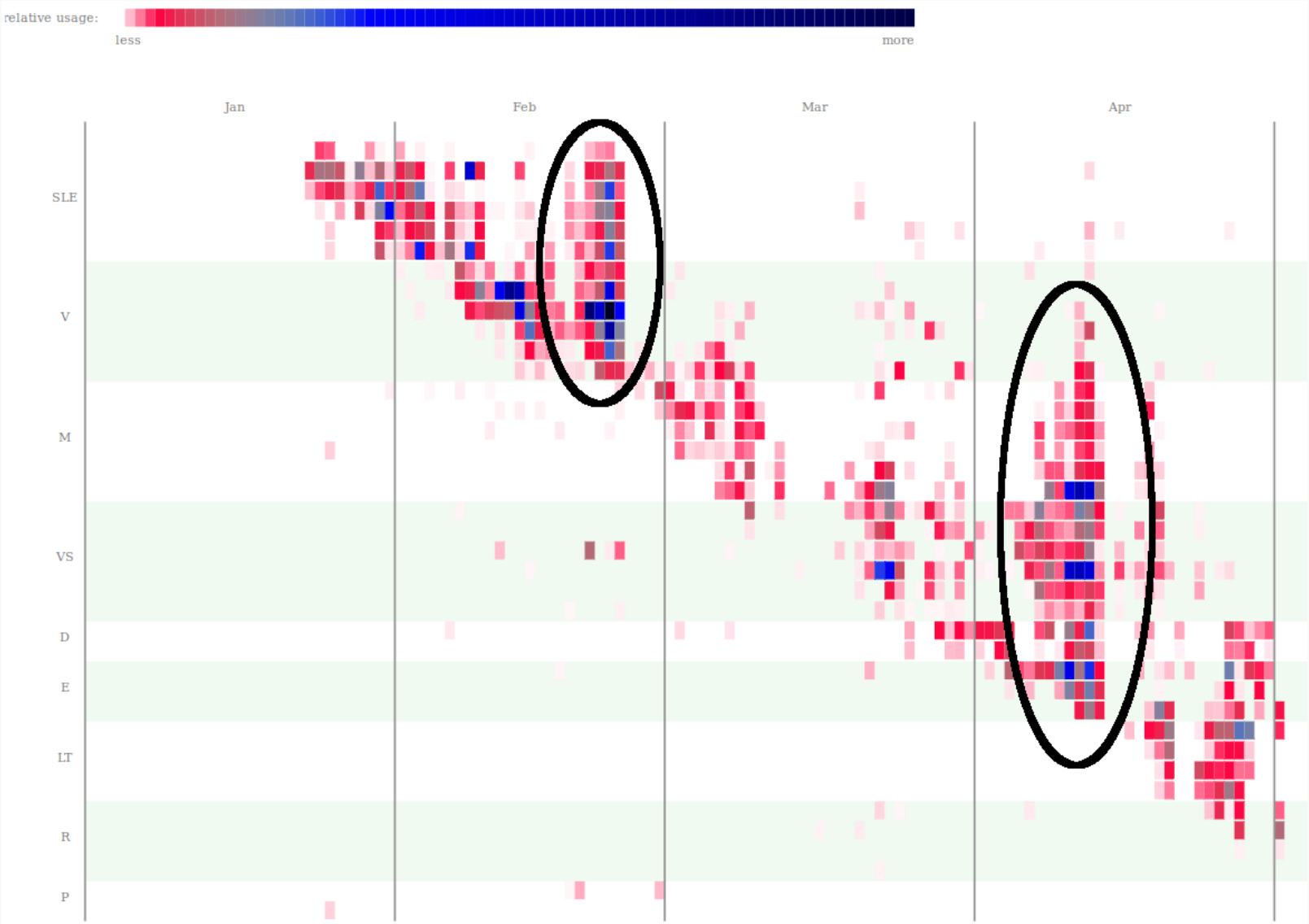
All Students for Entire Semester

Rows are sections, columns are days



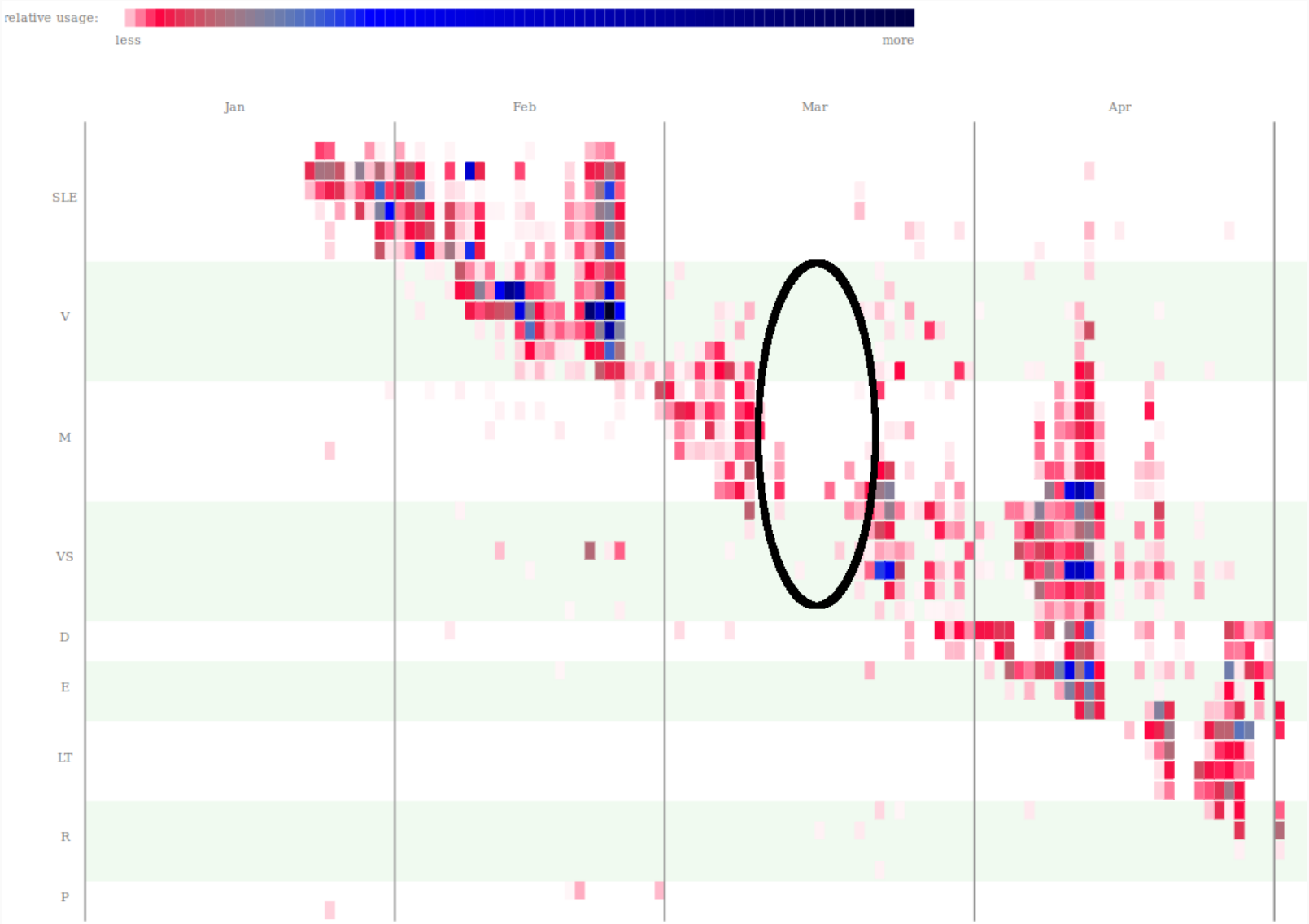
Exams

Rows are sections, columns are days



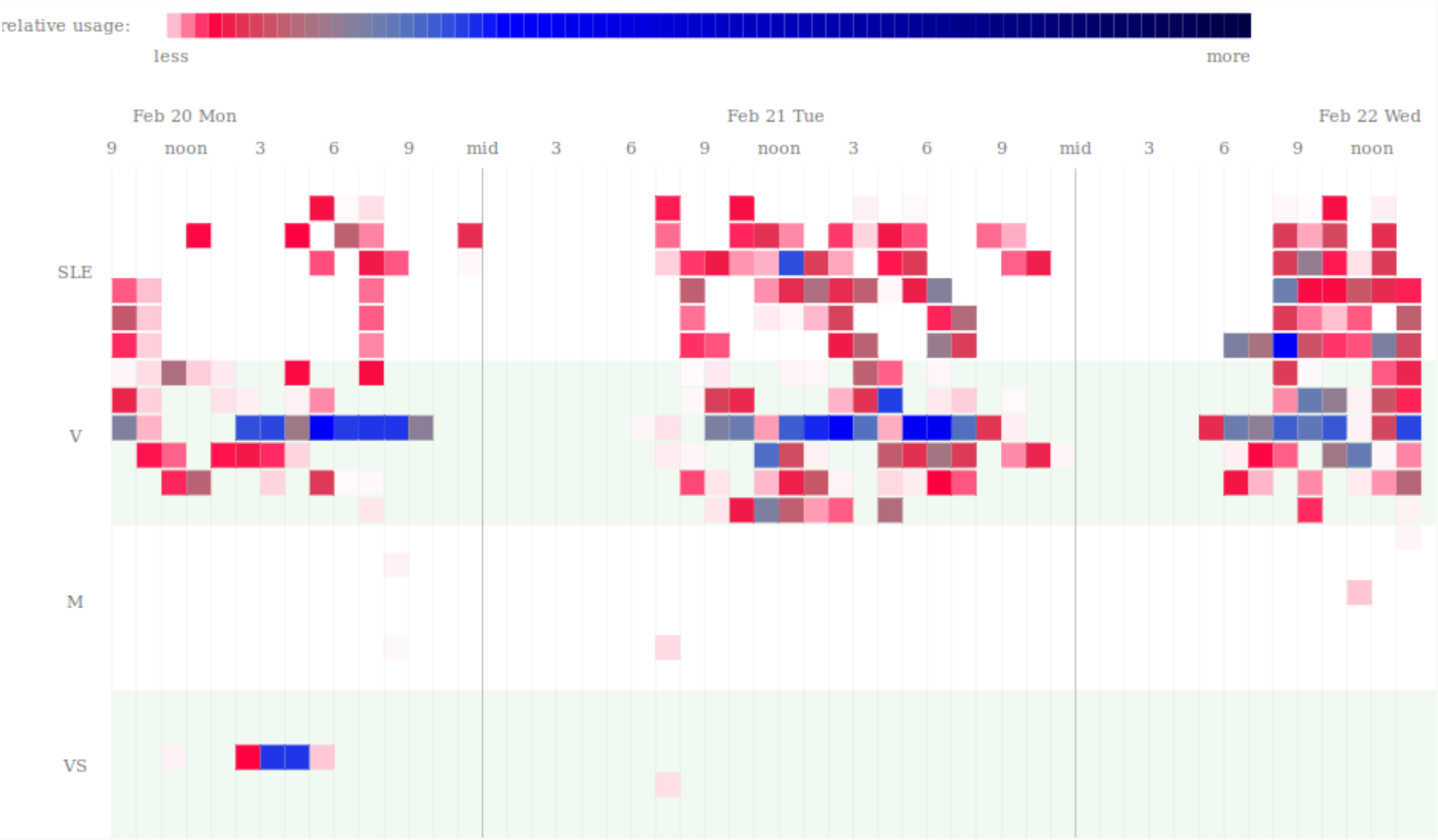
Spring Break!

Rows are sections, columns are days



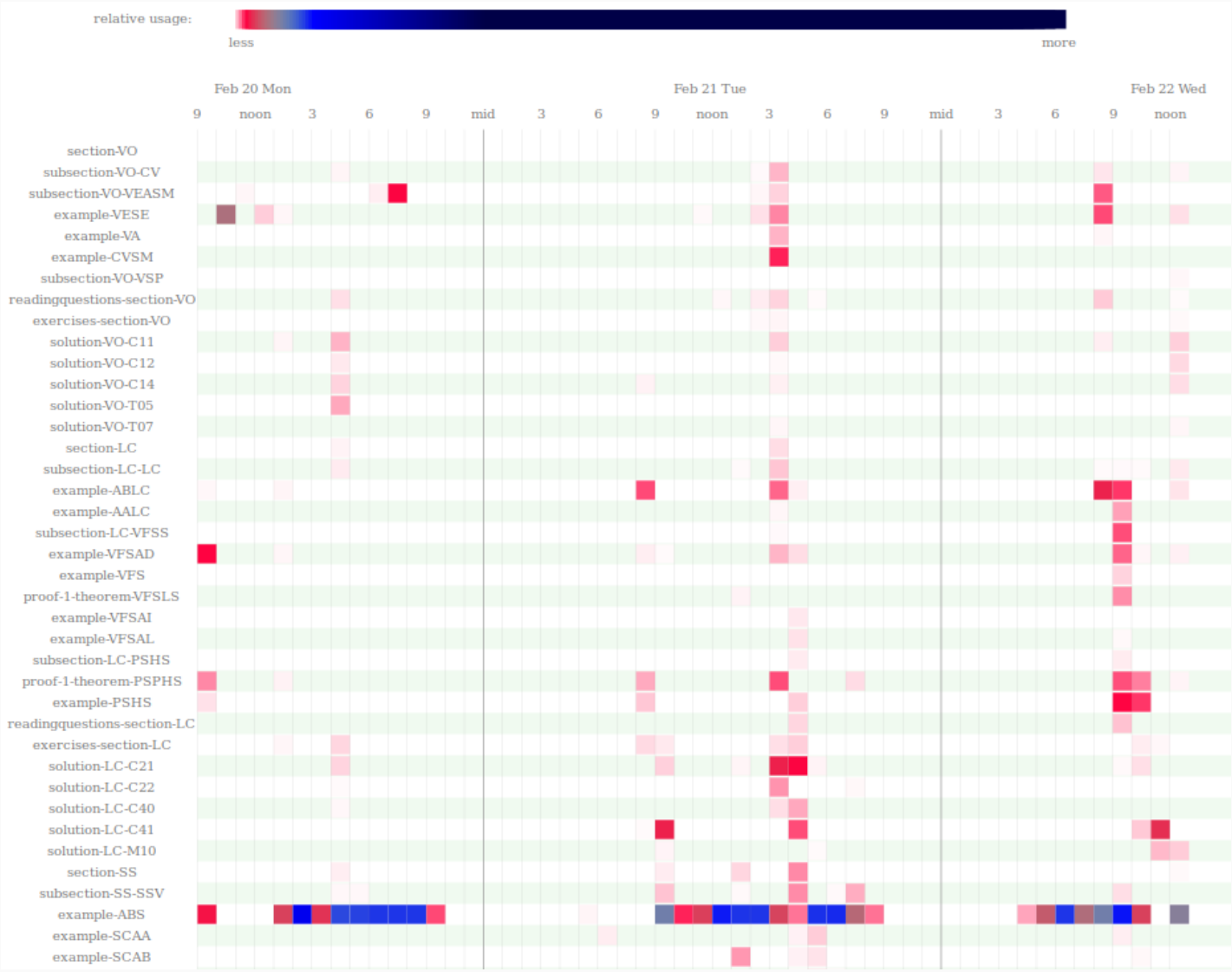
All Students on Tuesday, February 21, 2017

Rows are sections, columns are hours



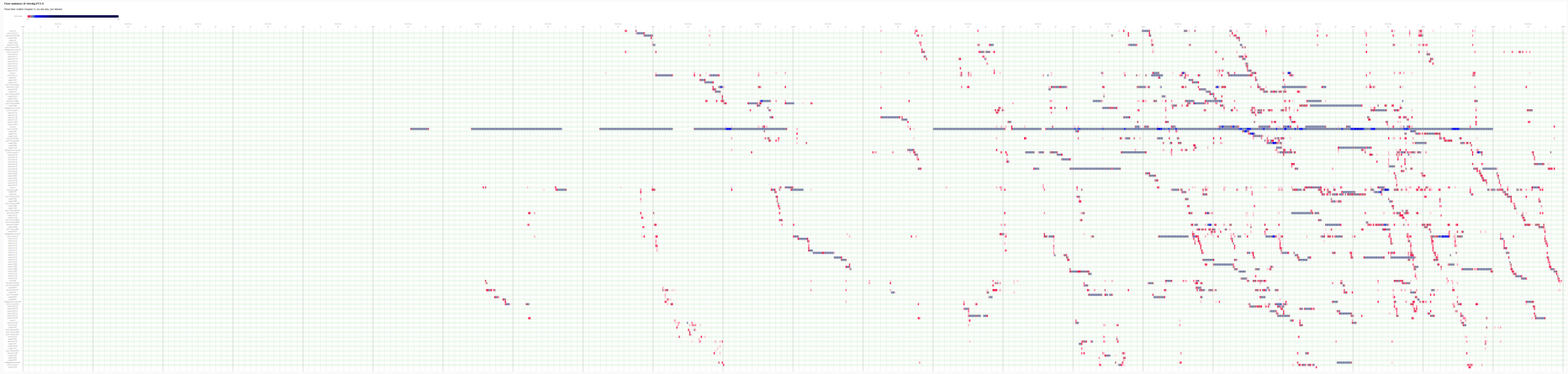
Detail: All Students on Tuesday, February 21, 2017

Rows are components (first third shown), columns are hours



All Students on Tuesday, February 21, 2017, by the Minute

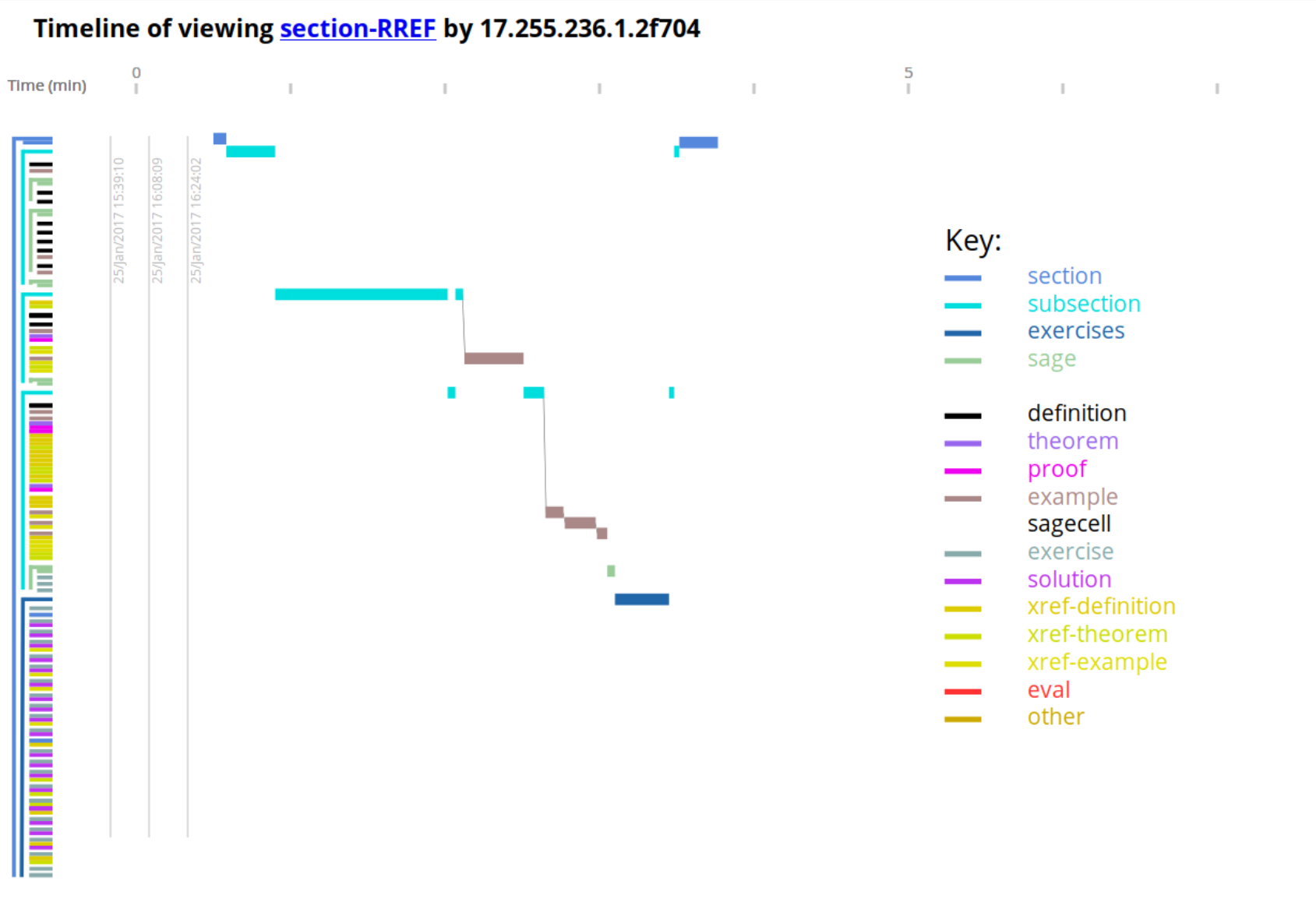
Rows are components, columns are minutes



- "Tracks" move down through material, to the right in time
- Denser in the evening — no surprise there

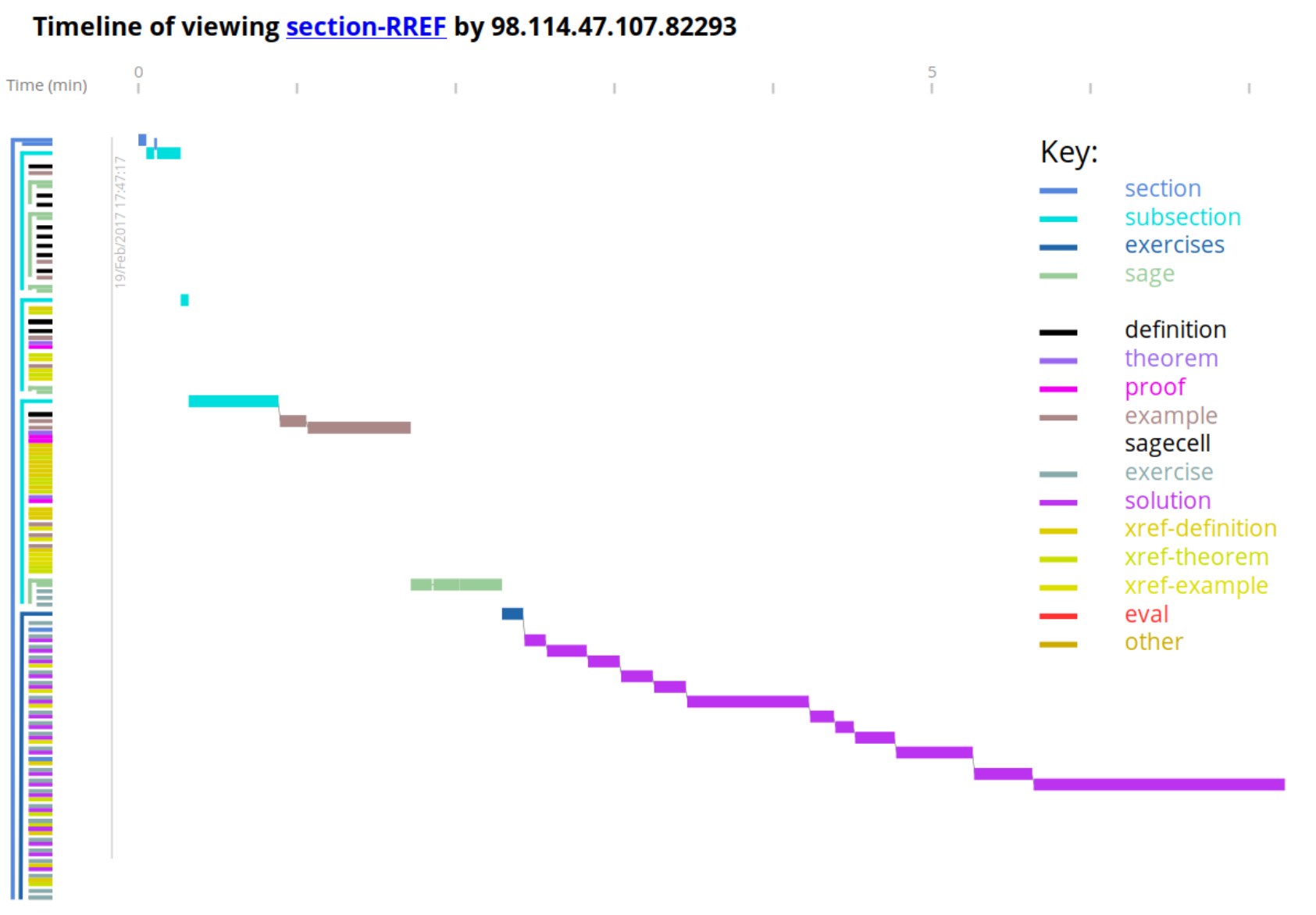
I Like Examples

One student, four minutes, four examples



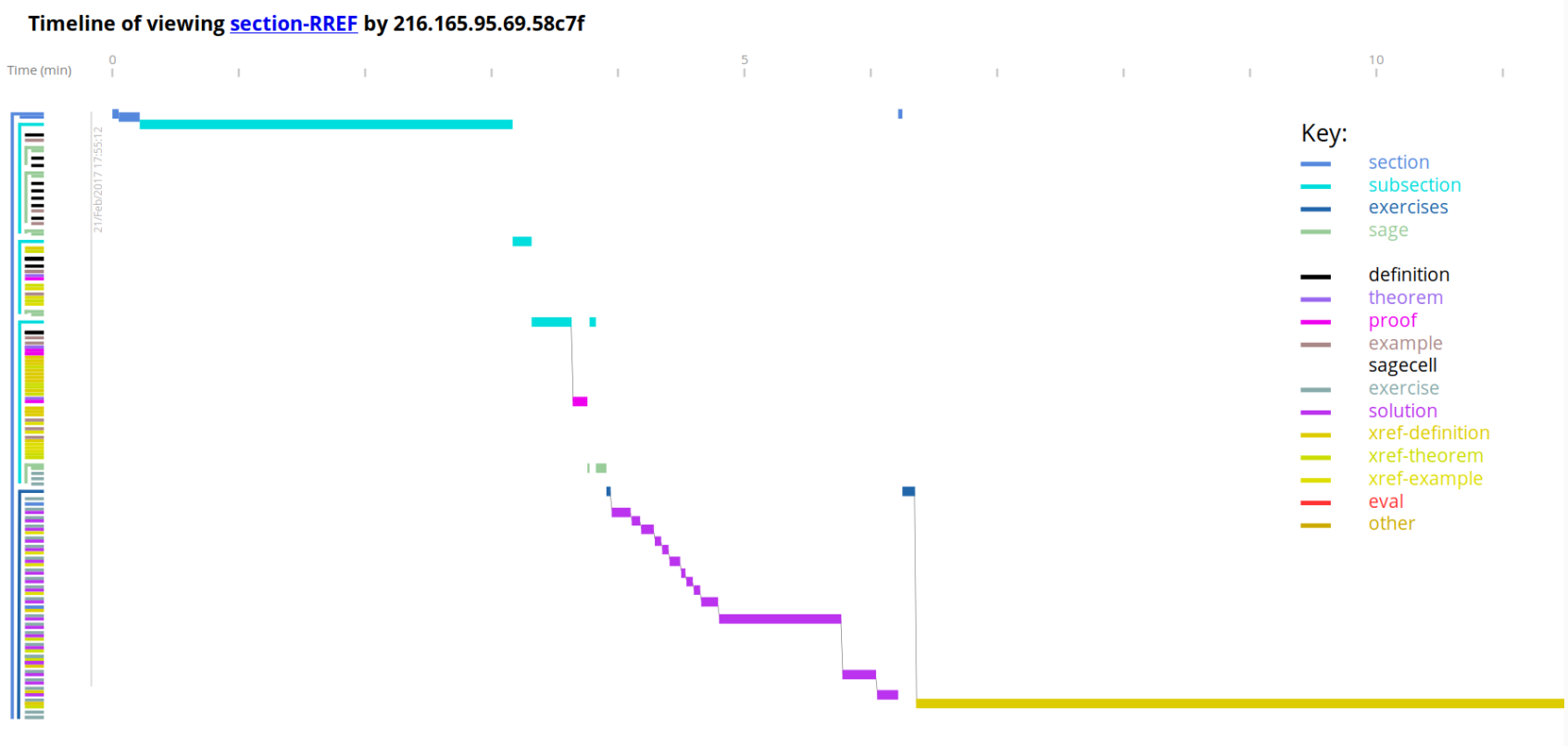
I Like Solutions to Exercises

One student, seven minutes, two examples, twelve solutions



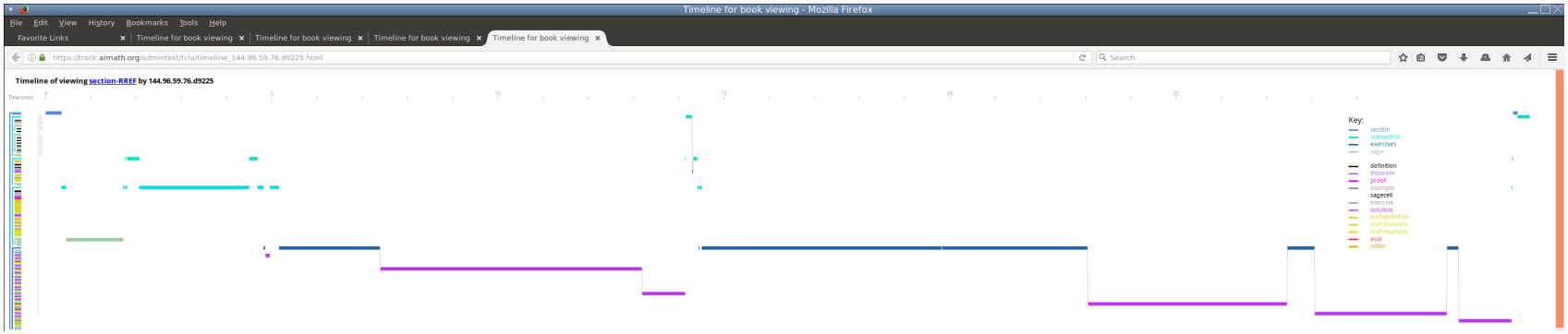
I Like Solutions Too

One student, seven minutes plus, first subsection, thirteen solutions, and cross-referenced an earlier definition as a knowl



I Like To Study

One student, half an hour, Reading Questions, third subsection, then alternately exercises and solutions



- Data display in web browser
- Tooltips on bars identify content
- Bars are links to actual component of the book
- We can match classroom sessions to student activity

UTMOST Project

Undergraduate Teaching in Mathematics with Open Software and Textbooks

Vilma Mesa	U of Michigan
Angeliki Mali	U of Michigan
Tom Judson	Stephen F Austin State U
Susan Lynds	U of Colorado
Kent Morrison	American Institute of Mathematics
David Farmer	American Institute of Mathematics
Rob Beezer	U of Puget Sound

`utmost.aimath.org`

`mathbook.pugetsound.edu`

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