Programming in MUDE

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Lecturers Civil Engineering and Geosciences

Python in Teaching, TU Delft, March 14, 2024

Python, Programming in Education…
…A Reflection from Civil Engineering and Geosciences

When did you acquire your programming/computer skills?

→ Probably not in your “Intro to Programming” BSc course!!!

We expect our students to learn everything here!

Programming problems:

- Students expected to do a lot
- Teachers unsatisfied with capabilities
- Rarely taught/used after BSc course
- We don’t teach students how to share
- A growing problem?

Typical Colleague?

“I don’t have time to learn Python”
“Find data, do analysis. Good luck!”
“What is a .ipynb file? I can’t read this!”
“Students can’t code”

We are part of the problem!

MUDE = Our Playground

Digital generation ≠ ability to use a computer

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What is MUDE?

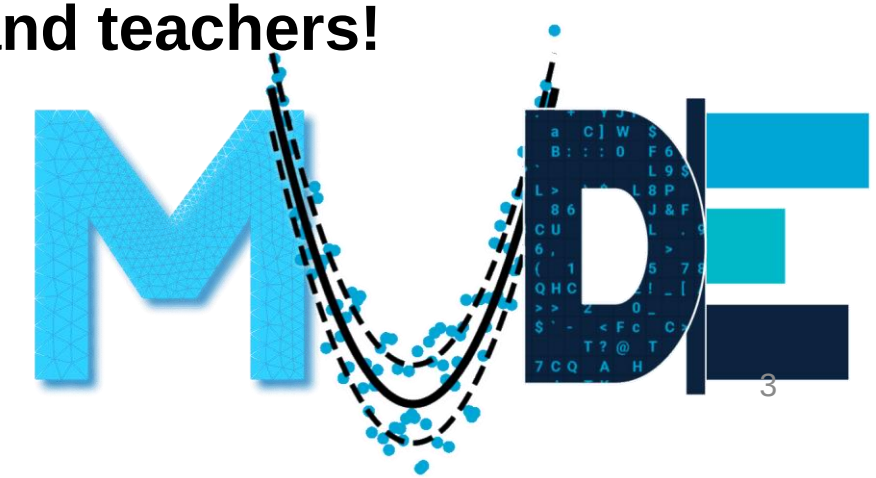
- CEGM1000: Modelling, Uncertainty and Data for Engineers (MUDE)
- 12 ECTS over Q1 and Q2
- 1st year MSc, all students in Civil Engineering and Geosciences (~300)

➢ Focus is on fundamental topics

➢ Programming and computer skills essential

➢ Many digital formats (videos, PDF, Jupyter Notebook, etc)

➢ **Challenge: diverse set of materials, students and teachers!**



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mude.citg.tudelft.nl/

Diversity of Topics

Q1

1. Modelling Concepts
2. Propagation of Uncertainty
3. Observation theory
4. Numerical Modeling
5. Continuous Distributions
6. Risk and Reliability Intro

Q2

1. Finite Volume Method
2. Finite Element Method
3. Signal Processing
4. Time Series Analysis
5. Optimization
6. Machine Learning
7. Extreme Value Analysis
8. Risk and Reliability, Part 2

Requires programming

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Diversity of Students

Survey based on 261 students (100% response rate)

- 74%: programming experience limited to 1 BSc course
- 60% have only used Python
- 18% have only used Matlab
- 17% have used other languages (overlap with Python/Matlab)
- 7% have zero programming experience (19 students)
  - Almost entirely international students (~30% of total)

Typical feedback:

As an international student I have little programming experience and found it difficult to contribute to my group. Sometimes my group members taught me things, but I could tell that I was a burden on them. I want to learn to use Python, but there isn't enough time.

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Diversity of Students

Our experience:

- Our BSc course prepares students to use numpy, matpotlib, etc
- Our BSc course does *not* teach students:
  - How to use a computer
  - To be comfortable with non-numpy data structures (e.g., dictionaries!)
  - How to communicate, collaborate or share effectively
  - The importance of reading code and writing readable code
  - Python ≠ Jupyter notebook!!!!!
- There are exceptions (CS minor – we hire them as TA's ☺)

These issues should be addressed at the curriculum level

We start by addressing them in MUDE

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Weekly Schedule

	Monday	Tuesday	Wednesday	Thursday	Friday
8:45	Lecture				Project Sessions Multiple rooms
10:30		Open Question Hours 1 room	In-Class Workshops Multiple rooms		
10:45					

Everything builds towards the project on Friday. Repeat for every week.

Jupyter notebook

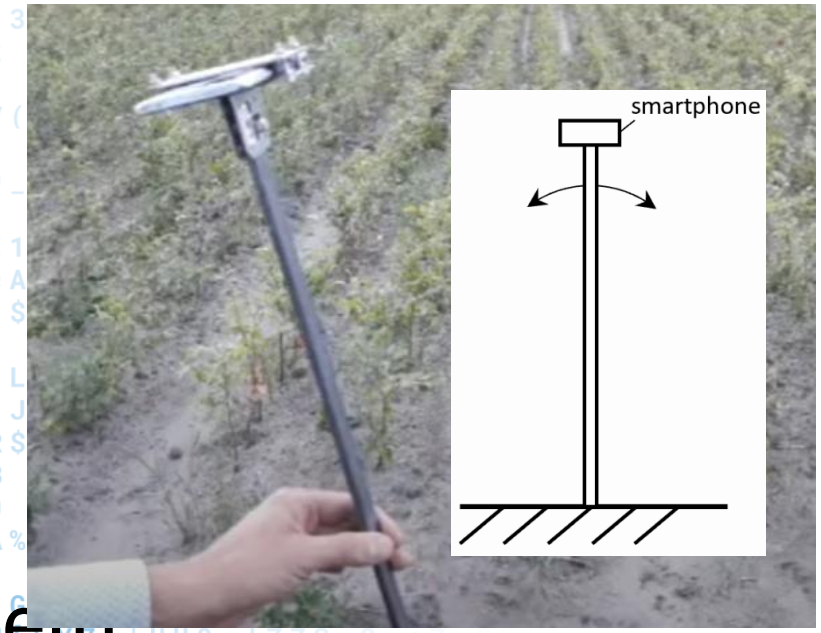
Instructions: README.md
Analysis: Jupyter notebook
Submit: Report.md
(via GitLab)

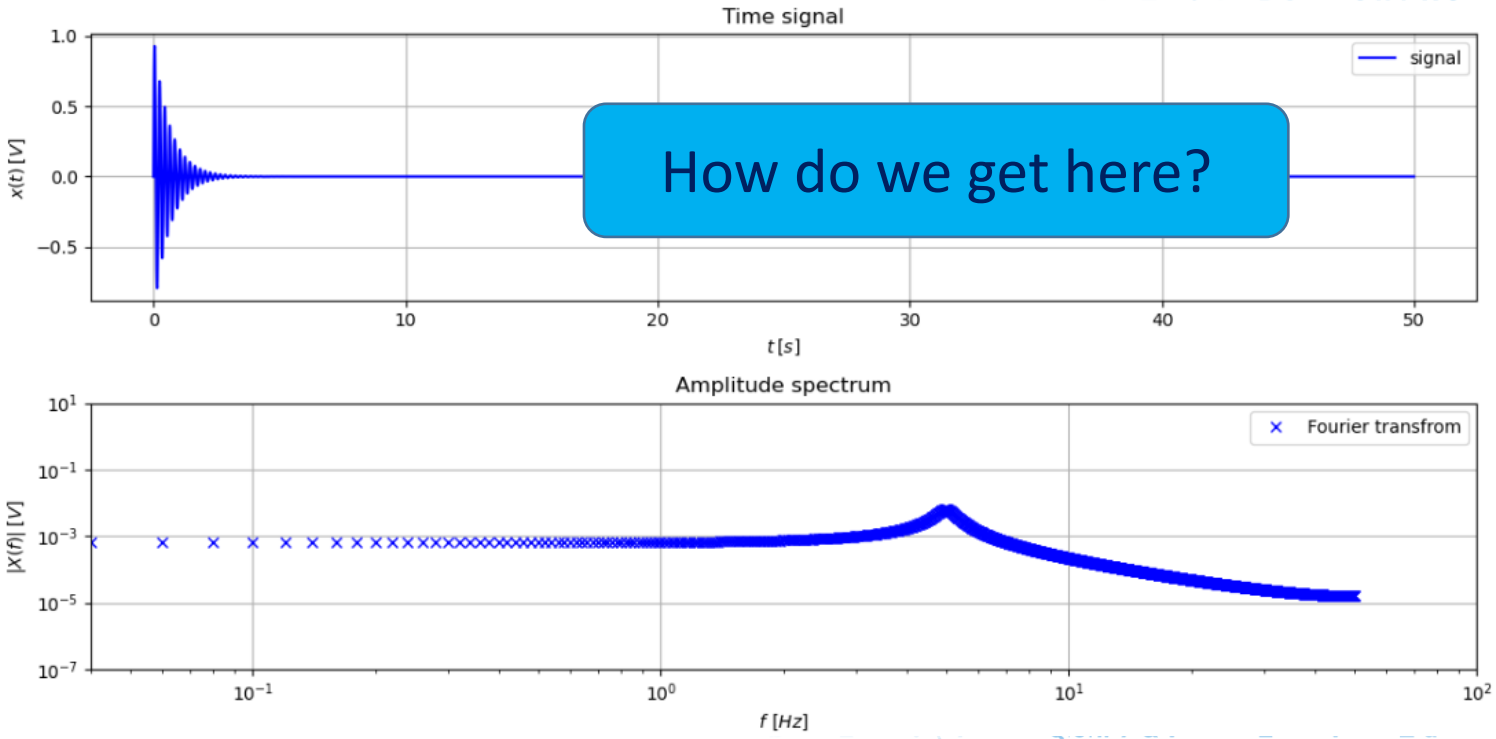
Learn material: read and interact with online textbook.

Programming Assignments: complete before Friday session. Submit via GitLab.

Example: Signal Processing (Q2, Week 3)

- Focus on analysis of signals in the frequency domain
  → Fourier Transform
- Project: apply and interpret for synthetic and real signals





Example: Signa

Programming Assignment

Overview of Ass

This assignment will addr
iterating in Python, illustr
simple, but will be used d

Specifically, we will look

- iterables and iterable
- iterables range, enume
- the modulo operator %
- plot type stem

```
team = ['green', 'red', 'blue']
score = [5, 9, 7]

# for YOUR_CODE_WITH_enumerate_HERE:
#     print(f'Team {} has {} points.'

for i, j in enumerate(score):
    print(f'Team {team[i]} has {j} po

Team green has 5 points.
Team red has 9 points.
Team blue has 7 points.
```

You may have noticed that enumerate is a b
define an unnecessary iteration index to acc
things easier:

Task 4:

Use zip to print out the summary of poi
statement.

```
team = ['green', 'red', 'blue']
score = [5, 9, 7]

# for YOUR_CODE_WITH_zip_HERE:
#     print(f'Team {} has {} points.'

for i, j in zip(team, score):
    print(f'Team {i} has {j} points.'

Team green has 5 points.
Team red has 9 points.
Team blue has 7 points.
```

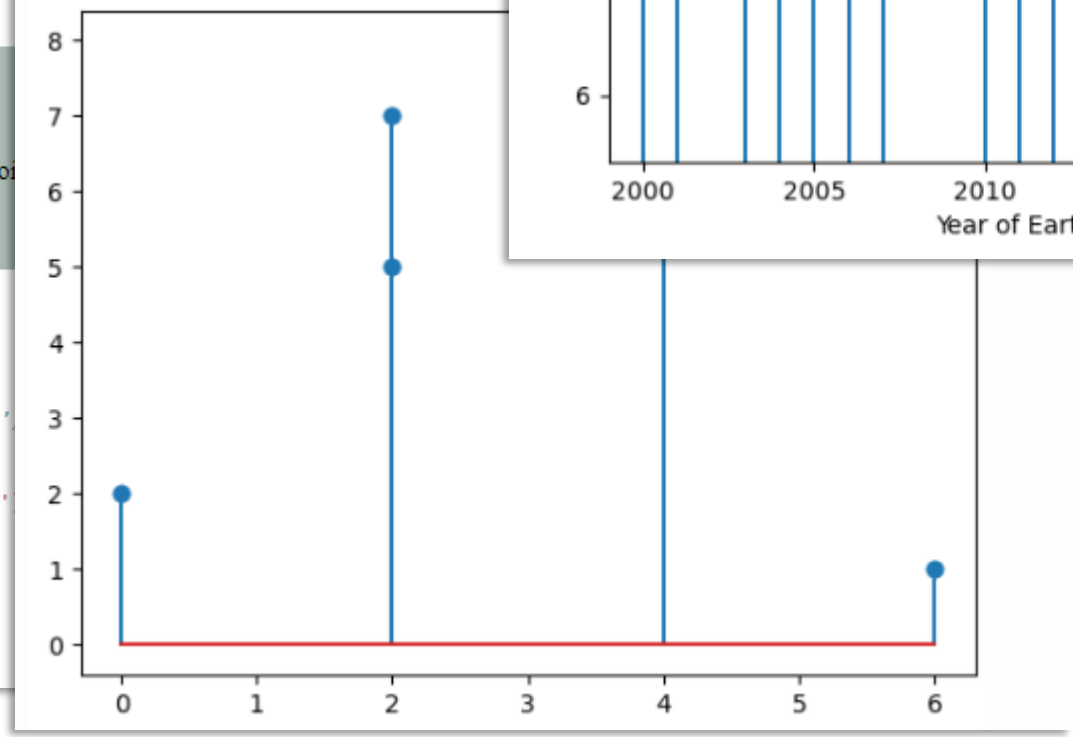
That's really compact!

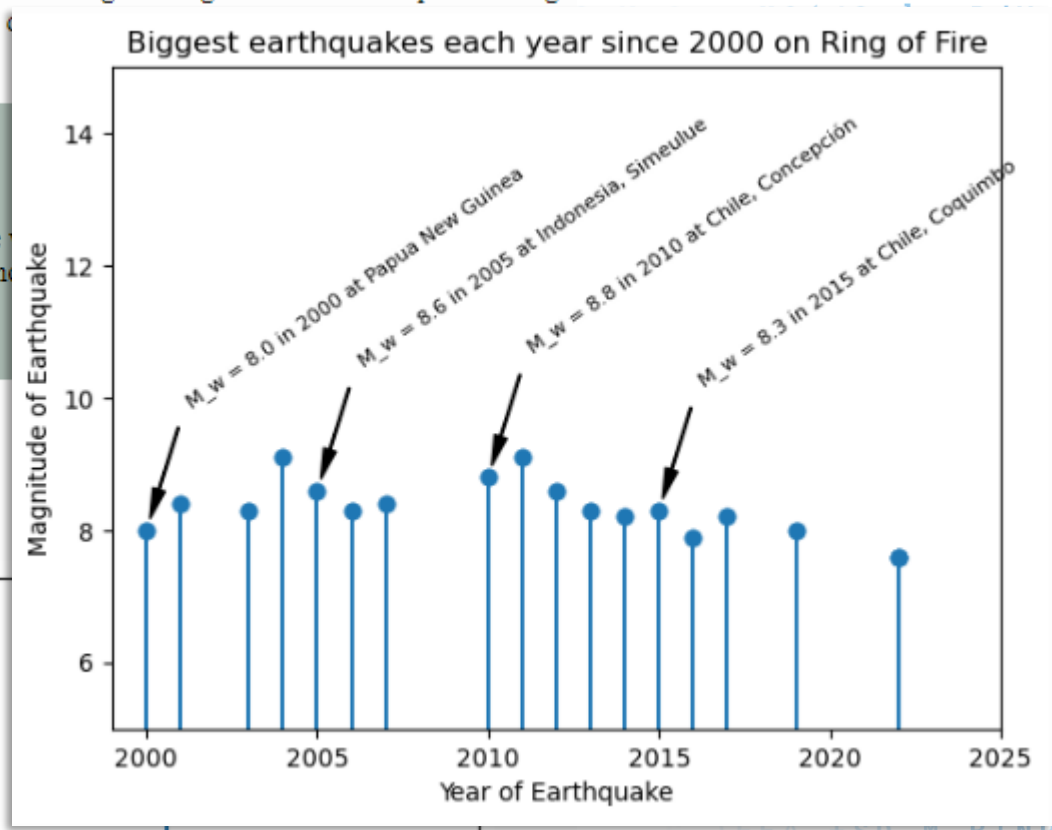
You have probably used the matplotlib plot types plot, hist and scatter frequently; another type is stem, which is useful for indicating the magnitude of various points along a number line. As with a scatter plot, the values are easy to handle.

Task 6:

Run the cell below and play with the with the stem plot type. Do you see h index?

```
value = [2, 7, 5, 1, 8]
index = [0, 2, 2, 6, 4]
plt.plot(index, value, 'o')
plt.stem(index, value);
```





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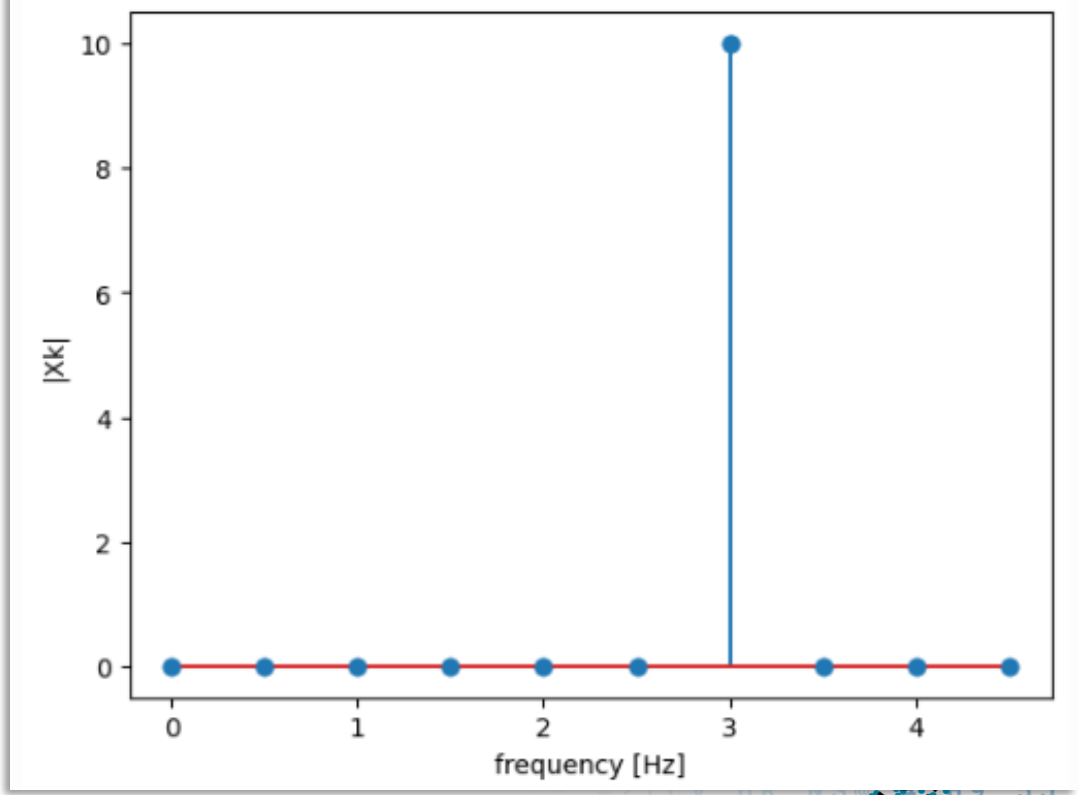
Example: Signal Processing (Q2, Week 3)

Workshop: make a DFT.
Easy after the Programming Assignment!

```
### SOLUTION

abs_fft = np.abs(np.fft.fft(xt))
freq=np.arange(0,fs,1/T)
plt.stem(freq[:int(N/2)], abs_fft[:int(N/2)])
plt.plot(freq[:int(N/2)], abs_fft[:int(N/2)], 'o')
plt.ylabel('|Xk|')
plt.xlabel('frequency [Hz]');
```



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Example: Signal Processing (Q2, Week 3)

Programming concepts are…

- Simple
- Used immediately
- Separated from theory
- Fun!

Theory in the book

$$X_k = \Delta t \sum_{n=0}^{N-1} x_n e^{-j\frac{2\pi}{N}kn}$$

This is the discrete Fourier transform (DFT), typically implemented in software packages as `fft` (in Python, we will use `numpy.fft.fft`).

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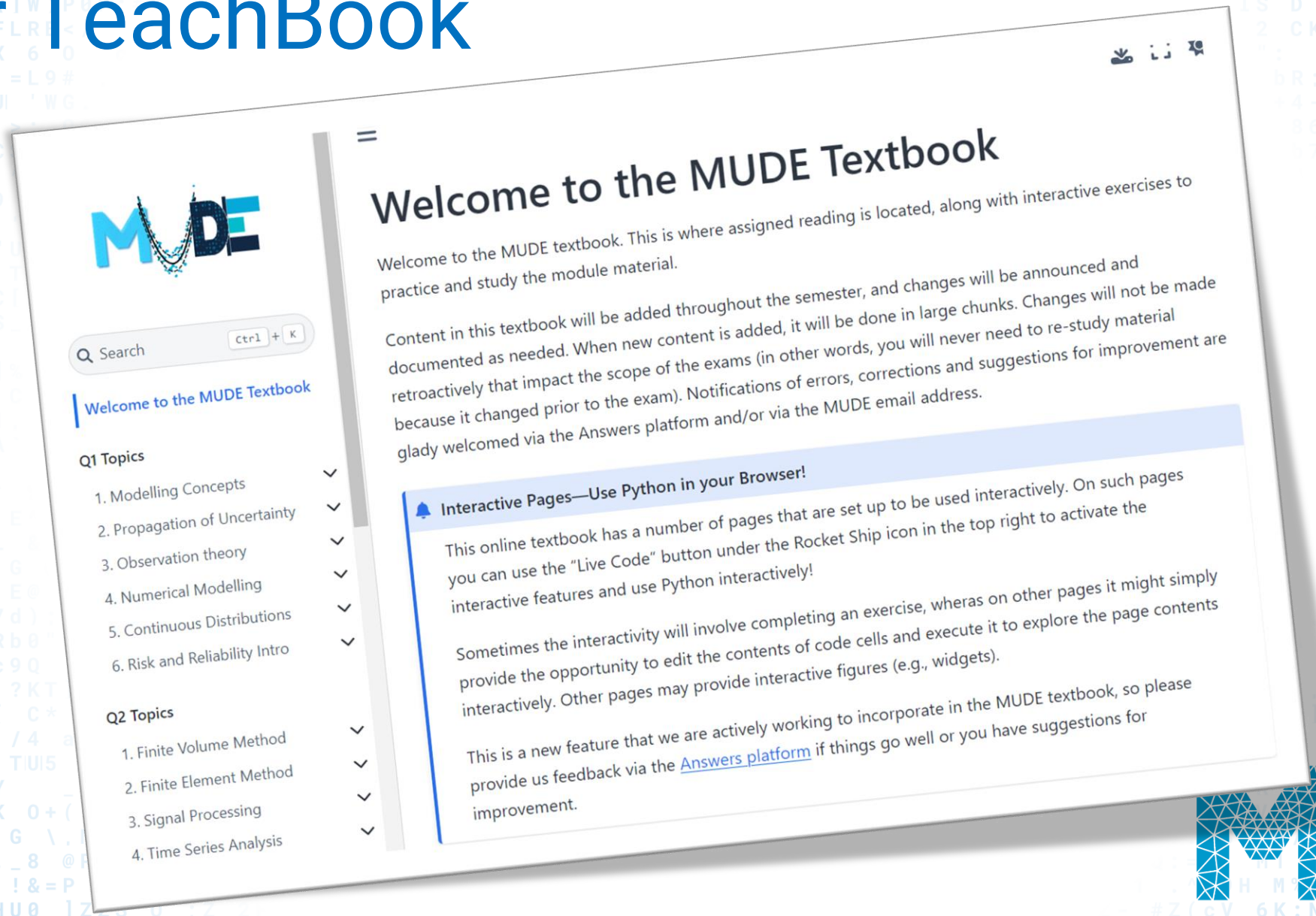
Our TeachBook



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Our TeachBook

The interactive Python features were illustrated using 3 demonstration videos that are not included in this PDF, but can be viewed at the following YouTube Links:

- Sympy: https://youtu.be/X0zrIwUKja4
- Quiz Questions: https://youtu.be/eUmdEu_Z5us
- Neural Network: https://youtu.be/8AeYnKn4Tcg
- Confidence Intervals: https://youtu.be/qCYA8z-u9DE

**As of March, 2024 the book is only accessible with a TU Delft account, but this will change in the future.*

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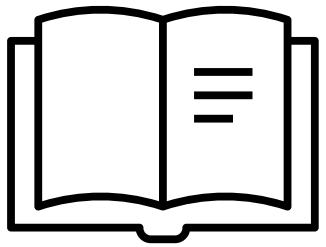
TeachBooks

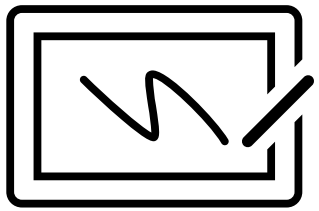
Teachers' Educational Assistance for interaCtive Hands-on Browser-based Online Open Knowledge for Students

interactivetextbooks.citg.tudelft.nl

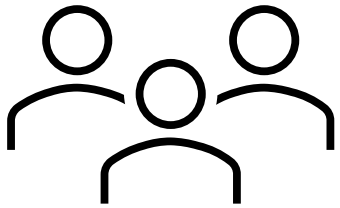
TeachBooks



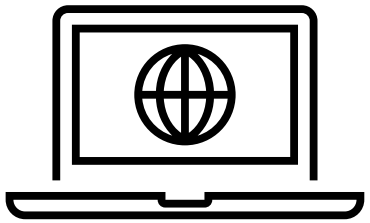
Manual on collaboration and interactivity



Template for your own book in 15 clicks



Share content, features and advice within community, supported by TAs



Your online book via GitHub or GitLab

Example – Python in browser (client-side)

Python-enabled interactivity

Our book has been enable to run Python code live in the browser (thanks Max!). This page contains some installation instructions and the other sections show how to use this functionality to create interactive figures and feedback on code

Setting up Python live coding

To set up the Python live coding you need to add our own sphinx-thebe extension to your book. This extensions doesn't rely on a 3rd party like Binder and it supports local python execution and custom features. Therefore, you need to add some lines to `requirements.txt` and `_config.yml`

For `requirements.txt` add the following lines:

```
--extra-index-url https://gitlab.tudelft.nl/api/v4/projects/11239/packages/pypi/simple
sphinx-thebe ~= 0.9.9
```

This will download the correct version of the sphinx extension when the book is build on the server (which loads the required packages from `requirements.txt`)

Afterwards, this sphinx extension needs to be enabled in your book. This can be done by adding the following lines to `_config.yml`:

```
launch_buttons:
  thebe: true
```

TeachBooks

Over 10 books actively used in education

Over 1000 students impacted

3 faculties

All of this with our “local” CEG support (TA’s)

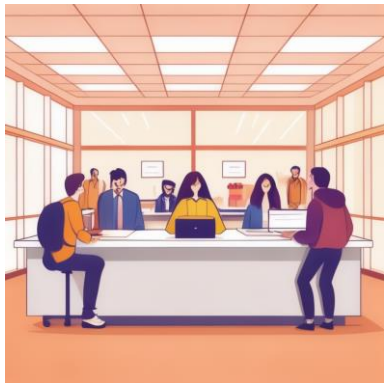
Imagine what we can do together with a pool of TA’s at the university!

We want You to be Involved

Feedback from student-view

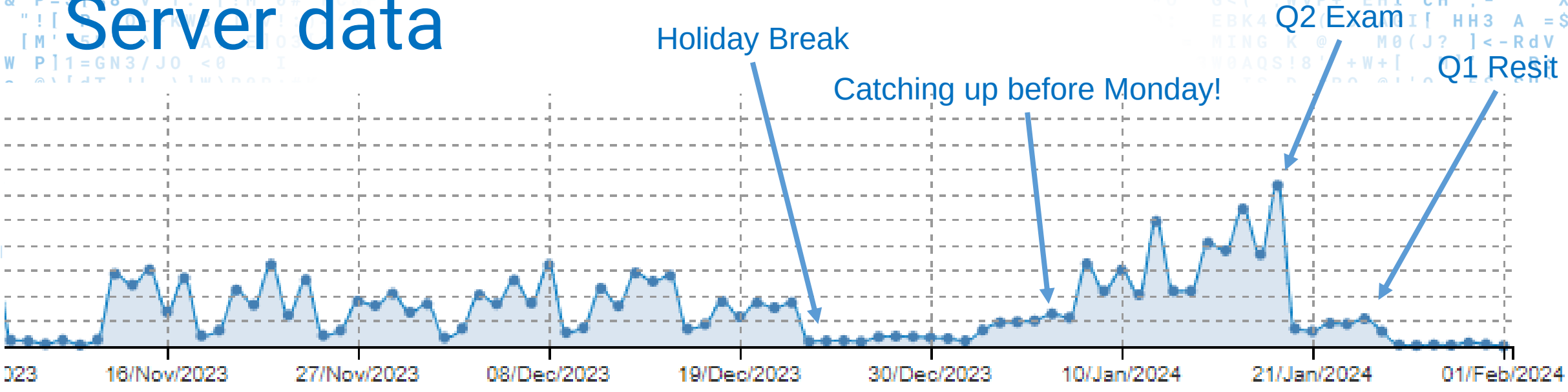
(Unexperienced) teachers promoting interactivity

Experts sharing content, features and learn us how to do this



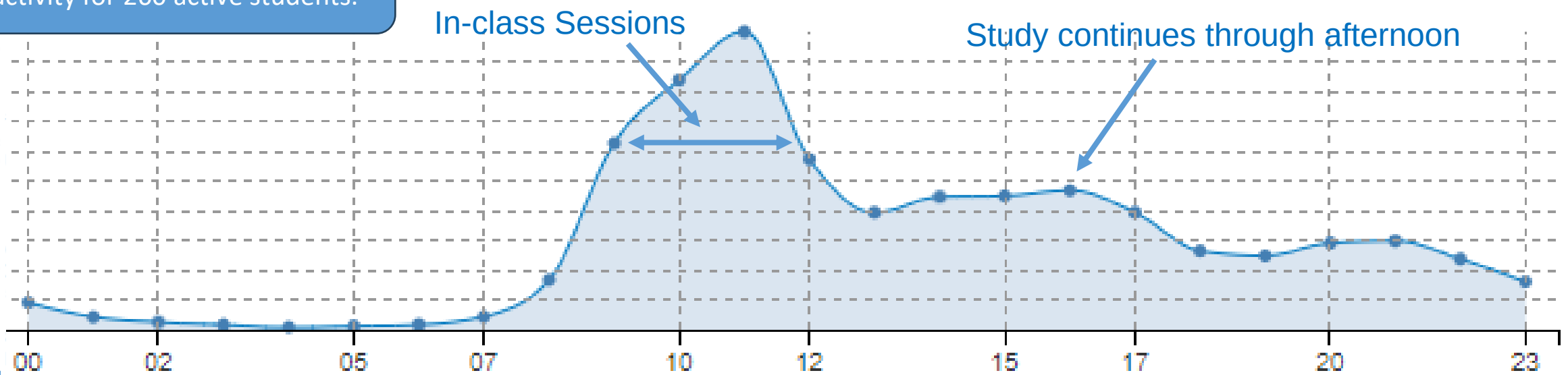
Administrators referring to our platform

Server data



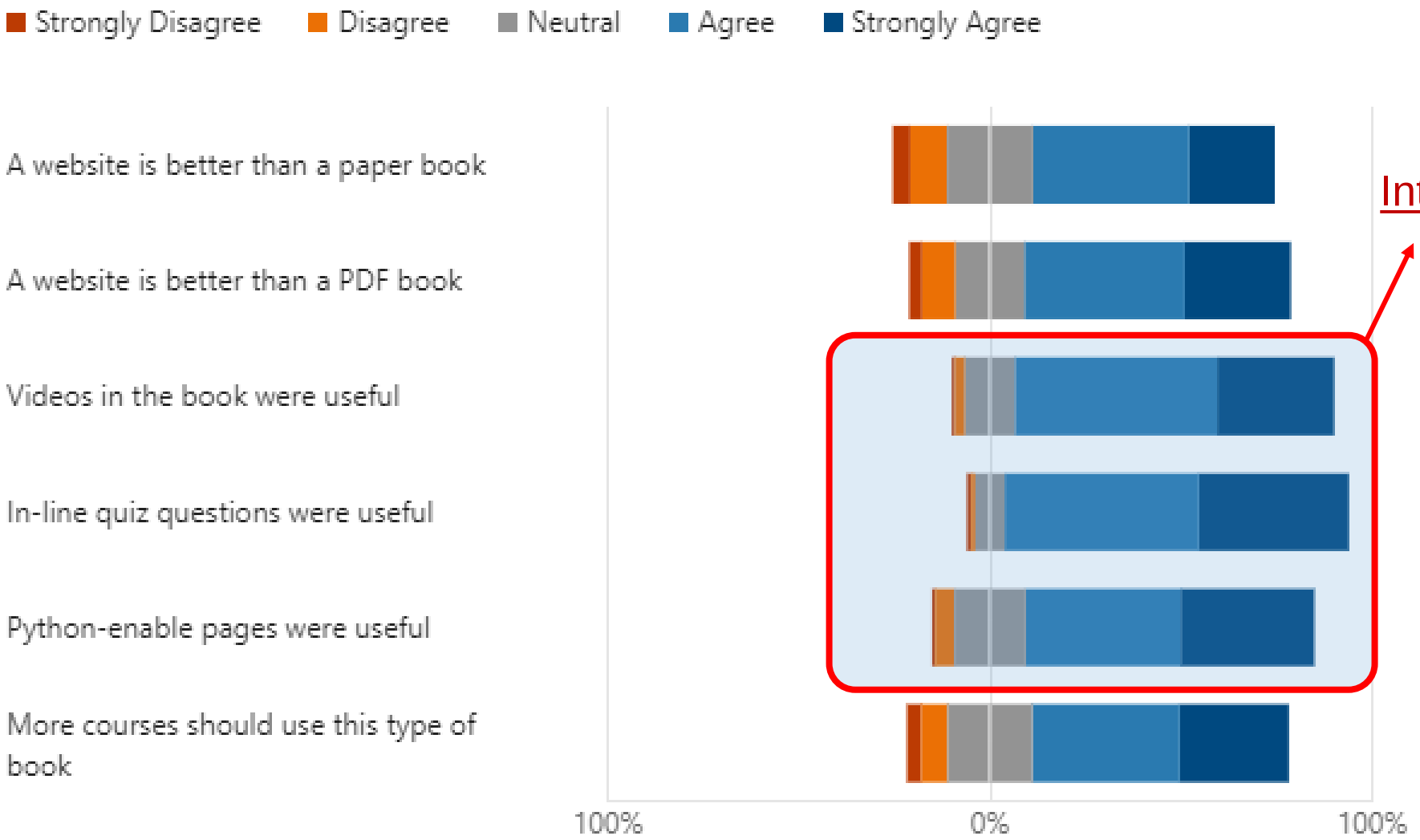
Usage of website during Q2

Vertical scales are relative measures of activity for 260 active students.



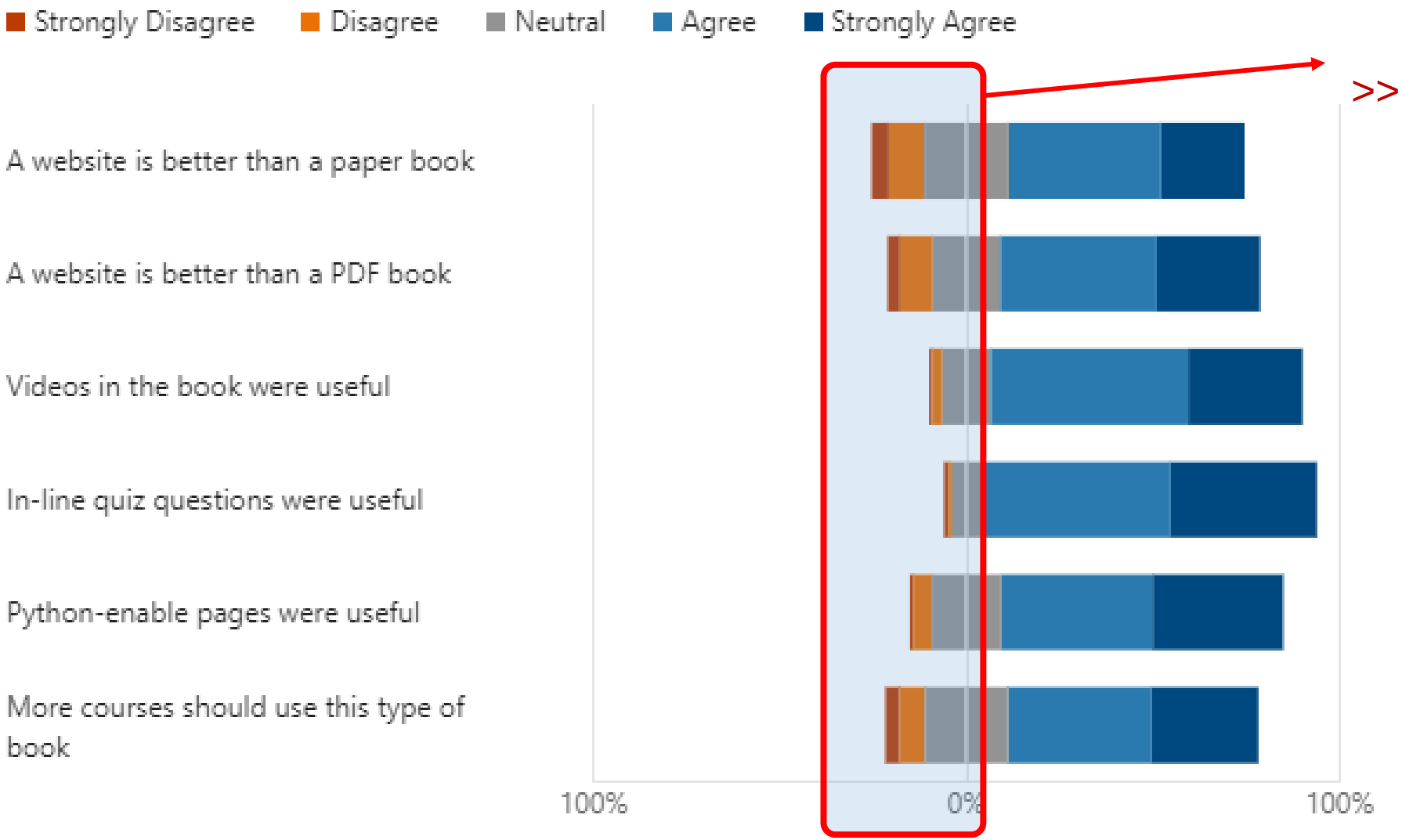
Usage of website by hour of day (all days)

How students perceive the book (100% response rate)



Interactivity is appreciated!

How students perceive the book (100% response rate)



Students want their "own" version to study

>>> We will work on this in March, get in touch if interested!

Book the one and only solution?

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Book is nice, but not everything

- How to work with your own Python environment?
- How to work with your own file system?
- Which IDE to use? And how to use it?
- How to collaborate with git?
- How to communicate using code?

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Programming on own device with open-source tools

eum

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Assignments via git

- MUDE group 2023-2024
  - Personal groups for students
    - One repository per assignment
  - Student group
    - One repository per assignment

- Repository are forks of central repository
- Linked to online file explorer with improved rendering

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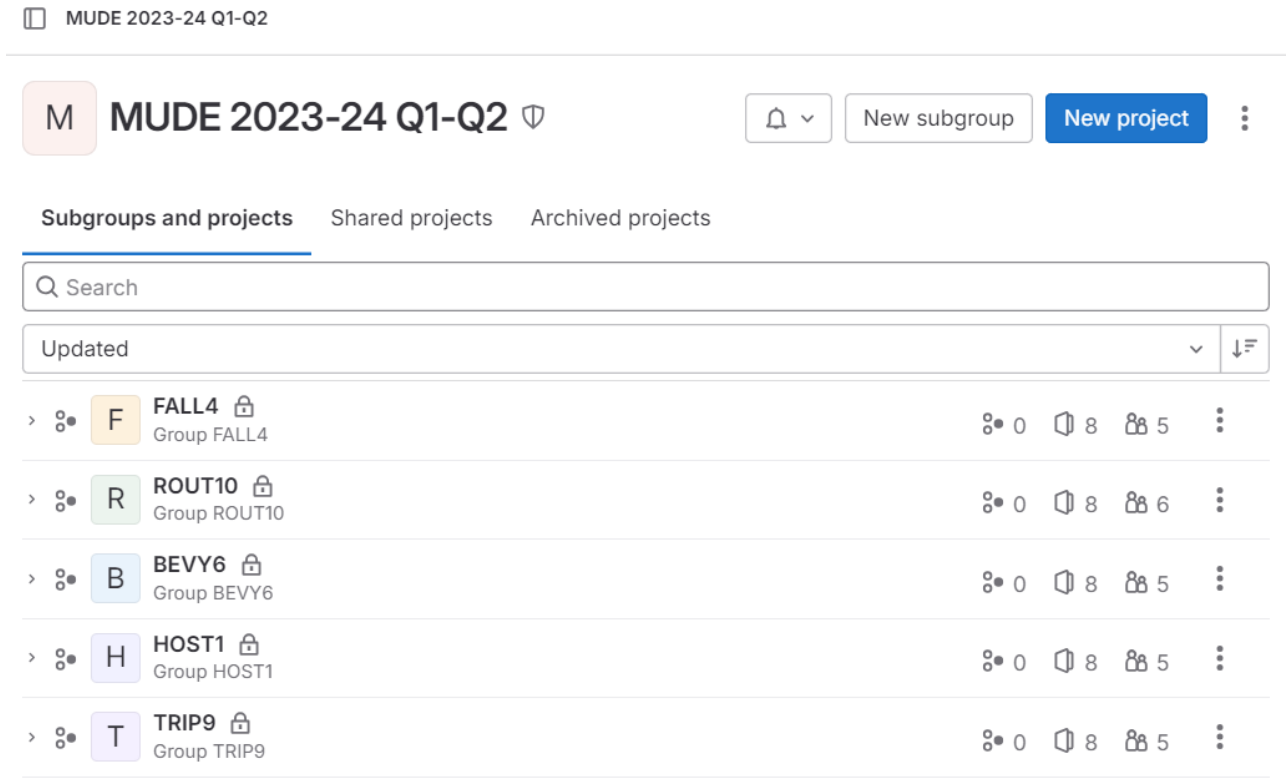
Distribution via git

Distribution via python scripts using GitLab API

- Only 2 people could use them on fixed moments in time
- NetID is used for students
- Preferred git environment TU Delft



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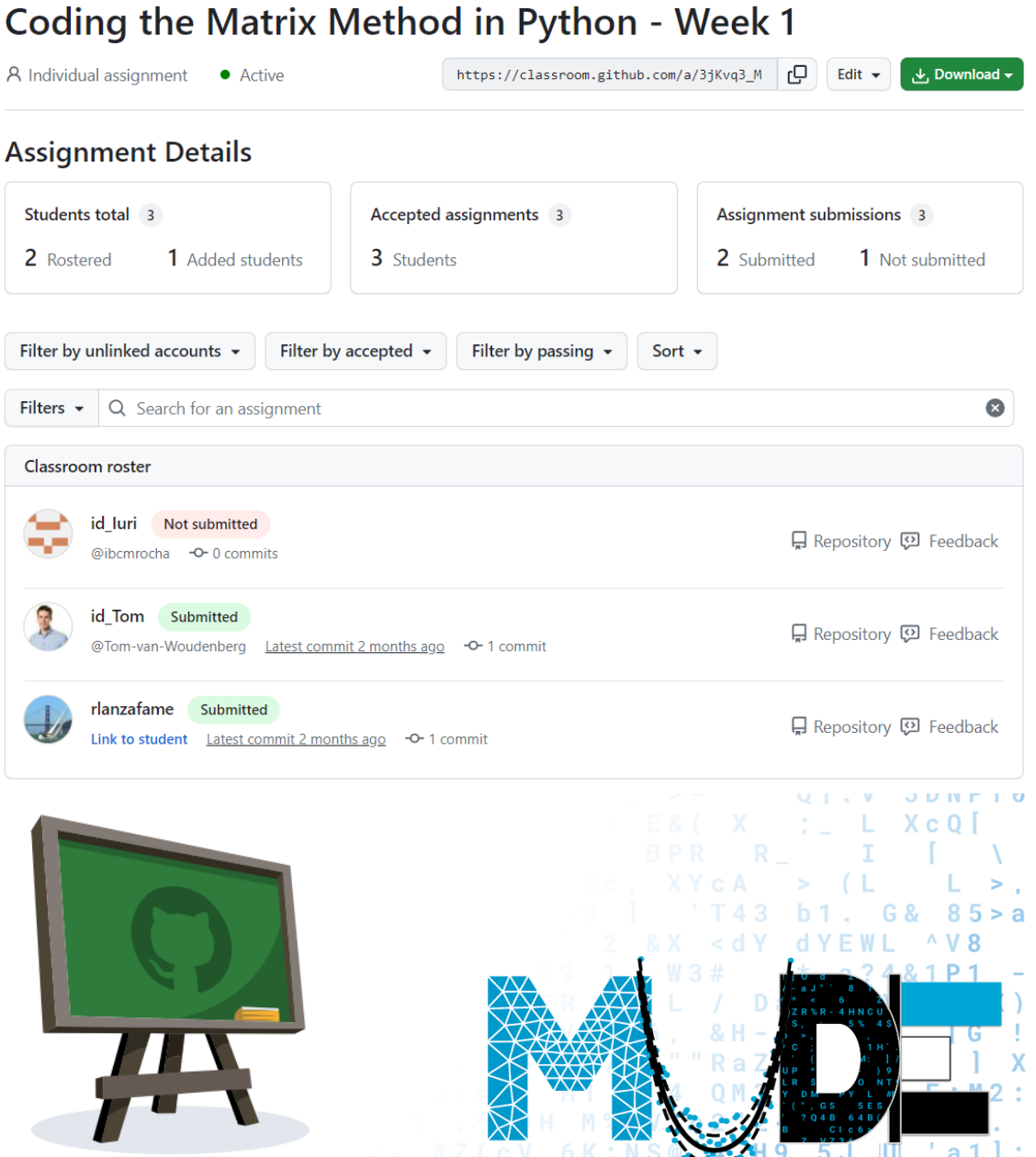
Assignments via git

- GitHub Classroom
- Students can start at any time
- GUI for administation and student overview
- Requires GitHub accounts for students
- Requested whether this workflow allow GitHub over GitLab



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Feedback via git?

Solution as:

- Branches
- Additional files

Feedback:

- Scripted automatic grading for programming assignments
- In a markdown file in their repo, or feedback via Brightspace

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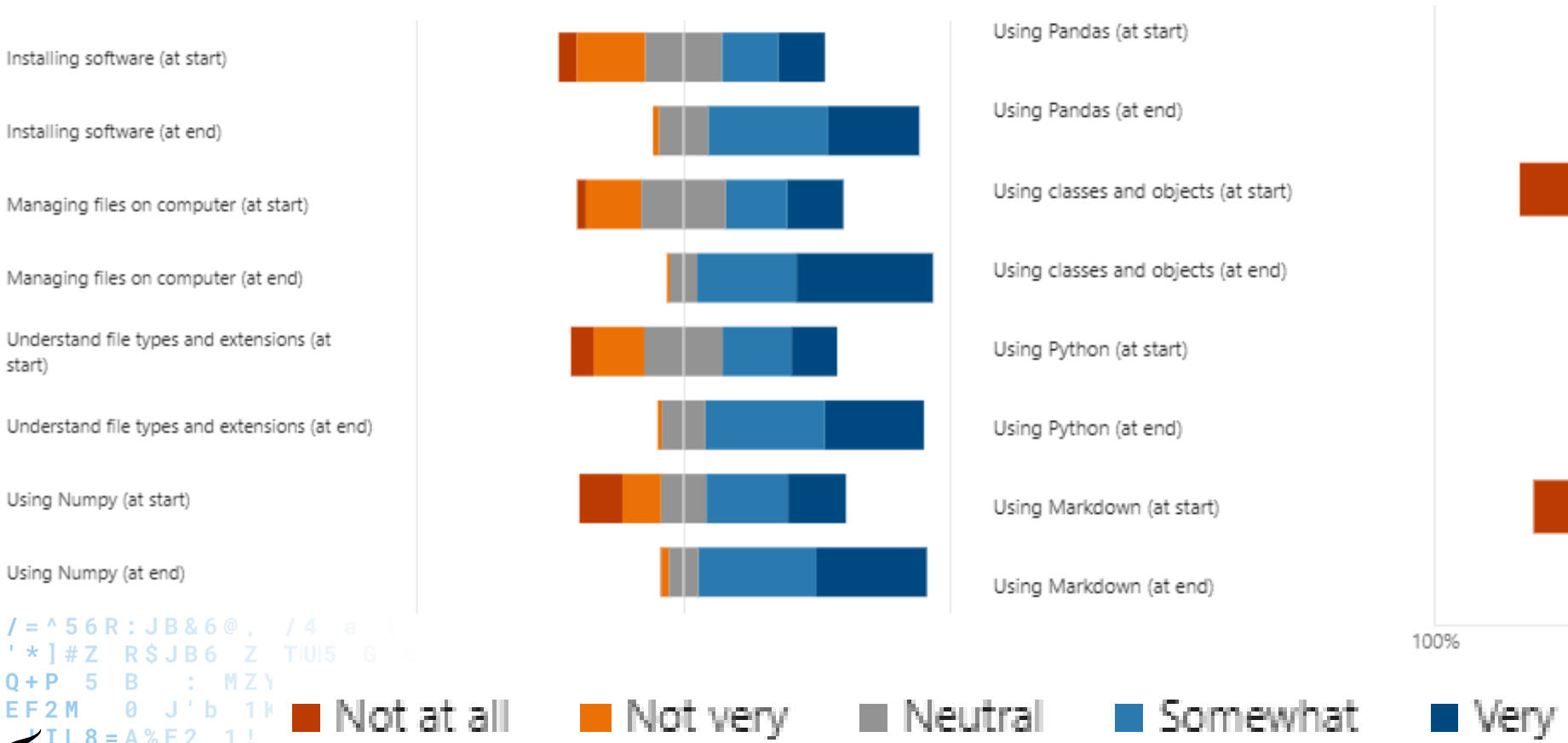
What do the students think?

- Survey asked paired questions:

  Describe comfort level with _____ at beginning of Q1 and end of Q2

N = 261, response rate = 100%

How comfortable with topic ____, before/after?



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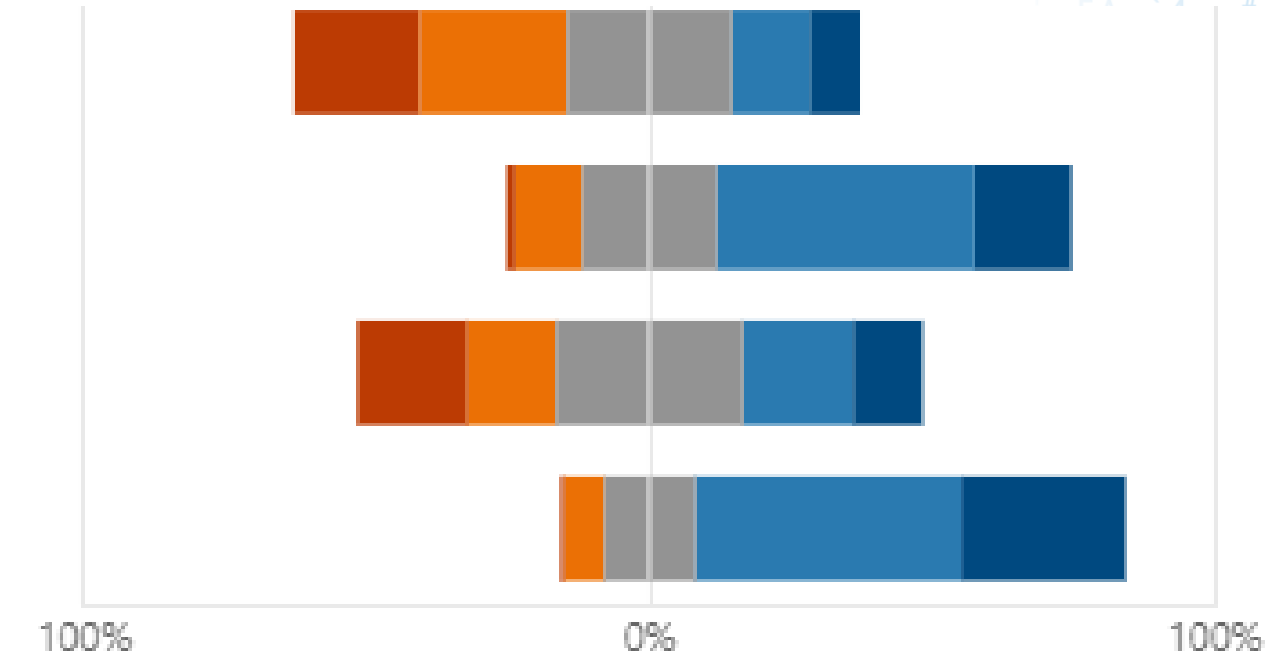
How comfortable applying for ____ that lists Python as a requirement, before/after?



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Thoughts for the future

Teaching materials work for students *and* teachers! ☺

- Supporting students: consider computer/programming context
- Supporting teachers: instructions, best practices, tech “support”
- Integration/alignment throughout curriculum: make information accessible
- Documentation + Communication is useful

- We will maintain links and resources on Digital Skills page
- Python: contribute examples to our book?

- Improving TeachBooks…with you!

Can you help us here?
…platform for communication / collaboration?
…license for edu material: only CC-BY?
…funding for book TA’s for all faculties?

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Dreams for the future

Frustrating:

- Explaining to administrators what we need as teachers
- Software and programming-related decisions lacking teacher perspective

→ Community of teachers collaborating on programming-related:

- Content
- Teaching
- Workflows

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Contact and Resources

Contact:

- Robert/Tom: TeachBooks@tudelft.nl
- MUDE: R.C.Lanzafame@tudelft.nl

Information websites:

- teachbooks.tudelft.nl
- github.com/teachbooks
- mude.citg.tudelft.nl/2023/overview

Our Python book:

- github.com/TeachBooks/learn-python
- teachbooks.github.io/learn-python

Our Prob/Stats book:

- github.com/TUDelft-CITG/learn-probability
- tudelft-citg.github.io/learn-probability
- May move to GH/TeachBooks soon….

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