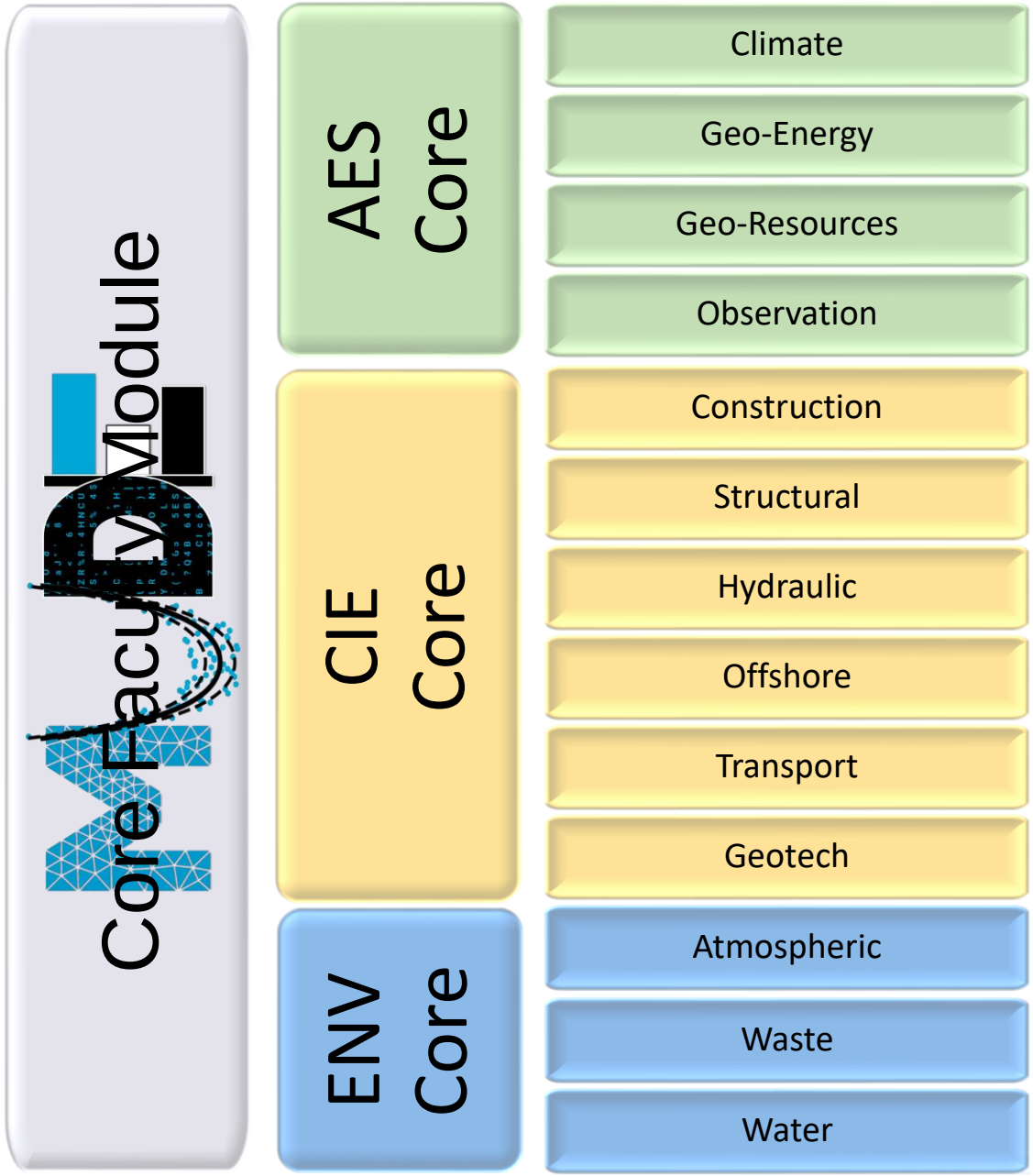
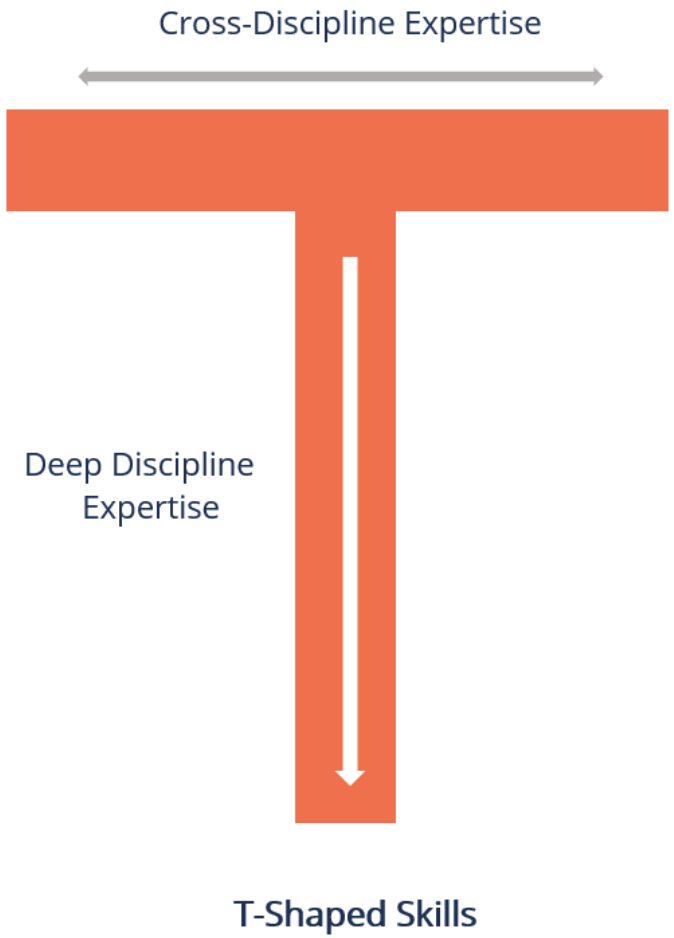
MSc Redesign

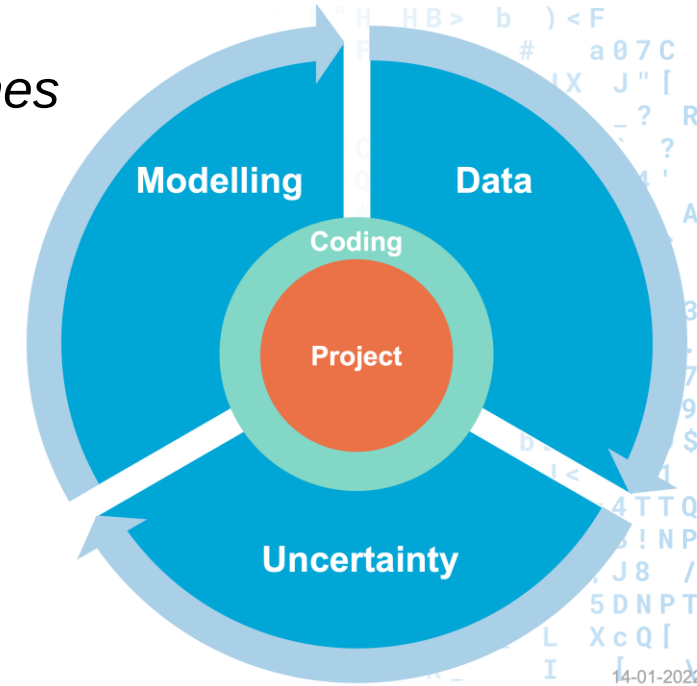


Philosophy



- *12 EC, Q1 + Q2, all programmes*

  [~500 students!]
- *Landing zone*
- *Engineering fundamentals*
- *Skills / Competences*



Challenges in design

- too many wishes, too many topics (16 courses → 1 module) :
- team formed (not organic)
- COVID, teams meetings
- resistance
- how to teach to so many students with so many backgrounds and interests
- …

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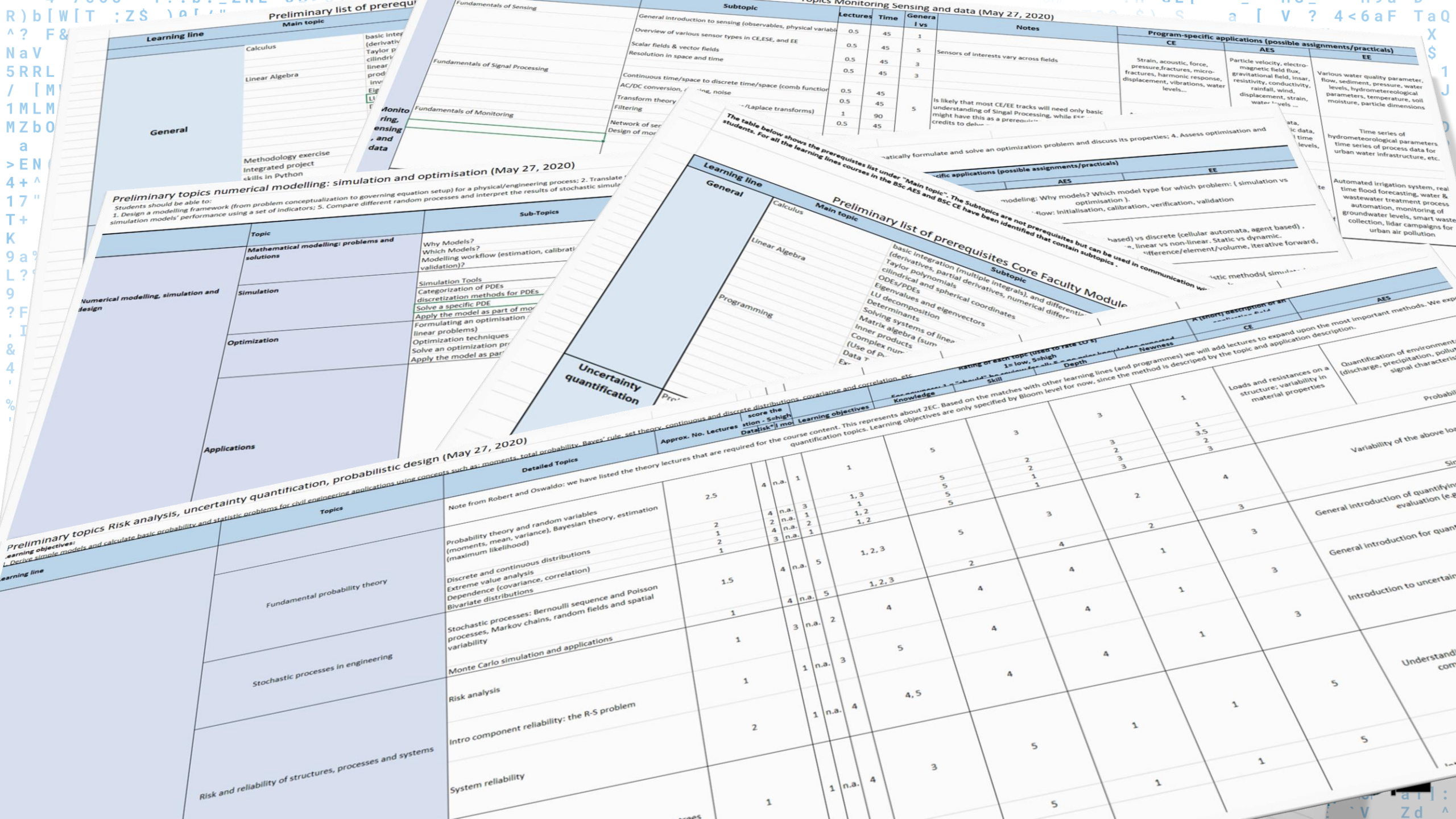

Preliminary list of prerequisites Core Faculty Modules (May 27, 2020)

Learning line	Main topic	Subtopic
General	Calculus	basic integration (multiple integrals), and differentiation (derivatives, partial derivatives, numerical differentiation), Taylor polynomials, cilindrical and spherical coordinates
	Linear Algebra	ODEs/PDEs, Eigenvalues and eigenvectors, LU decomposition, Determinants, Solving systems of linear equations, Matrix algebra (sum, Inner products, Complex numbers, (Use of Python), Data types, Examples
	Programming	
Uncertainty quantification	Probability theory	

Preliminary topics Monitoring Sensing and data (May 27, 2020)

	Subtopic	Lectures	Time	General vs	Notes	Program-specific applications (possible assignments/practicals)		
						CE	AES	EE
Fundamentals of Sensing	General introduction to sensing (observables, physical variables, ...)	0.5	45	1				
	Overview of various sensor types in CE,ESE, and EE	0.5	45	5	Sensors of interests vary across fields	Strain, acoustic, force, pressure,fractures, micro-fractures, harmonic response, displacement, vibrations, water levels...	Particle velocity, electro-magnetic field flux, gravitational field, insar, resistivity, conductivity, rainfall, wind, displacement, strain, water levels ...	Various water quality parameter, flow, sediment, pressure, water levels, hydrometereological parameters, temperature, soil moisture, particle dimensions
	Scalar fields & vector fields	0.5	45	3				
	Resolution in space and time	0.5	45	3				
Fundamentals of Signal Processing	Continuous time/space to discrete time/space (comb function)	0.5	45					
	AC/DC conversion, ing, noise	0.5	45					
	Transform theory (Laplace transforms)	1	90	5	Is likely that most CE/EE tracks will need only basic understanding of Singal Processing, while EE might have this as a prerequisite credits to deliv			
Fundamentals of Monitoring	Filtering	0.5	45					
	Network of sen							Time series of hydrometeorological parameters time series of process data for urban water infrastructure, etc.
	Design of mon							Automated irrigation system, real time flood forecasting, water & wastewater treatment process automation, monitoring of groundwater levels, smart waste collection, lidar campaigns for urban air pollution

Monitoring, sensing, and data

The table below shows the prerequisites list under "Main topic". The Subtopics are not prerequisites but can be used in communication with students. For all the learning lines courses in the BSc AES and BSc CE have been identified that contain subtopics .

matically formulate and solve an optimization problem and discuss its properties; 4. Assess optimisation and

cific applications (possible assignments/practicals)	
AES	EE
modeling: Why models? Which model type for which problem: (simulation vs optimisation).	
flow: Initialisation, calibration, verification, validation	
based) vs discrete (cellular automata, agent based) , , linear vs non-linear. Static vs dynamic. fference/element/volume, iterative forward,	
tic methods(simul	

Preliminary topics numerical modelling: simulation and optimisation (May 27, 2020)

Students should be able to:
1. Design a modelling framework (from problem conceptualization to governing equation setup) for a physical/engineering process; 2. Translate simulation models' performance using a set of indicators; 5. Compare different random processes and interpret the results of stochastic simul

	Topic	Sub-Topics
Numerical modelling, simulation and design	Mathematical modelling: problems and solutions	Why Models? Which Models? Modelling workflow (estimation, calibrati validation)?
	Simulation	Simulation Tools Categorization of PDEs discretization methods for PDEs Solve a specific PDE Apply the model as part of mo
	Optimization	Formulating an optimisation linear problems) Optimization techniques Solve an optimization pr Apply the model as par
Applications		

Preliminary topics Risk analysis, uncertainty quantification, probabilistic design (May 27, 2020)

Learning objectives:
1. Derive simple models and calculate basic probability and statistic problems for civil engineering applications using concepts such as: moments, total probability, Bayes' rule, set theory, continuous and discrete distributions, covariance and correlation, etc

Learning line	Topics	Detailed Topics	Approx. No. Lectures	Learning objectives	Rating of each topic (used to rate LO's) 1= low, 5=high: Knowledge	Skill	Depth	Newness	A (short) description of an application field: CE	AES
		Note from Robert and Oswaldo: we have listed the theory lectures that are required for the course content. This represents about 2EC. Based on the matches with other learning lines (and programmes) we will add lectures to expand upon the most important methods. We exp								
	Fundamental probability theory	Probability theory and random variables (moments, mean, variance), Bayesian theory, estimation (maximum likelihood)	2.5						Loads and resistances on a structure; variability in material properties	Quantification of environment (discharge, precipitation, pollu signal characteris
		Discrete and continuous distributions Extreme value analysis Dependence (covariance, correlation) Bivariate distributions	1.5							Probabil
	Stochastic processes in engineering	Stochastic processes: Bernoulli sequence and Poisson processes, Markov chains, random fields and spatial variability	1							Variability of the above loa
		Monte Carlo simulation and applications	1							Sir
	Risk and reliability of structures, processes and systems	Risk analysis	1							General introduction of quantifyinv evaluation (e.g
		Intro component reliability: the R-S problem	2							General introduction for quan
		System reliability								Introduction to uncertain
			1							Understand com

Diversity of Topics

Q1

1. Modelling Concepts
2. Propagation of Uncertainty
3. Observation theory
4. Numerical Modelling
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

What is your experience with Python programming?

1	None	15%	42
2	Just started	17%	47
3	Basic - intermediate	58%	163
4	Experienced	10%	27

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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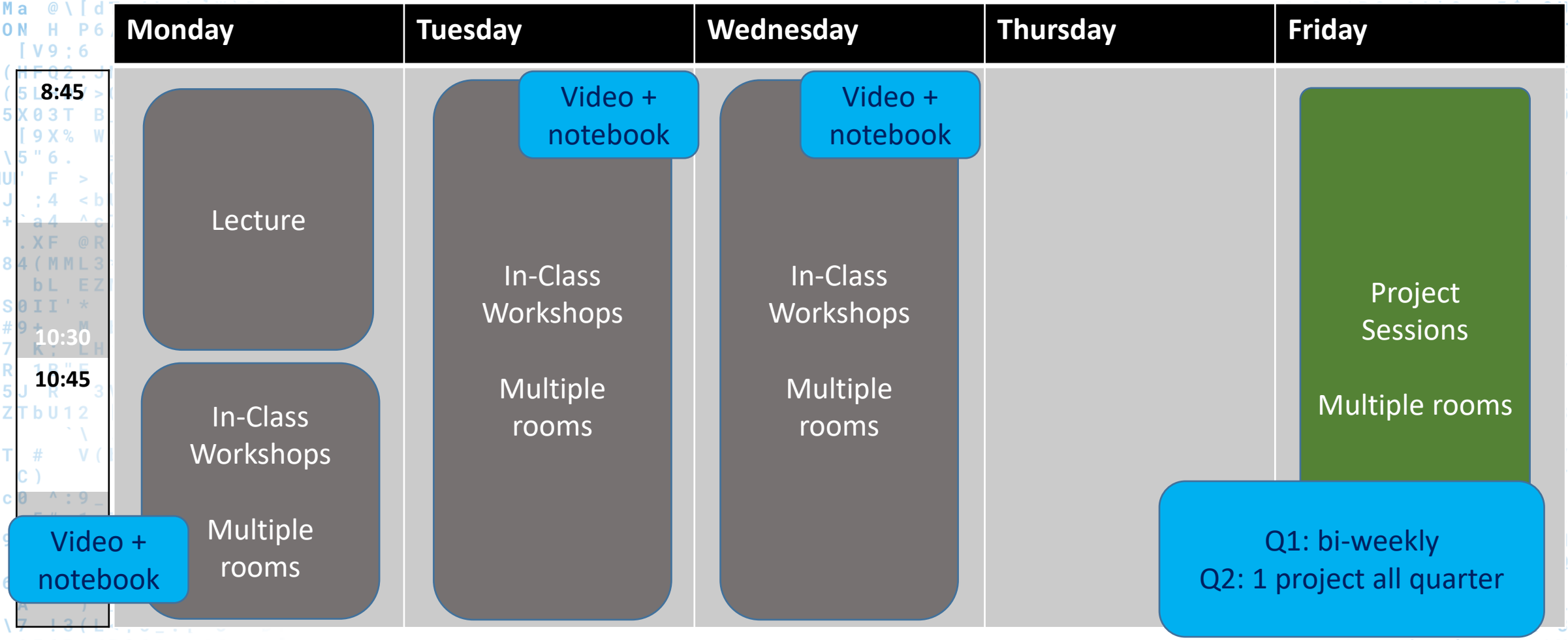
Weekly Schedule – Week 1

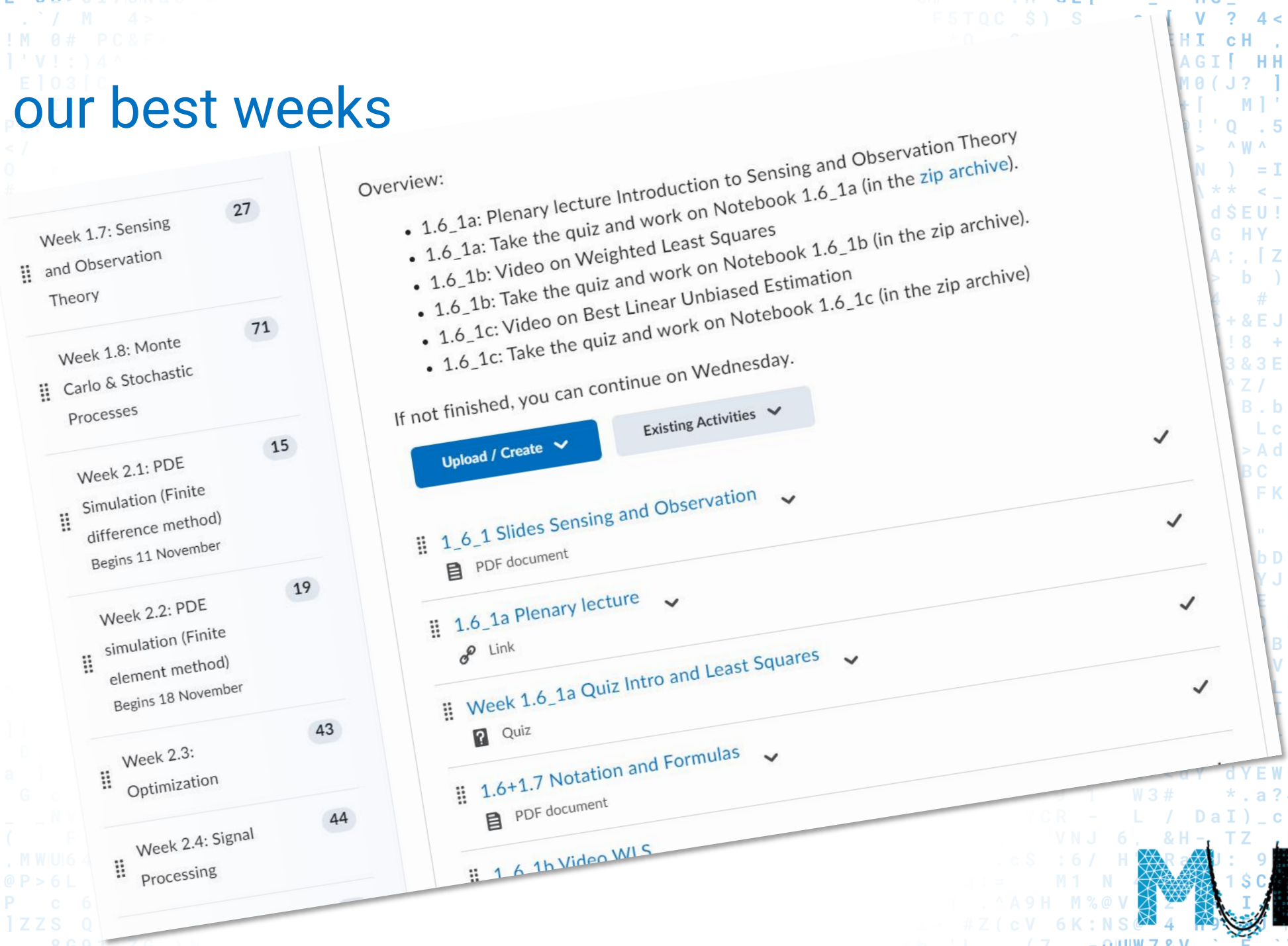


Materials provided via Brightspace: Jupyter notebooks, videos

Programming: 4-hour workshops in Tue or Wed sessions (~10 total).

One of our best weeks

https://bright



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The good and the less good – Year 1

Good	Less good
• Structured BS page	• Material not suited (for BS) • No time to standardize BS
• Relevant topics • Engineering / applications	• Way too many (sub)topics • Programming not tailored
• Projects useful and fun	• Projects too stressful
• Team motivation, adaptation to feedback	• Team organization / preparation

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Year 2

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Learning Objectives – simplified 17 → 6

After successfully completing the MUDE module a student is able to …

1. Apply a diverse set of models and analysis techniques to solve engineering problems through a combination of mathematical formulation and implementation in computer code.
2. Process and analyze data from different sources and formats to gain insight on the underlying systems and incorporate in modeling approaches.
3. Mathematically formulate, solve and discuss estimation, risk, reliability and optimization problems for systems to support decision making.
4. Analyze and reflect on the methodology, performance, and results of modeling approaches and analysis techniques, accounting for uncertainty.
5. Implement and carry out analysis using Python programming language following specific coding standards and best practices while facilitating collaboration.
6. Communicate and interpret results of analyses with appropriate documentation, metrics and visualization techniques.

https://studiegids.tudelft.nl/a101_displayCourse.do?course_id=65595

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MUDE

Learning Objectives

After successfully comp able to …

1. Apply a diverse set solve engineering problems through a tion and implementation in computer code.
2. Process and analyz hats to gain insight on the underlying systems nes.
3. Mathematically form isk, reliability and optimization probler king.
4. Analyze and reflect d results of modeling approaches and ana rtainty.
5. Implement and carr ning language following specific coding stan ting collaboration.
6. Communicate and i priate documentation, metrics and visualiz

Do stuff…

…using data.

Set up model…

…and reflect…

…with Python,

…share results.

https://studiegids.tudelft.nl/a101_displayCourse.do?course_id=65595

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MUDE

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!

Digital generation ≠ ability to use a computer

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MUDE

Diversity of Students

Our experience:

- Our BSc course prepares students to use numpy, matplotlib, 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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MUDE

Focus of Year 2, Programming and Digital Skills

What?

- Cover topics that aren't in BSc course
- Keep topics small and simple
- Use the topics immediately
- Use platforms commonly used in industry to build digital skills (not compatible with Brightspace)

How?

- Consistent formatting of assignments
- Online textbook
- Custom website
- Assignments, files, feedback via GitLab

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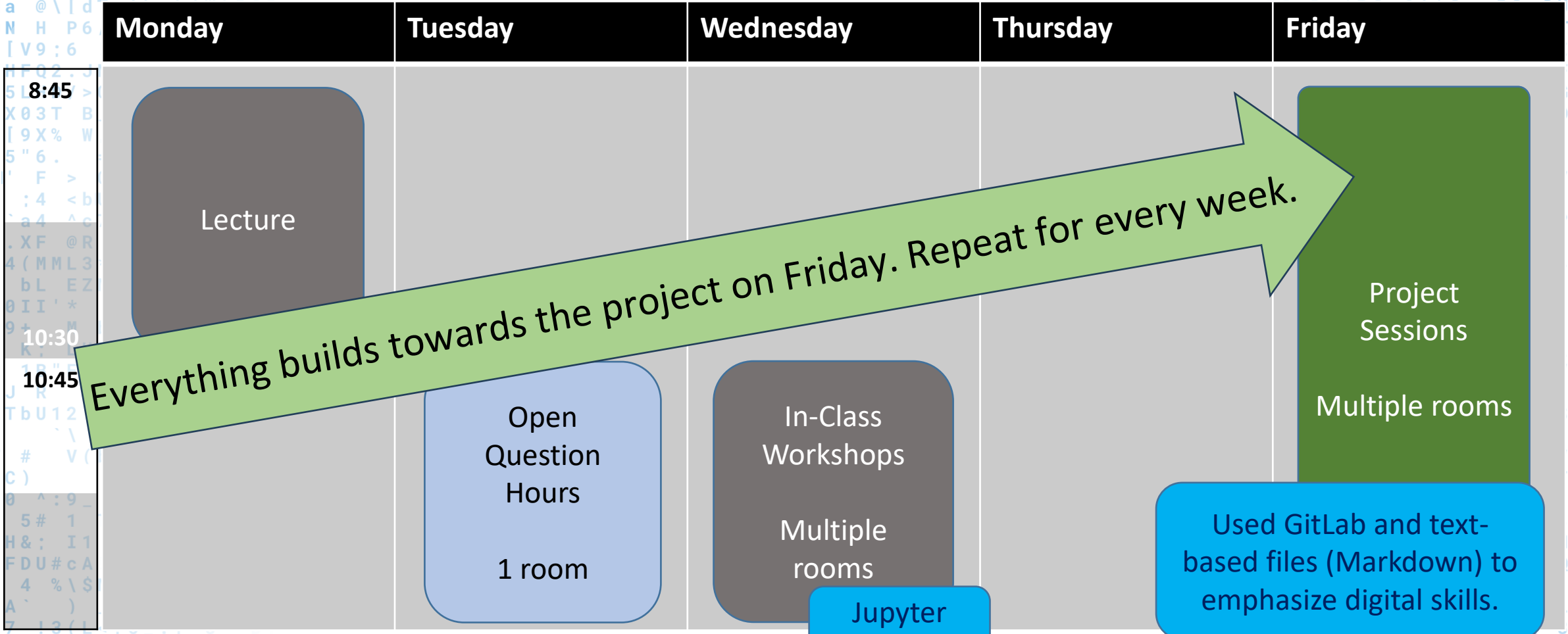
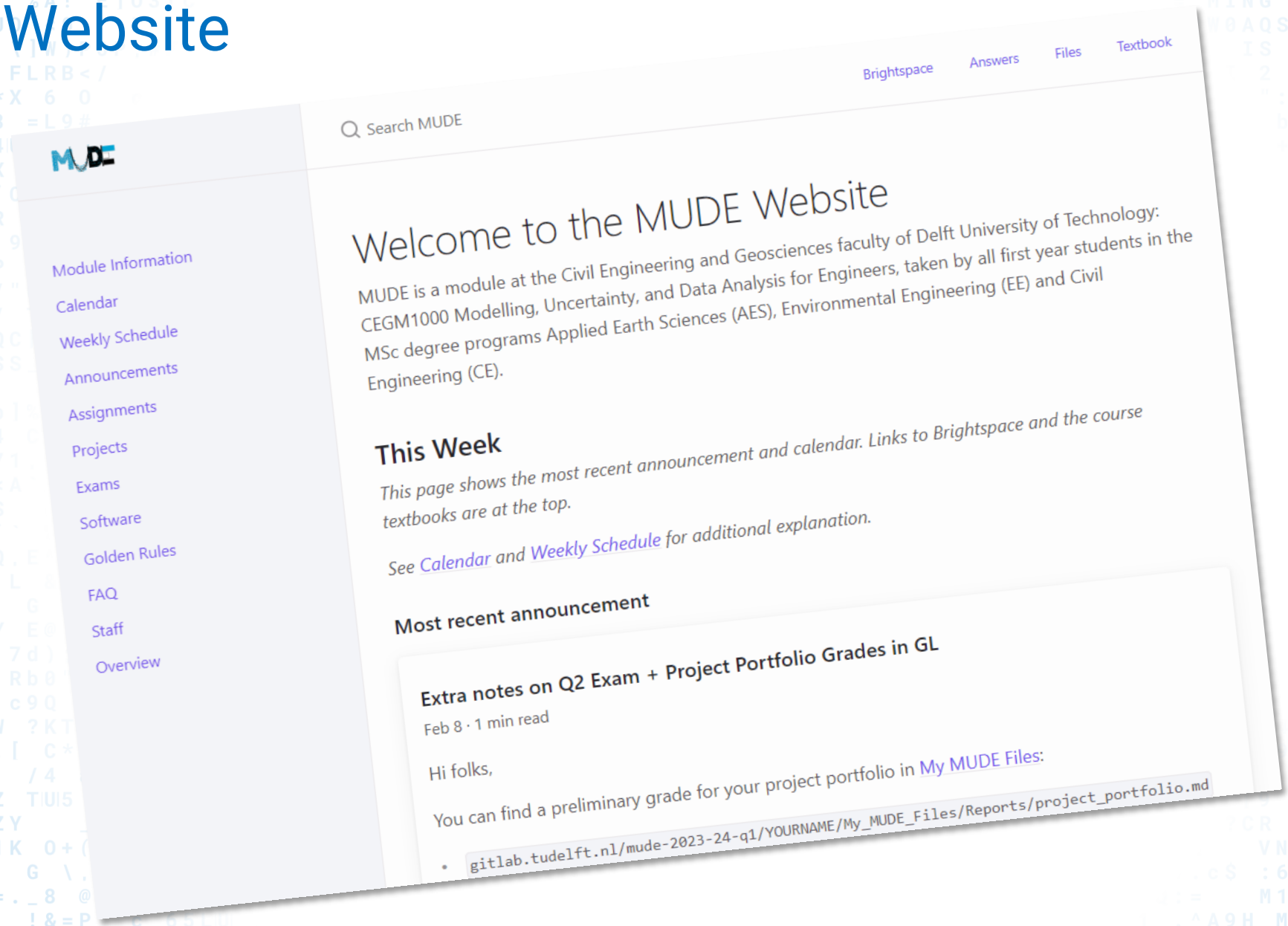
Weekly Schedule



Our Website

mude.citg.tudelft.nl



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mude.citg.tudelft.nl/book *

Book example p 21 slide

The interactive Python features were illustrated using 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 November, 2024 the book is only accessible with a TU Delft account or special login, but this will change in the future.*

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Example: Signal Proc

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.
```

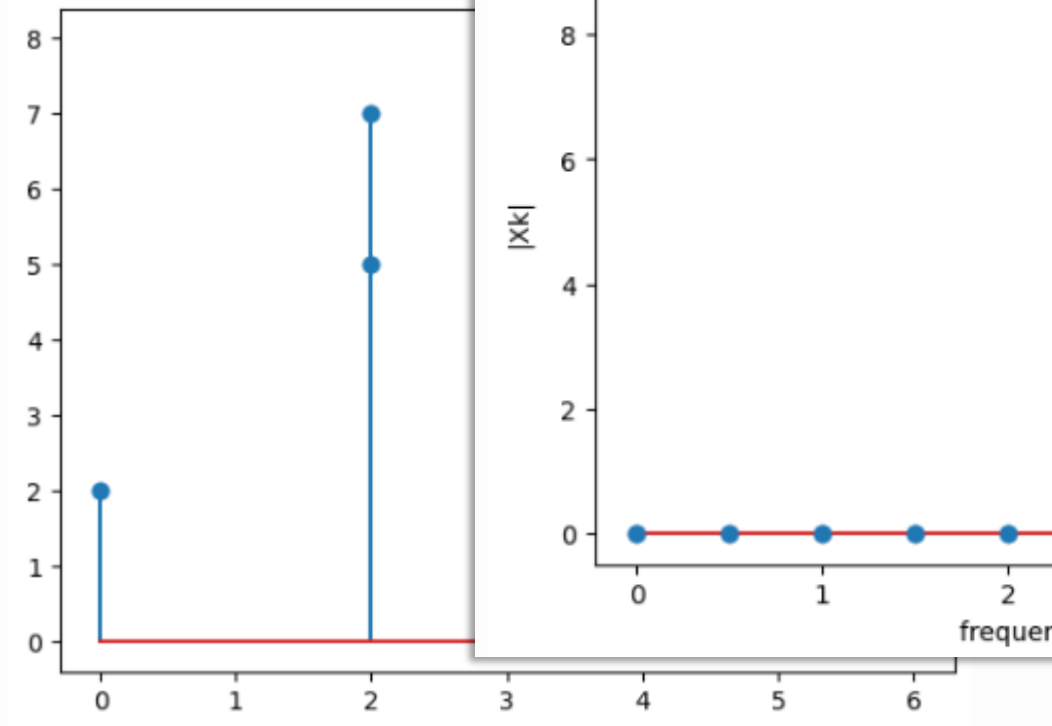
That's really compact!

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

Task 6:

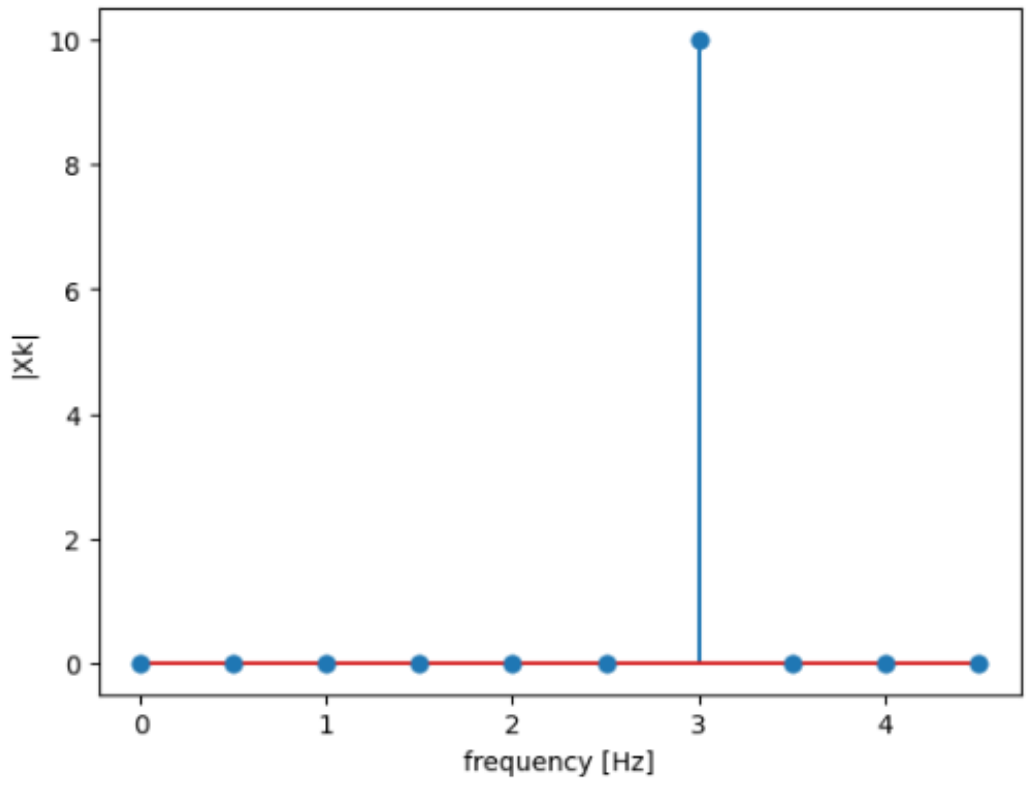
Run the cell below and play with the
with the stem plot type. Do you see
index?

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



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

```
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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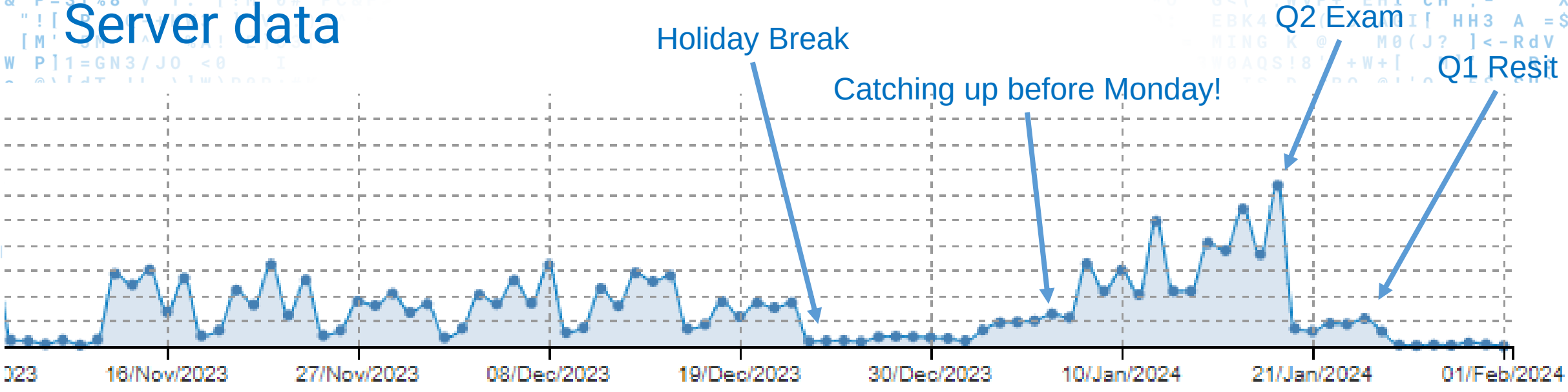
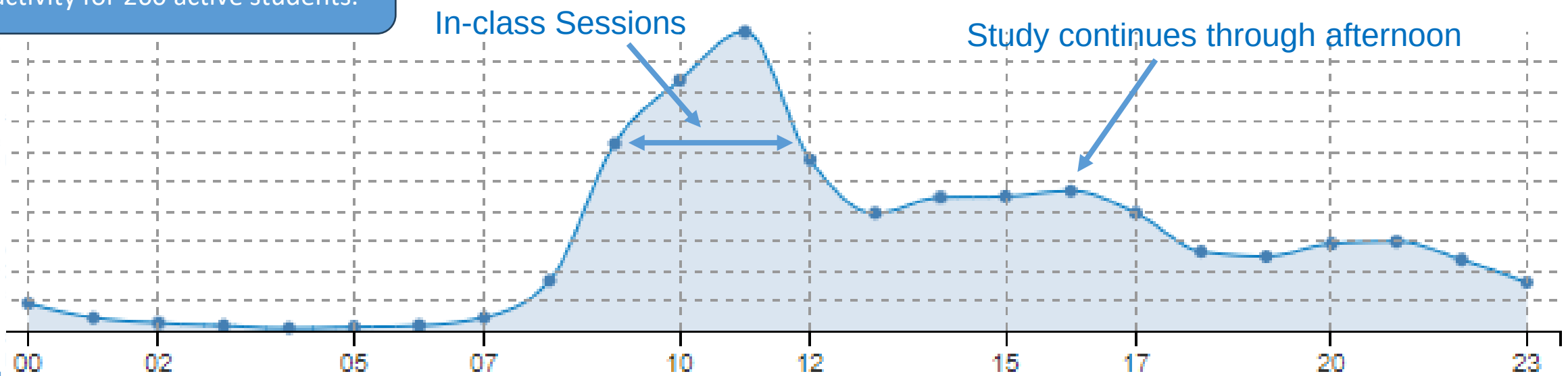
Server data



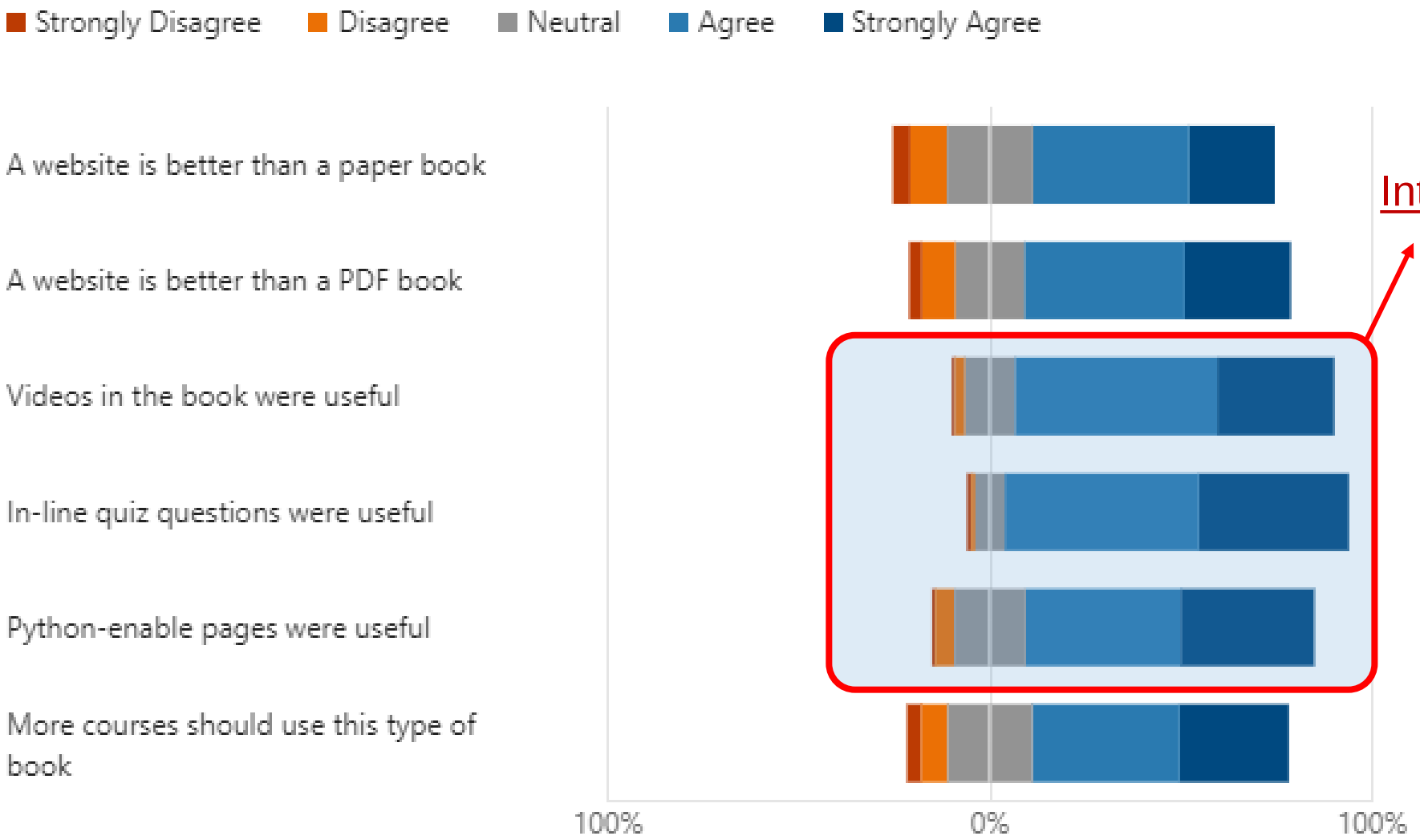
Usage of website during Q2

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



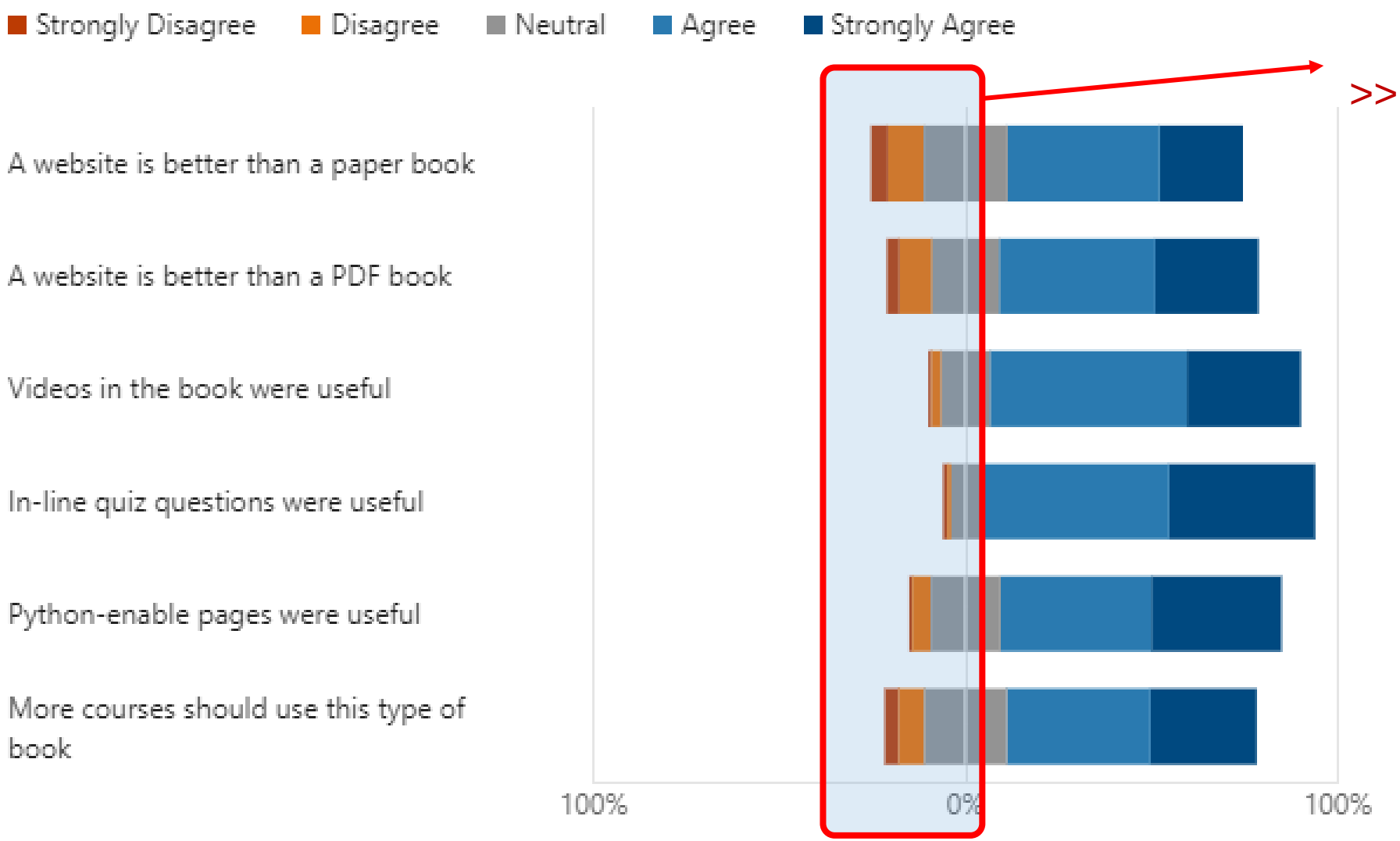
Usage of website by hour of day (all days)

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!

How did we make the changes?

Student Feedback

Year 1:

- Listen and talk with students during class, outside of class
- Make changes in real time
- Sometimes the changes were drastic!

>>> We quickly built trust with students;
they approached us with issues (and patience)

>>> Teachers grew accustomed to small-group decisions, in real time

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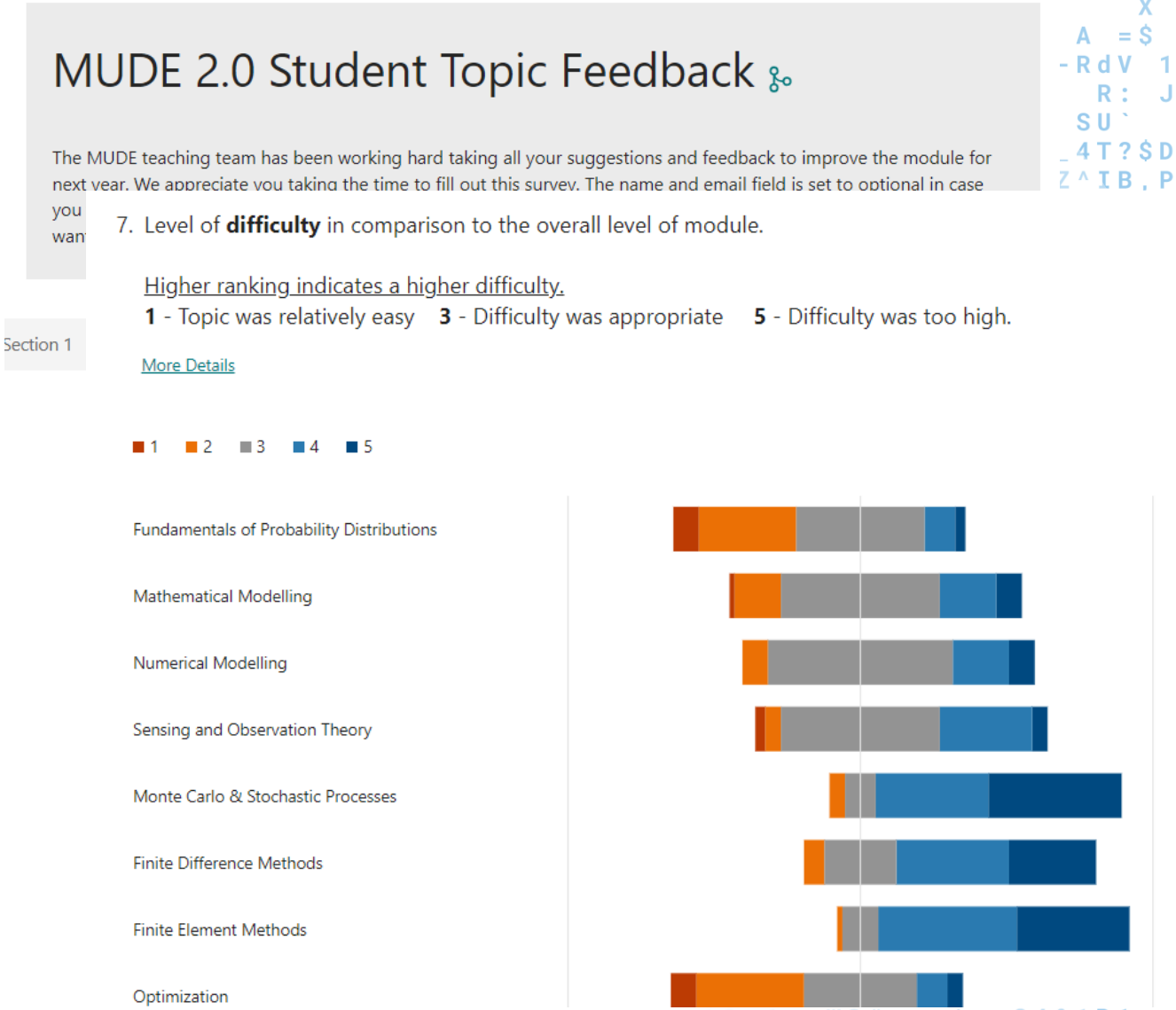
Focus Groups

- Send advance survey
- Use study associations to reach students (N = 57; ~20%)
- Meet students to discuss survey results
- … with sandwiches!!!

- Get better insights into ideas
- Can ask students about experience directly



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How did we make the changes?

Student Feedback

Year 2:

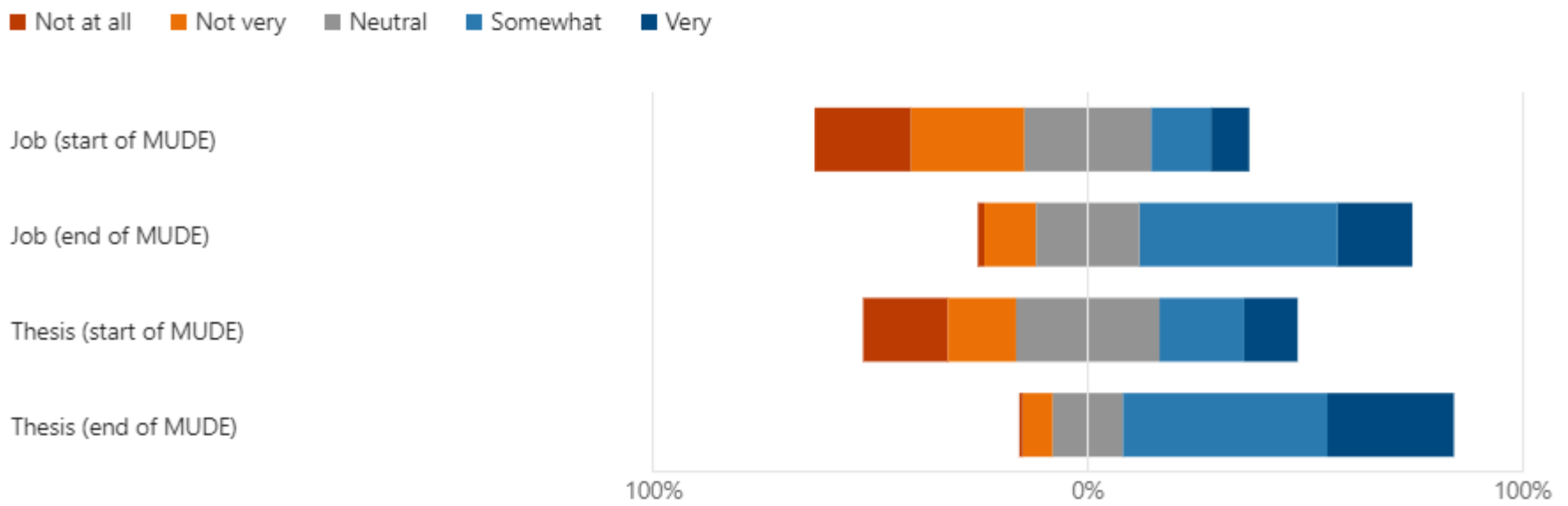
- Focus groups during the “off-season”
- Pre- and post-surveys

Pre- and Post-surveys

7. Describe your comfort level, *based on your programming experience at the start and end of MUDE*, with regards to whether or not you would apply to a job or thesis project where the job listing specifically requested Python experience from all interested applicants.

   In other words, select the answer that completes the sentence: *the comfort level I would feel in applying for a job/thesis project is ....., given my programming experience at the start of MUDE/now.*

More Details



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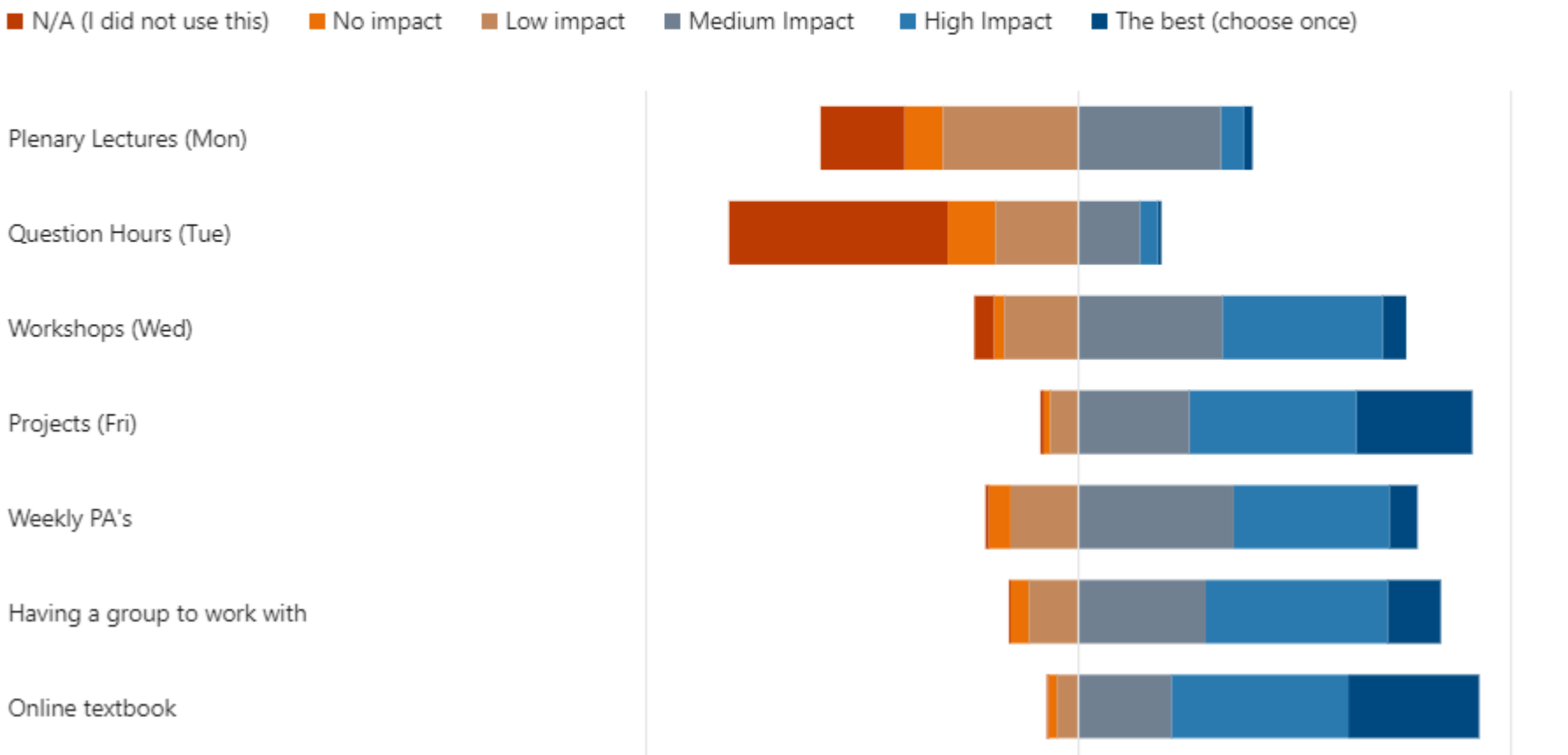
Pre- and Post-surveys

8. Given your progress in the topics listed above, which of the following activities had the biggest impact on your learning and growth?

More Details



How did we make the changes?

Teaching Team

- Focus inward (e.g., reducing number of large meetings)
- Reduce team size (part on purpose, part by voluntary involvement)
- Organic team development

Observations:

- Smaller team was more efficient, fun, produced higher quality education
- Also able to respond more quickly
- Students appreciated recognizable faces
- Downside: spread thin! (5 rooms, 250 students…)

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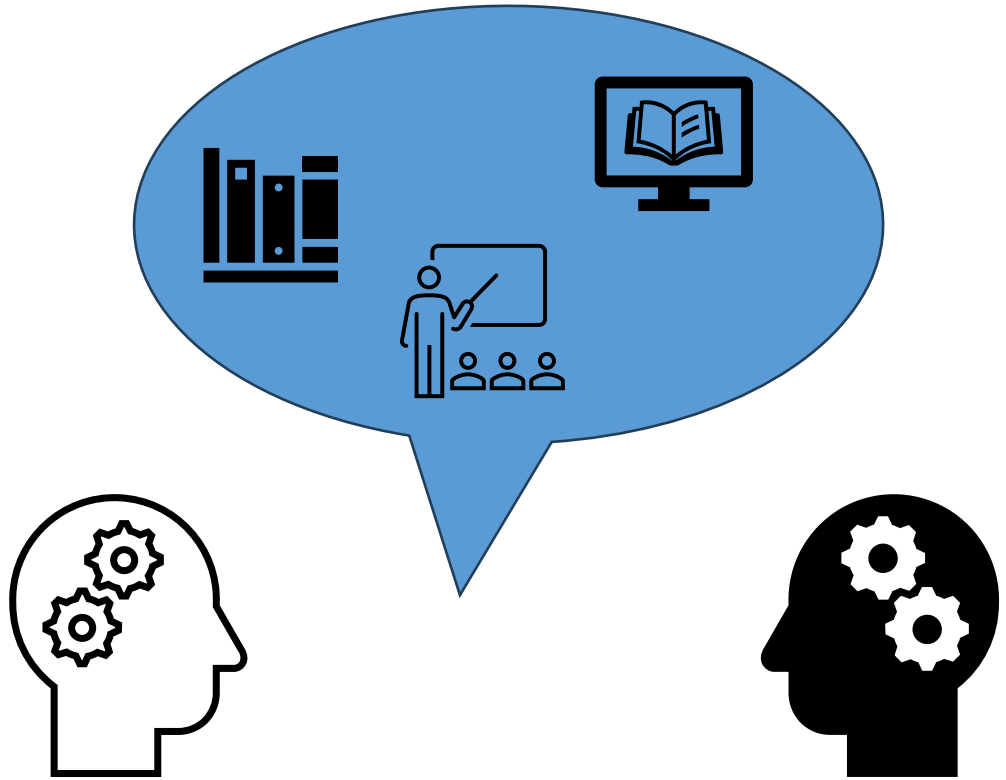
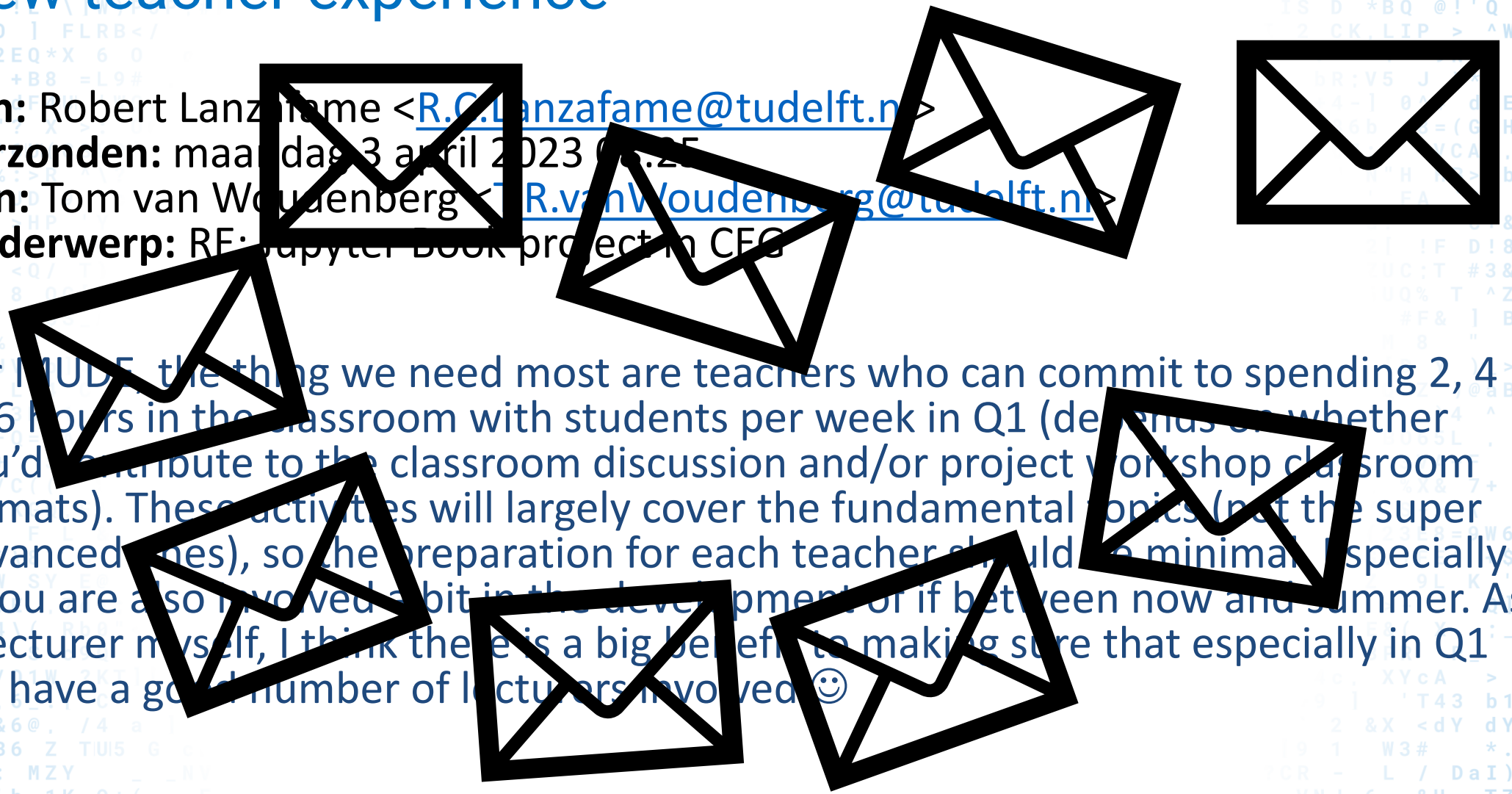
New teacher experience



New teacher experience



Van: Robert Lanzafame <R.C.Lanzafame@tudelft.nl>
Verzonden: maandag 3 april 2023 [illegible]
Aan: Tom van Woudenberg <T.R.vanWoudenberg@tudelft.nl>
Onderwerp: RE: Jupyter Book project in CEG

For MUDE, the thing we need most are teachers who can commit to spending 2, 4 or 6 hours in the classroom with students per week in Q1 (depends on whether you'd contribute to the classroom discussion and/or project workshop classroom formats). These activities will largely cover the fundamental topics (not the super advanced ones), so the preparation for each teacher should be minimal. Especially if you are also involved a bit in the development of it between now and summer. As a lecturer myself, I think there is a big benefit to making sure that especially in Q1 we have a good number of lecturers involved ☺

New teacher experience

Van: Robert Lanzafame <R.C.Lanzafame@tudelft.nl>
Verzonden: donderdag 6 april 2023 14:17
Aan: Tom van Woudenberg <T.R.vanWoudenberg@tudelft.nl>
Onderwerp: RE: Jupyter Book project in CEG

And finally, an invitation to another event, this one for MUDE. We have a team teaching workshop on April 18th, which you are welcome to join (see the message below). On the one hand you might be a bit in the dark because you aren't as familiar with Q1 topics yet, but on the other hand, if you want to get involved next year it might be a great way to get started. If you can make it, let me know and I will forward the invitations.

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New teacher experience

New teacher experience

Monday	Tuesday	Wednesday	Thursday	Friday
Join lecture	Do some non-MUDE stuff	Last minute preparations	Improve book	Project
Discuss plans for week	Join question hour	In-class Workshops	Prepare non-mude lecture	Project evaluation
Proofread book and make exercises	Make book better	Rewrite project based on workshops results	Non-mude lecture	Stare at screen
			Do some non-MUDE stuff	

MUDE stuff

Non-MUDE stuff

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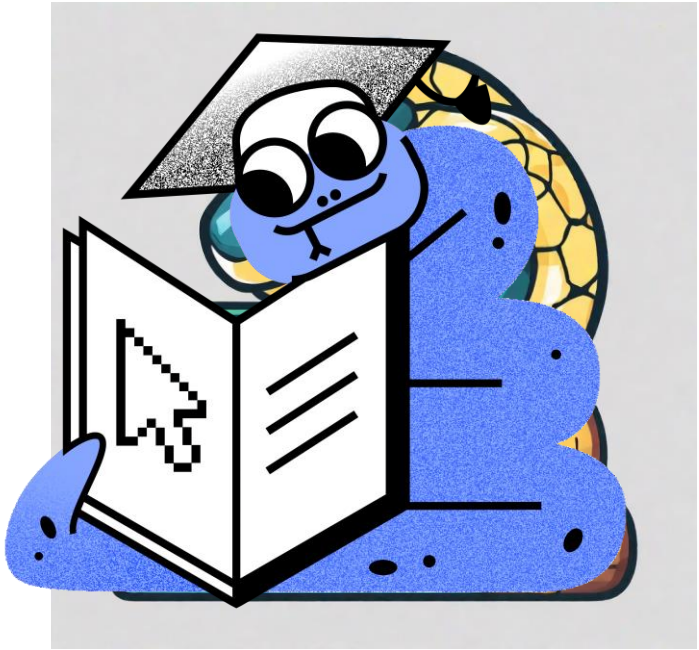
TeachBooks



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

More about this tomorrow!

teachbooks.tudelft.nl

The good and the less good – Year 2

Good

- Well-organized module!
- Scope within each week is good
- Highly efficient at covering a certain topic in a given week

Less good

- “Bigger picture” …
- Higher Bloom levels (engineering type thinking, etc)
- Group interaction / group work
- Redesigning Project feedback
- Finding dedicated teachers

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Our Tips for IIT Madras based on Year 2

- Keep the discussions limited in scope and number of people
- A small team is efficient; key skills?
  → project mgmt, decision-making, author/implementer, programmer
- Get started now choosing platforms
- The earlier you create your first assignment and test it, the better!
- Remember to keep things simple and explain the fundamentals well
- Keep in mind diversity of incoming students (>>> Year 3…)

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The good and the less good – Year 3

Good

- Format proves to be interesting/motivating for new teachers

Less good

- Lots of tools, platforms
- New teacher onboarding = 1 year (in part because of long history, but also because it is complicated!)
- We are still working on some Year 2 challenges

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MADE

Summary

- MUDE is complicated, but fun!
- Expect it to take years to converge
- A small, close-knit team is effective
- Start working now
- Communicate constantly with your students, and be prepared to react
- Keep track of the feedback (also impotant for improving materials)

- We are optimistic this workshop will help!
- This is a lot to absorb, so we start by taking it all in as a student

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