

How I (try to) engage students in the classroom

Valeria Barra, Ph.D.

Assistant Professor,

Math Department + Computational Science Research Center, SDSU

 valeribarra.org

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Overview

- 1 Introduction
- 2 Tools
- 3 Conclusions

About me

- From Siena, Tuscany, Italy
- B.S. and M.Sc. in Mathematical Sciences at the University of Siena
- Exchange program + Ph.D. program in Applied Math at NJIT, Newark, NJ
- Postdoc in the Computer Science Department at the University of Colorado at Boulder, supervised by Jed Brown
- Research Software Engineer (3+ years) at Caltech in the CiMA project
- 1-st year Assistant Professor at SDSU



University of Colorado
Boulder

Caltech

SDSU

Interest in teaching

- Math education was one of my favorite classes in undergrad, although my career path took other directions. Mostly interested in the cognitive processes when learning about math, logic, and geometry.
- As a postdoc, took the Center for the Integration of Research, Teaching and Learning (CIRTL) Evidence-Based Introduction to Teaching course that got me even more interested in *active learning*.
- But really learned a ton from my postdoc supervisor, Prof. Jed Brown (CU Boulder) especially for the computational tools and frameworks used.
- Kept myself active by organizing and giving workshops/tutorials, even in 100% research positions.



The CIRTL Network

The Center for the Integration of Research, Teaching and Learning

What I teach

For the Computational Science Research Center, at San Diego State University:

- Fall 24 - Comp 526: *Computational Methods for Scientists*. Class size: 12
- Spring 25 - Comp 605: *Scientific Computing*. Class size: 20

Audience:

- 45%: PhD students in Computational Science
- 45%: MSc students in Computational Science (multiple tracks)
- 10%: undergrad

Tools I used

- Canvas is the Learning Management System at SDSU. I mainly use it for announcements and grade book keeping
- A public website for class materials, built with Jupyter Book
- Jupyter Notebooks for in-class presentations: a mix of lectures and hands-on live demos
- Google Forms, for Background Assessment Survey and Mid-term Feedback Survey
- PollEverywhere, for live trivia/quizzes in class
- GitHub Classroom for Assignments and Reviews

Background Assessment Survey

I asked students a few questions about their prior knowledge on some topics, such as programming languages, version control, etc

Questions Responses 13 Settings

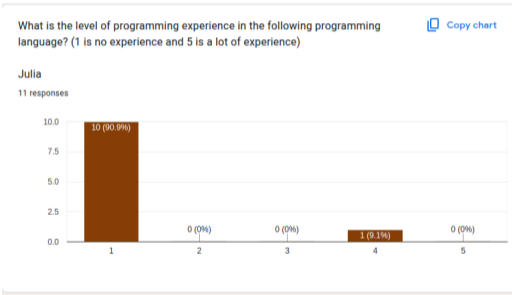
Background Assessment (not graded)

B *I* U

This Background Assessment form will assist your instructor in preparing class material that can be better aligned with your background and interests. When an educator knows about their audience, they can cater towards different specific needs. The information you share is private between you and your instructor.

This form is automatically collecting emails from all respondents. [Change settings](#)

Background Assessment Survey (cont'd)



Sample of questions from Fall 24:

- What are your main academic interests?
- Do you have any concerns or questions about the upcoming school year?
- What are your thoughts on collaboration? Do you think it's important, or do you prefer to work independently?

Things I wish I'd asked (and I did this Spring semester):

- Do you have any other major commitments outside of school (e.g., work, taking care of family members, etc)?

Course website and live demos

Examples of the Fall 24 course website pages:

- Home
- Syllabus
- SVD
- Splines interpolation

The screenshot shows a web browser displaying the course website for SDSU. The header includes the SDSU logo and the course title 'Comp Methods for Scientists'. A search bar is visible. The main content area is titled 'Welcome' and includes a 'Logistics' section with office hours information and a 'Note' section with a bio of the instructor. The instructor is an Assistant Professor in the Department of Mathematics & Statistics and the Computational Science Research Center, with previous roles at Caltech, CU Boulder, and Pixar.

SDSU
Comp Methods for Scientists

Search [ctrl] [k]

Welcome

Syllabus

Slides

Welcome

Welcome to **Computational Methods for Scientists, Comp-526**

Logistics

- Office hours: announced on the course [Canvas page](#) or by appointment.

Note

Who am I?

- Assistant Professor in the Department of Mathematics & Statistics and the Computational Science Research Center
- Previously:
 - Research Software Engineer for 3+ years at Caltech, in the [ClIMA](#) group
 - Postdoctoral Research Associate at CU Boulder, in [Jed Brown's PhyPID](#) group
 - PhD in Applied Math from NJIT
 - some industry experience with CAD/CAM system development and at Pixar in the [Research](#) group

Course website tools

The course website is built and deployed/published with Jupyter Book.

The screenshot shows the Jupyter Book website interface. On the left is a navigation sidebar with sections: Tutorials, Topic Guides, Reference, and About Jupyter Book. The main content area features a header with the Jupyter Book logo (JB) and a 'Get started' button. Below the header is a grid of six cards describing different content types: Text content, MyST Markdown, Executable content, Live environments, Build and publish, and UI components. At the bottom of the main content area, it says 'Built with Jupyter Book'.

Build beautiful, publication-quality books and documents from computational content.

JB

Get started

Items 44 | cur1 | 100,000,000,000,000,000

Text content	MyST Markdown	Executable content
Structure books with text files and Jupyter Notebooks with minimal configuration.	Write MyST Markdown to create enriched documents with publication-quality features.	Execute notebook cells, store results, and insert outputs across pages.
Live environments	Build and publish	UI components
Connect your book with Binder, JupyterHub, and other live environments	Share your built books via web services and hosted websites.	Create interactive and web-native components and services.

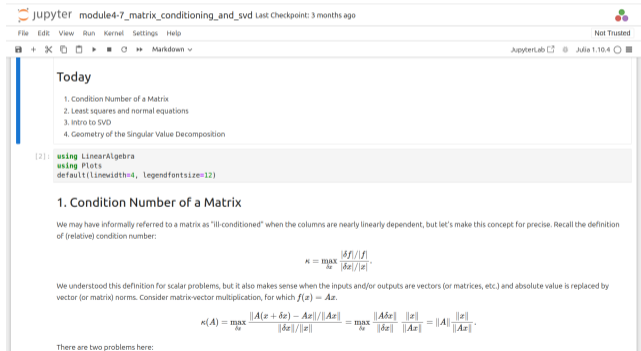
This documentation is organized into a few major sections.

- **Tutorials** are step-by-step introductory guides to Jupyter Book.
- **Topic Guides** cover specific areas in more depth, and are organized as discrete "how-to" sections.
- **Reference** sections describe the API/syntax/etc. of Jupyter Book in detail.

Built with Jupyter Book

Live demos tools

In-class live demos are done using Jupyter Notebooks, mainly with Julia.



The screenshot shows a Jupyter Notebook window titled "jupyter module4-7_matrix_conditioning_and_svd". The interface includes a menu bar (File, Edit, View, Run, Kernel, Settings, Help) and a toolbar with navigation icons. The main content area is divided into two sections:

- Today**: A table of contents listing four topics:
 1. Condition Number of a Matrix
 2. Least squares and normal equations
 3. Intro to SVD
 4. Geometry of the Singular Value Decomposition
- Code Cell [2]**: Contains the following Julia code:

```
using LinearAlgebra
using Plots
default(Linewidth=4, Legendfontsize=12)
```

Below the code cell, the notebook displays the following text:

1. Condition Number of a Matrix

We may have informally referred to a matrix as "ill-conditioned" when the columns are nearly linearly dependent, but let's make this concept for precise. Recall the definition of (relative) condition number:

$$\kappa = \max_x \frac{|\delta f|/|f|}{|\delta x|/|x|}.$$

We understood this definition for scalar problems, but it also makes sense when the inputs and/or outputs are vectors (or matrices, etc.) and absolute value is replaced by vector (or matrix) norms. Consider matrix-vector multiplication, for which $f(x) = Ax$.

$$\kappa(A) = \max_x \frac{\|A(x + \delta x) - Ax\|/\|Ax\|}{\|\delta x\|/\|x\|} = \max_x \frac{\|A\delta x\|}{\|\delta x\|} \frac{\|x\|}{\|Ax\|} = \|A\| \frac{\|x\|}{\|Ax\|}.$$

There are two problems here:



Activities

Activity is now locked. Responses are not accepted at this time.

If $A \in \mathbb{R}^{m \times m}$, which of these doesn't belong?

01:50 10

1. A has an inverse, A^{-1}
2. $\text{rank}(A) = m$
3. $\text{null}(A) = \{0\}$
4. $AA^T = A^T A$
5. $\det(A) \neq 0$
6. $Ax = 0$ implies that $x = 0$

< 1/1 > [Navigation icons] [Submissions] [Responses] [Answers] [Clear responses]

Activity is now locked. Responses are not accepted at this time.

If $A \in \mathbb{R}^{m \times m}$, which of these doesn't belong?

01:50

1. A has an inverse, A^{-1} 0%
2. $\text{rank}(A) = m$ 0%
3. $\text{null}(A) = \{0\}$ 50%
4. $AA^T = A^T A$ 40%
5. $\det(A) \neq 0$ 10%
6. $Ax = 0$ implies that $x = 0$ 0%

< 1/1 > [Navigation icons] [Submissions] [Responses] [Answers] [Clear responses]

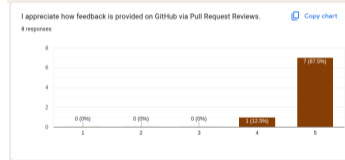
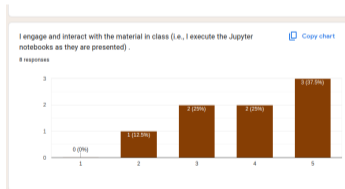
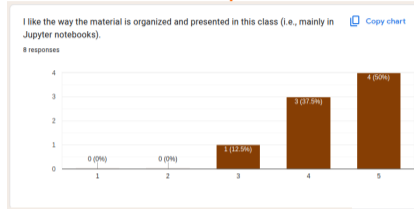
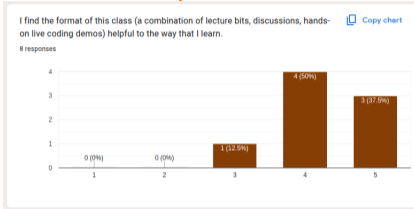
- PollEverywhere for in-class trivia
- In-class reading and discussion

Projects

The screenshot shows the SDSU Scientific Computing website. The navigation menu on the left includes: Welcome, Syllabus, Lectures, 1) First Class: Reproducibility and Git (highlighted), 2) The Linux Filesystem and commands, 3) Introduction to Computer Architectures, 4) Introduction to Vectorization, 5) Measuring Performance, and 6) CPU Optimization: Matrix-Matrix Multiply. The main content area displays the title '1) First Class: Reproducibility and Git' and a list of topics: 1. Reproducibility, 2. Git, 3. Package environments and managers (with sub-items 3.1. Julia and 3.2. Python), and 4. IDE or editors. Below this is the heading '1. Reproducibility in computational sciences' and the question 'What is reproducible code?'. A quote box contains the text 'But it works on my machine!'. At the bottom, a definition states: 'Code is reproducible if someone is able to easily re-run it and get the same results.'

Because I care so much about reproducible and open science (which includes open-source software), I ask students to make a contribution to an open-source software project of their choice as Final Project.

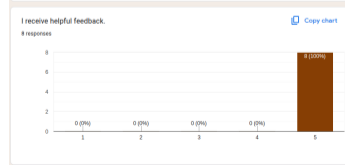
How did I do? Anonymous Midterm Feedback Survey



If not, why?
2 responses

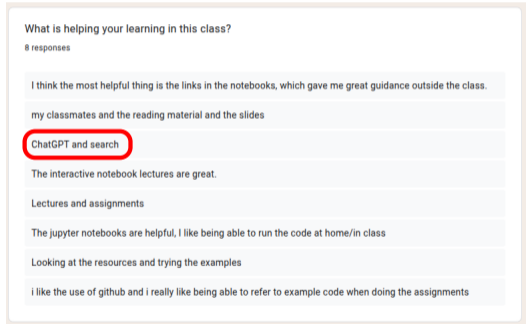
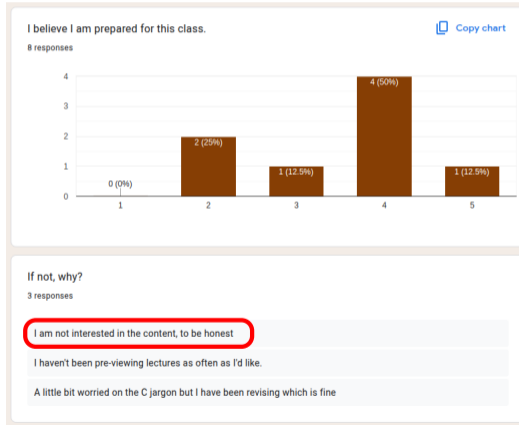
I'm not completely aware of the julia language so sometimes understanding some of the functions or plotting can be an issue, but I am starting to get a better understanding of everything

sometimes i just watch the demonstration because i know my computer will have the same result and i'm too lazy to click the button



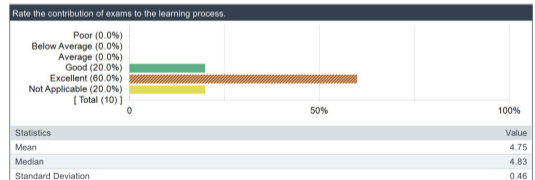
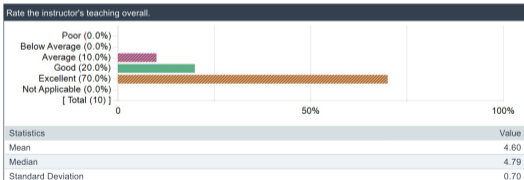
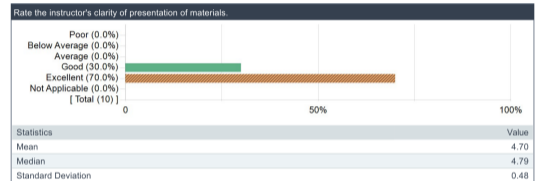
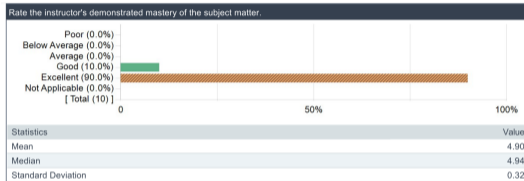
How did I do? Anonymous Midterm Feedback Survey (cont'd)

Things I was not prepared for:



How did I do? Official Anonymous Student Feedback Surveys Fall 2024

COMP526-01: Computational Methods for Scientists Valeria Barra



Observations and Conclusions

- Some tools used, e.g., GitHub Classroom for assignments, do not scale for large classes and requires a lot of manual intervention for reviews/grading (unless you setup autograder for easy problems).
- Things I wish went better: **Class participation.** 🙄
- I hope I made them feel that their feedback/voice matters.
- This was **very time consuming**. Hopefully, I will be able to reuse most of the infrastructure/content next time I teach the same class.
- Things to be careful about: Will remove solutions to the homework assignments from the public website, but they could be downloaded already.
- Suggestions/Feedback will be much appreciated!

Thank you!