

Welcome & get ready for the course

Research Beyond the Lab: Open Science and Research Methods
for a Global Engineer

Prof. Elizabeth Tilley and Lars Schöbitz

Feb 22, 2024



This class is being recorded. Access to the recording is restricted to ETH members.

Welcome! 🙌

Meet the lecturers

Prof. Elizabeth Tilley



Lars Schöbitz



- Environmental Engineer
- Economist
- ...

- Environmental Engineer
- Retired researcher
- RStudio certified instructor
- Data steward at ETHZ

Learning Goals (for the course)

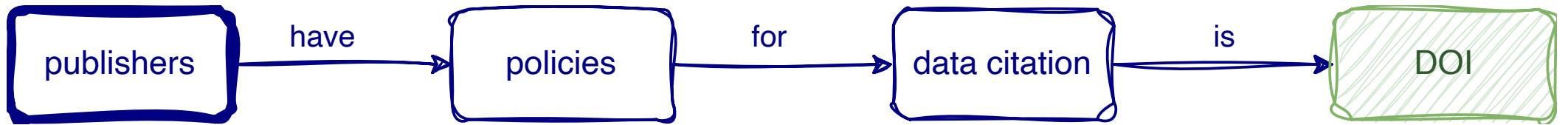
1. Be able to use a common set of data science tools (R, RStudio IDE, Git, GitHub, tidyverse, Quarto) to illustrate and communicate the results of data analysis projects.
2. Learn to use the Quarto file format and the RStudio IDE visual editing mode to produce documents with citations, footnotes, cross-references, figures, and tables.
3. Be able to design a questionnaire to collect information that can be analysed to answer a waste-related research question that is relevant for Zurich.
4. Understand the main challenges associated with managing different types of waste, and how they differ between Europe and Africa.

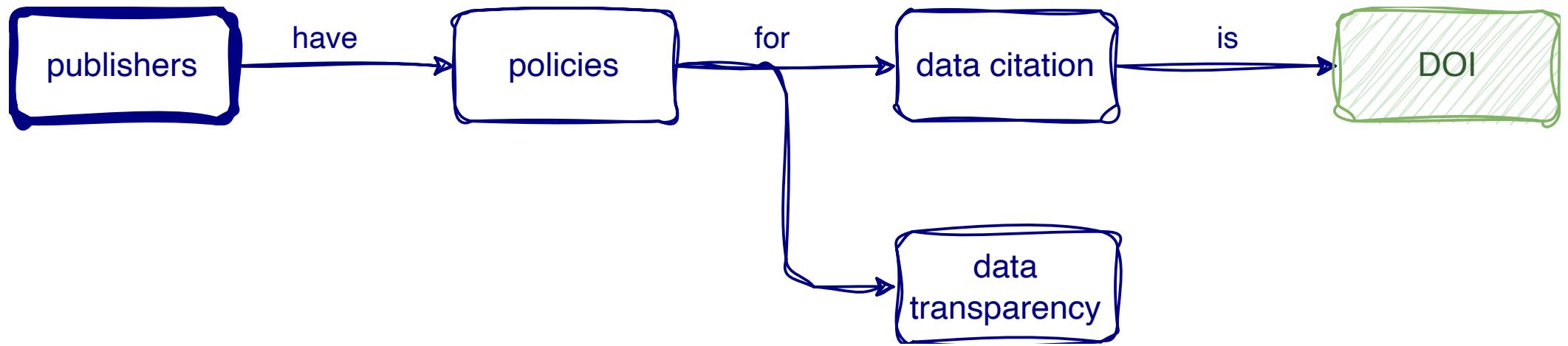
Why all of this?

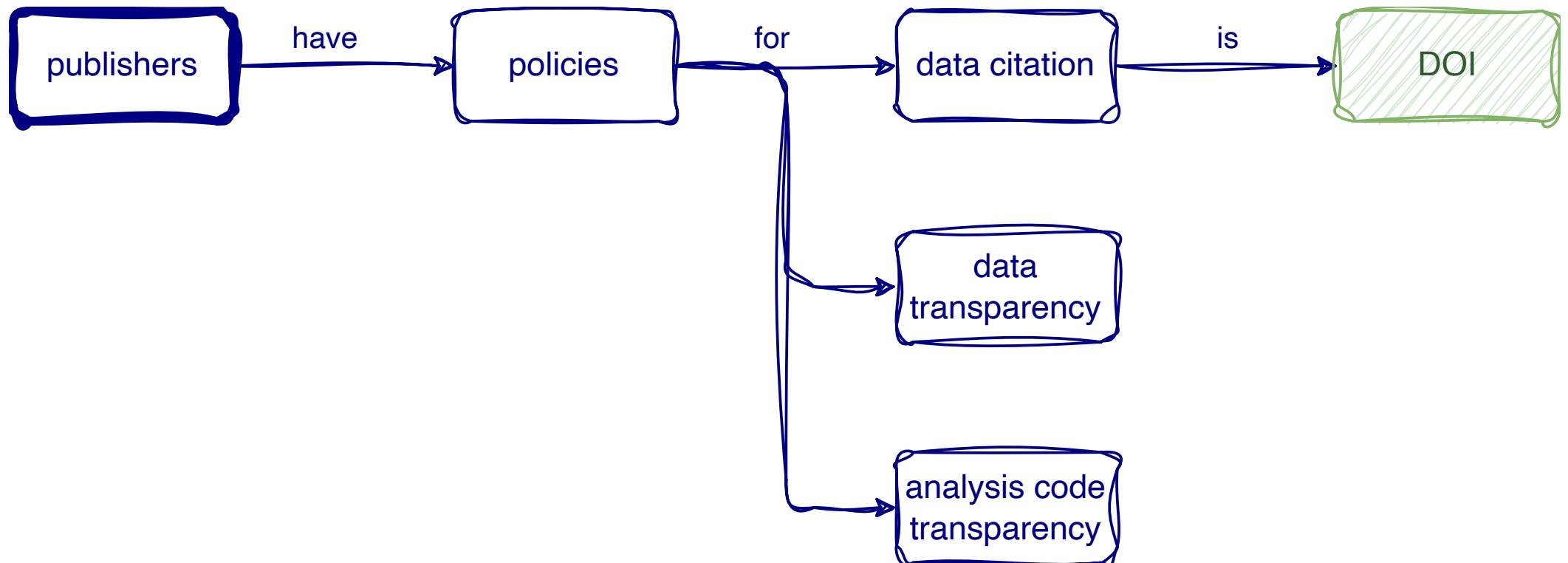
publishers

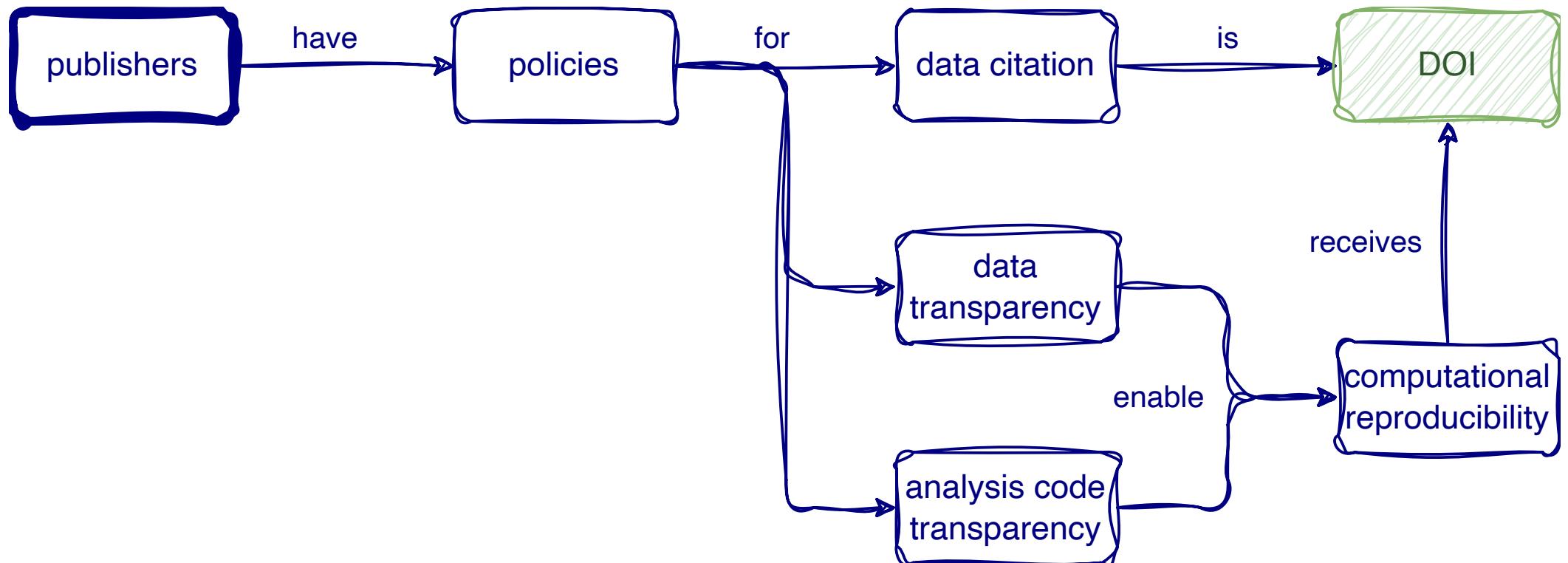
have

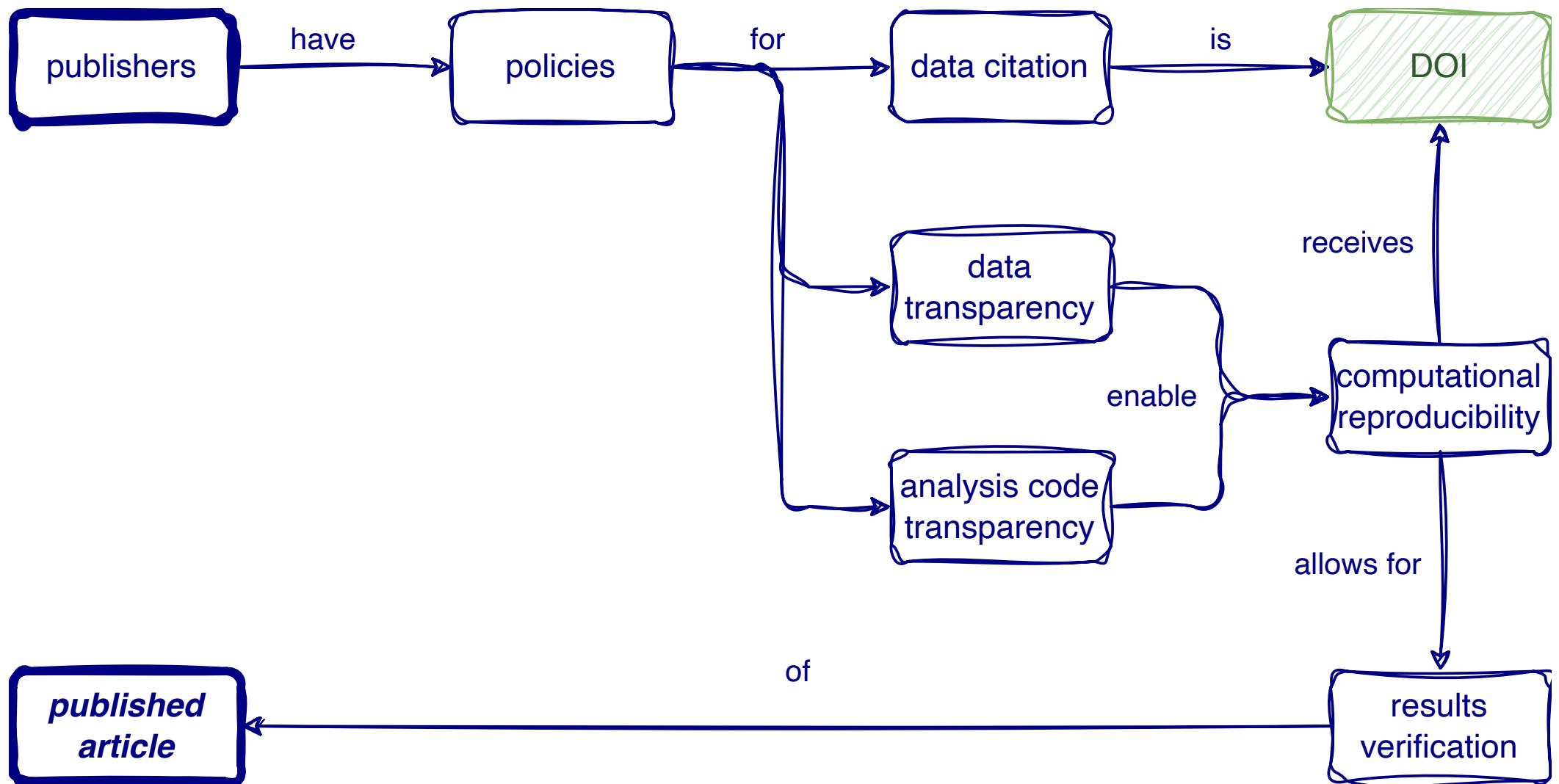
policies

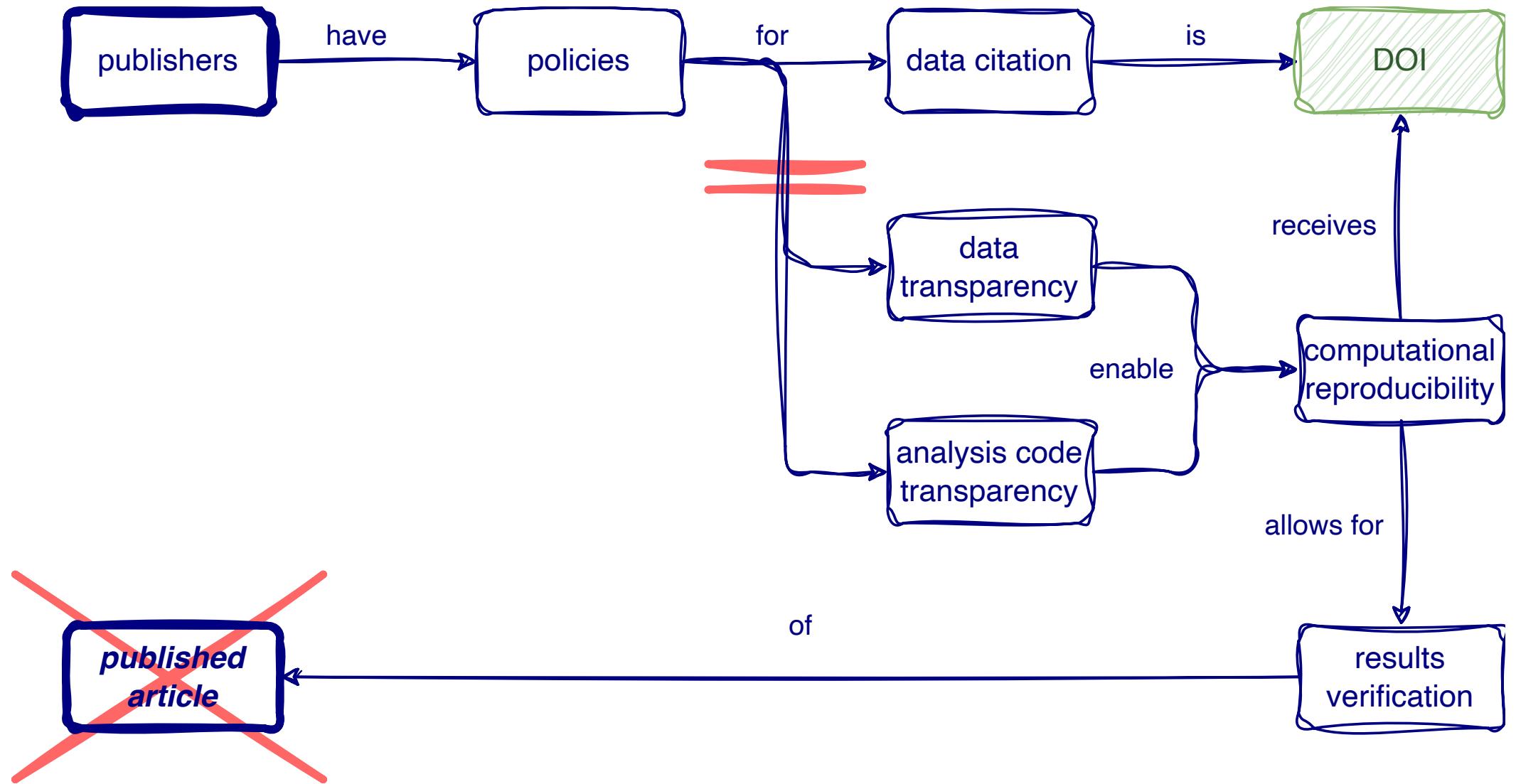












Your turn: About you

Pick an item and take notes for 1 minute:

What does the item you have picked have to do with the reason for you being here?



Images from: <https://openclipart.org/>

In pairs

Take 2 minutes each to share with your partner:

What does the item you have picked have to do with the reason for you being here?



Images from: <https://openclipart.org/>

Course Calendar

module	date	topic
1	22 February 2024	Welcome & get ready for the course
2	29 February 2024	Data science lifecycle & Exploratory data analysis using visualization
3	07 March 2024	Data transformation with dplyr
4	14 March 2024	Data import & Data organization in spreadsheets
5	21 March 2024	Conditions & Dates & Tables
6	28 March 2024	Data types & Vectors & Pivoting
	04 April 2024	Easter Break
7	11 April 2024	Joining tables & Creating and publishing scholarly articles with Quarto and GitHub pages
8	18 April 2024	Waste Research
9	25 April 2024	Research Design
10	02 May 2024	Survey Design
	09 May 2024	Auffahrt Break
11	16 May 2024	Pre-test and logistics
	23 May 2024	Data collection
12	30 May 2024	Data analysis & report writing
	06 June 2024	Project Submission Deadline
13	June 2024	Exam

Course structure

- My turn: Lecture segments + live coding
- Our turn: Live coding + follow along
- Your turn: Exercises in pairs

My turn: Lecture segments + live coding

- Instructor writes and narrates code out loud
- Instructor explains concepts and principles that are relevant
- Code is displayed on screen

Our turn: Live coding + follow along

- Instructor writes and narrates code out loud
- Instructor explains concepts and principles that are relevant
- Code is displayed on screen
- Learners join by writing and executing the same code

Your turn: Exercises in pairs

- Two learners work together in pairs
- One person does the typing (the driver)
- One person offers comments and suggestions (the navigator)

Getting help

- (from next week), please use a pink sticky note to indicate that you have a problem. I will try to address your issue if time permits.
- (from next week), during your turn exercises, please use a yellow sticky note to indicate when you have completed an exercise.

Platforms and Tools

- R
- tidyverse R Packages
- Posit Cloud
- RStudio IDE
- Quarto publishing system
- Zotero reference management
- Google Workspace (Sheets & Forms)

Bookmark

rbtl-fs24.github.io/website/

Learning Objectives (for this week)

1. Learners can access the Posit Cloud workspace for the course.
2. Learners can use the Element chat to introduce themselves.
3. Learners can open an issue on GitHub and tag the course instructor.
4. Learners can clone a repository from GitHub and use the GitHub PAT to push a commit from their local repository to GitHub.
5. Learners can navigate the course website and understand the learning objectives of the course.



Version Control

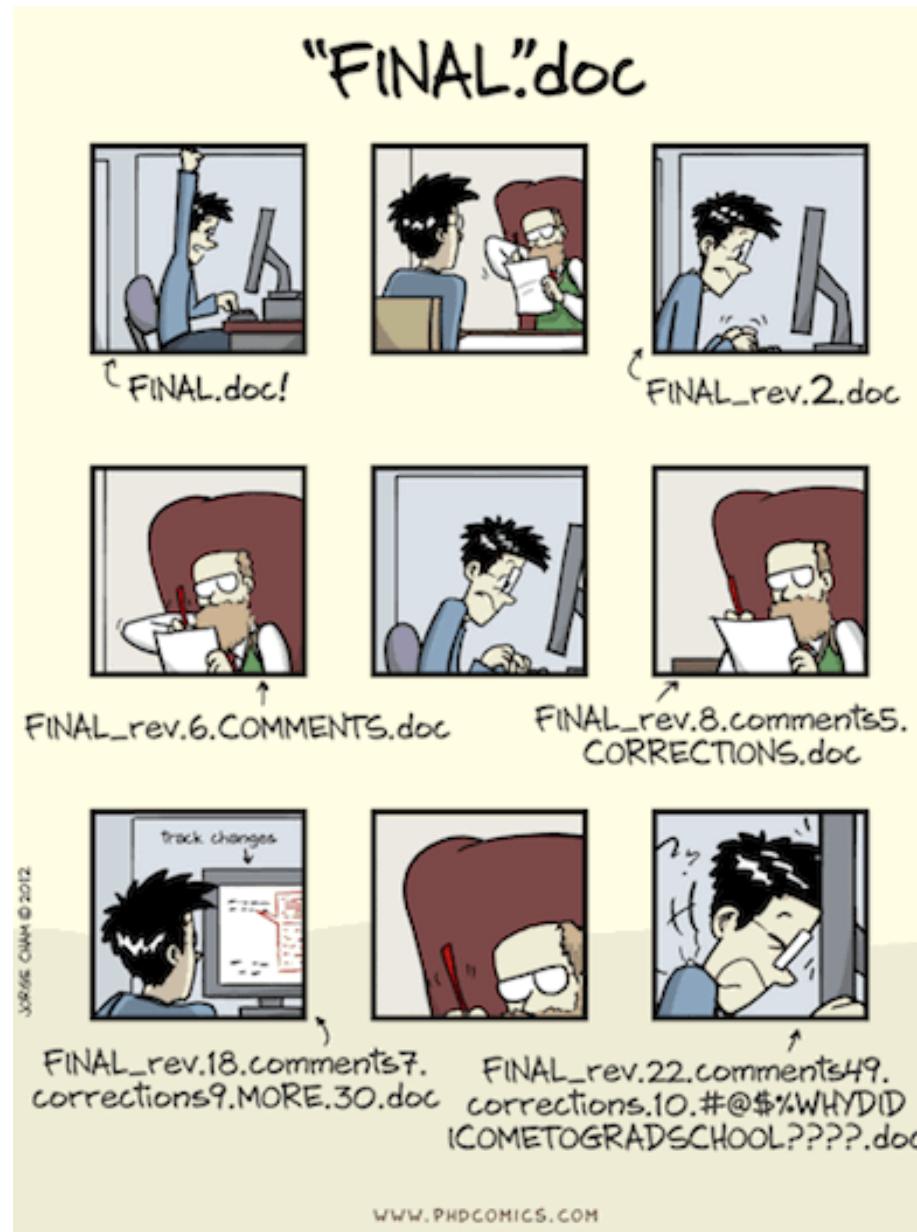
Version Control with Git and GitHub

A way to share files with others, so they can:

- download
- re-use
- contribute

You can view the history of files, and jump back in time to any point.

Why is it useful?



Git and GitHub



- Git is a software for version control
- Created in 2005
- Popular among programmers collaboratively developing code
- Tracks changes in a set of files (directory/folder/repository)
- GitHub is a hosting platform for version control using Git
- Launched in 2008, acquired by Microsoft in 2018, Microsoft for US\$ 7.5 billion
- 100 million Users (20.5 in 2022 alone) ([October, 2023](#))
- Social media for software developers

My turn: A tour of GitHub

Sit back and enjoy!

Your turn: Get a GitHub account

1. Open a web browser on your laptop.
2. Navigate to the course website: rbtl-fs24.github.io/website/
3. If you haven't yet, bookmark the course website
4. In the left-hand menu, click on Module 1, then select am-01: GitHub
5. Follow the instructions
6. Place a yellow sticky note on your laptop when you have completed the assignment

Posit Cloud

Posit Cloud

https://posit.cloud/spaces/426916/content/6930256

Ds4owd-001 / md-01-exercises

Lars Schöbitz

RAM

R 4.3.1

hello-quarto.qmd x

Source Visual B I Normal Format Insert Table

```
---  
title: "Hello Quarto"  
format: html  
editor: visual  
---
```

Environment History Connections Git Tutorial

Import Dataset 171 MiB Global Environment

Environment is empty

Data

Data can be imported from many different sources. In this exercise, we import data from:

(Top Level) Quarto

Console Terminal Background Jobs

R 4.3.1 · /cloud/project/

```
R version 4.3.1 (2023-06-16) -- "Beagle Scouts"  
Copyright (C) 2023 The R Foundation for Statistical Computing  
Platform: x86_64-pc-linux-gnu (64-bit)

R is free software and comes with ABSOLUTELY NO WARRANTY.  
You are welcome to redistribute it under certain conditions.  
Type 'license()' or 'licence()' for distribution details.

R is a collaborative project with many contributors.  
Type 'contributors()' for more information and  
'citation()' on how to cite R or R packages in publications.
```

Files Plots Packages Help Viewer Presentation

New Folder New Blank File Upload Delete Rename More

Cloud > project

	Name	Size	Modified
..			
	.gitignore	40 B	Oct 31, 2023, 11:18 AM
	.Rhistory	0 B	Oct 31, 2023, 11:18 AM
	hello-quarto-complete.qmd	1.2 KB	Oct 31, 2023, 11:18 AM
	hello-quarto.qmd	1.1 KB	Oct 31, 2023, 11:18 AM
	md-01-exercises.Rproj	205 B	Oct 31, 2023, 1:07 PM

@ rbt-fs24.github.io/website/ 36

Posit Cloud

Browser tab

<https://posit.cloud/spaces/426916/content/6930256>

Ds4owd-001 /

Posit Cloud Workspace

RAM Lars Schöbitz

File Edit Code View Plots Session Build Debug Profile Tools Help

Go to file/function Addins

R 4.3.1

hello-quarto.qmd x

Source Visual B I Normal Format Insert Table

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---  
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Environment History Connections Git Tutorial

Import Dataset 171 MiB Global Environment

Environment is empty

Files Plots Packages Help Viewer Presentation

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md-01-exercises.Rproj		

@ rbt-fs24.github.io/website/ 37

Posit Cloud

https://posit.cloud/spaces/426916/content/6930256

Lars Schöbitz

R 4.3.1

RAM

File Edit Code View Plots Session Build Debug Profile Tools Help

Addins

hello-quarto.qmd x

Render

Source Visual

Normal

Format Insert Table

title: "Hello Quarto"

format: html

editor: visual

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```

RAM

Environment History Connections Git Tutorial

Import Dataset 171 MiB

Global Environment

Environment is empty

RStudio IDE Menu

Files Plots Packages Help Viewer Presentation

New Folder New Blank File Upload Delete Rename More

Cloud > project

	Name	Size	Modified
..			
	.gitignore	40 B	Oct 31, 2023, 11:18 AM
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	md-01-exercises.Rproj	205 B	Oct 31, 2023, 1:07 PM

@ rbt-fs24.github.io/website/ 38

The screenshot shows the RStudio IDE interface with a yellow overlay titled "Rstudio IDE Menu".

Code Editor: Displays a Quarto document (hello-quarto.qmd) with the following code:

```
---
title: "Hello Quarto"
format: html
editor: visual
---
```

A large blue box highlights the word "Code Editor".

Data:

Data can be imported from many different sources. In this exercise, we import data from:

Console:

```
R version 4.3.1 (2023-06-16) -- "Beagle Scouts"  
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File Browser:

Files | Plots | Packages | Help | Viewer | Presentation

Name	Size	Modified
..		Oct 31, 2023, 11:18 AM
.gitignore	40 B	Oct 31, 2023, 11:18 AM
.Rhistory	0 B	Oct 31, 2023, 11:18 AM
hello-quarto-complete.qmd	1.2 KB	Oct 31, 2023, 11:18 AM
hello-quarto.qmd	1.1 KB	Oct 31, 2023, 11:18 AM
md-01-exercises.Rproj	205 B	Oct 31, 2023, 1:07 PM

User Information: RAM usage, gear icon, three dots, and user profile for Lars Schöbitz.

Page Footer: [@ rbtl-fs24.github.io/website/](https://rbtl-fs24.github.io/website/)

Posit Cloud https://posit.cloud/spaces/426916/content/6930256

Ds4owd-001 / md-01-exercises

RStudio IDE Menu R 4.3.1

Code Editor

```
---  
title: "Hello Quarto"  
format: html  
editor: visual  
---
```

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(Top Level) Quarto

Environment

Git

Console Terminal Background Jobs

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Files Plots Packages Help Viewer Presentation

New Folder New Blank File Upload Delete Rename More

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	md-01-exercises.Rproj	205 B	Oct 31, 2023, 1:07 PM

@ rbt-fs24.github.io/website/ 40

The image shows a composite screenshot of the RStudio IDE interface, divided into four main sections by color-coded borders:

- Code Editor (Yellow Border):** Displays a Quarto document titled "Hello Quarto" with the following code:

```
---  
title: "Hello Quarto"  
format: html  
editor: visual  
---
```
- Environment (Orange Border):** Shows the RStudio IDE menu bar at the top, followed by the Environment tab selected in the global environment panel.
- Git (Orange Border):** Shows the Git tab selected in the global environment panel.
- Console (Pink Border):** Displays the R console output for version 4.3.1, including the Beagle Scouts logo, copyright information, and a welcome message about R being free software.

At the bottom center of the image is a watermark: [@ rbtl-fs24.github.io/website/](https://rbtl-fs24.github.io/website/).

RAM: 1.6 GB / 16 GB (75%)

Lars Schöbitz

File Edit Code View Plots Session Build Debug Profile Tools Help

Go to file/function Addins

hello-quarto.qmd x

Source Visual B I Normal Format Insert Table

ABC Render Run

title: "Hello Quarto"
format: html
editor: visual

Code Editor

Data

Data can be imported from many different sources. In this exercise, we import data from:

(Top Level) Ouarto

Console Terminal Background Jobs

R 4.3.1 · /cloud/project/

R version 4.3.1 (2023-06-16) -- "Beagle Scouts"
Copyright (C) 2023 The R Foundation for Statistical Computing
Platform: x86_64-pc-linux-gnu

Console

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Files Plots Packages Help Viewer Presentation

New Folder New Blank File Upload Delete Rename More

Cloud > project

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hello-quarto-complete.qmd	1.1 KB	Oct 31, 2023, 11:18 AM
hello-quarto.qmd	205 B	Oct 31, 2023, 1:07 PM
md-01-exercises.Rproj		

@ rbtl-fs24.github.io/website/

The image shows a screenshot of the RStudio IDE interface, divided into four main quadrants by color-coded overlays:

- Top Left (Yellow Overlay):** Labeled "Code Editor". It displays a Quarto document titled "hello-quarto.qmd" with the following code:

```
---  
title: "Hello Quarto"  
format: html  
editor: visual  
---
```
- Top Right (Yellow Overlay):** Labeled "Rstudio IDE Menu". It shows the main menu bar with "File", "Edit", "Code", etc., and the R version "R 4.3.1". Below the menu are tabs for "Environment", "History", "Connections", "Git", and "Tutorial". A large orange box covers the "Environment" and "Global Environment" sections.
- Bottom Left (Pink Overlay):** Labeled "Console". It shows the R console output:

```
R version 4.3.1 (2023-06-16) -- "Beagle Scouts"  
Copyright (C) 2023 The R Foundation for Statistical Computing  
Platform: x86_64-pc-linux-gnu
```

R is free software and comes with ABSOLUTELY NO WARRANTY.
You are welcome to redistribute it under certain conditions.
Type 'license()' or 'licence()' for distribution details.

R is a collaborative project with many contributors.
Type 'contributors()' for more information and
'citation()' on how to cite R or R packages in publications.
- Bottom Right (Green Overlay):** Labeled "File Manager" and "Viewer". It shows the file browser and viewer panes. The file browser lists "Cloud > project" with files "hello-quarto.qmd" (1.1 kB, modified Oct 31, 2023, 11:18 AM) and "md-01-exercises.Rproj" (205 B, modified Oct 31, 2023, 1:07 PM). The viewer pane is empty.

At the bottom center, there is a footer with the text "@ rbt-fs24.github.io/website/" and a page number "42" in the bottom right corner.

Your turn: Log into Posit Cloud with GitHub account

1. Open a web browser on your laptop.
2. Navigate to the course website: rbtl-fs24.github.io/website/
3. If you haven't yet, bookmark the course website
4. In the left-hand menu, click on Module 1, then select **am-02: Posit Cloud**
5. Follow the instructions
6. Place a yellow sticky note on your laptop when you have completed the assignment



GitHub Authorisation

- If this is your first time logging in to Posit Cloud with your GitHub account, you will be prompted to authorize Posit Cloud to access your GitHub account information.
- Once you have authorized access, you will be redirected back to the Posit Cloud website and logged in to your account.

Hello Quarto

Meeting you where you are

I'll assume you

- do **not** have R or git experience
- have **not** worked in an IDE before (e.g. RStudio IDE)
- want to **learn** about R
- want to **learn** about Quarto and publishing
- want to **learn** about project management with GitHub

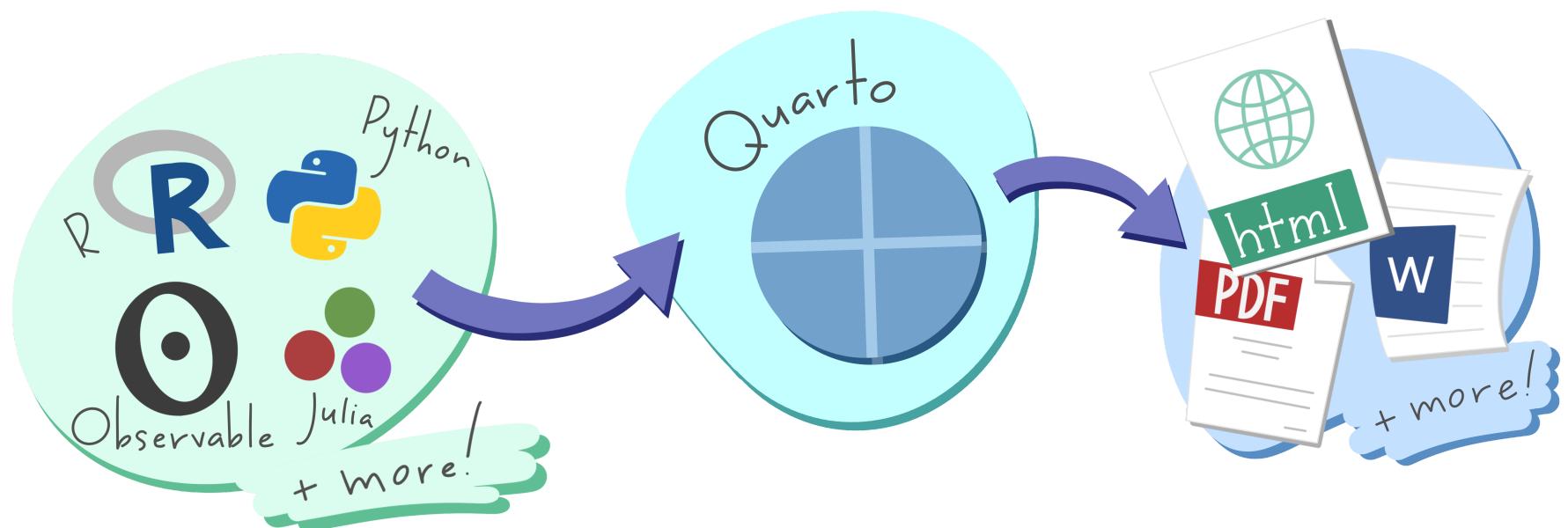
I'll **teach** you

- R
- Quarto syntax and formats
- Markdown
- Git via RStudio GUI
- GitHub issues, project management, and publishing

What is Quarto?

Quarto ...

- is a new, open-source, scientific, and technical publishing system
- aims to make the process of creating and collaborating dramatically better



My turn: A tour of Quarto

Sit back and enjoy!

Take a break

Please get up and move! Let your emails rest in peace.



Your turn: md-01-exercises

1. Open [posit.cloud](#) in your browser (use your bookmark).
2. Open the rbt-fs24 workspace for the course.
3. Click Start next to md-01-exercises.
4. In the File Manager in the bottom right window, locate the `hello-quarto.qmd` file and click on it to open it in the top left window.
5. Render the document.
6. Add `author:` to the YAML header and add your name
7. Re-render the document
8. Inspect components of the document and make one more update and re-render.
9. Discuss notes about updates you've made with your neighbor. Note any aspects of the document that are not clear after the tour and your first interaction with it.

From the comfort of your own workspace

The screenshot shows a Jupyter Notebook interface with two main panes:

- Left Pane (EXPLORER):** A sidebar with various icons and sections:
 - OPEN EDITORS:** Shows several Quarto files: execution-options.qmd, julia.qmd, jupyter-kernels.qmd, ojs.qmd, palmer-penguins.csv, parameters.qmd, and python.qmd.
 - QUARTO-WEB:** Shows the same list of files.
 - OUTLINE** and **TIMELINE** sections.
 - QUARTO: HELP:** Contains:
 - Plot y versus x as lines and/or markers.
 - Call signatures:

```
plot([x], y, [fmt], *, data=None,  
     **kwargs)  
plot([x], y, [fmt], [x2], y2,  
     [fmt2], ..., **kwargs)
```
 - The coordinates of the points or line nodes are given by *x*, *y*.
 - The optional parameter *fmt* is a convenient way for defining basic formatting like color, marker and linestyle. It's a shortcut string notation described in the *Notes* section below.
- Right Pane (python.qmd):** A code editor showing a Quarto document with a Python block.

```
1 ---  
2 title: "matplotlib demo"  
3 format:  
4   html:  
5     code-fold: true  
6 jupyter: python3  
7 ---  
8  
9 For a demonstration of a line plot on a  
polar axis, see @fig-polar.  
10  
11 > Run Cell  
12 ````{python}  
13 #| label: fig-polar  
14 #| fig-cap: "A line plot on a polar axis"  
15  
16 import numpy as np  
17 import matplotlib.pyplot as plt  
18  
19 r = np.arange(0, 2, 0.01)  
20 theta = 2 * np.pi * r  
21 fig, ax = plt.subplots(  
22     subplot_kw = {'projection': 'polar'}  
23 )  
24 ax.plot(theta, r)  
25 ax.set_rticks([0.5, 1, 1.5, 2])  
26 ax.grid(True)  
27 plt.show()  
```
```
- Bottom Right (Interactive-1):** An IPython 7.25.0 session showing the output of the code:

```
Python 3.9.5 (v3.9.5:0a7dcdb13, May 3 2021,
13:17:02)
Type 'copyright', 'credits' or 'license' for more
information
IPython 7.25.0 -- An enhanced Interactive
Python. Type '?' for help.
```

The output shows a polar plot of concentric circles centered at the origin, with radial grid lines and labels at 0°, 45°, 90°, 135°, 180°, 225°, 270°, and 315°. The plot area has a radius scale from 0.5 to 2.0.



# Quarto formats

# One install, “Batteries included”

- RMarkdown grew into a large ecosystem, with **varying syntax**.
- Quarto comes “**batteries included**” straight out of the box
  - HTML reports and websites
  - PDF reports
  - MS Office (Word, Powerpoint)
  - Presentations (Powerpoint, Beamer, `revealjs`)
  - Books
- Any language, *exact same* approach and syntax

# Many Quarto formats

| Feature         | R Markdown                                                                                     | Quarto                                                              |
|-----------------|------------------------------------------------------------------------------------------------|---------------------------------------------------------------------|
| Basic Formats   | <a href="#">html_document</a><br><a href="#">pdf_document</a><br><a href="#">word_document</a> | <a href="#">html</a><br><a href="#">pdf</a><br><a href="#">docx</a> |
| Beamer          | <a href="#">beamer_presentation</a>                                                            | <a href="#">beamer</a>                                              |
| PowerPoint      | <a href="#">powerpoint_presentation</a>                                                        | <a href="#">pptx</a>                                                |
| HTML Slides     | <a href="#">xaringan</a><br><a href="#">ioslides</a><br><a href="#">revealjs</a>               | <a href="#">revealjs</a>                                            |
| Advanced Layout | <a href="#">tufte</a><br><a href="#">distill</a>                                               | <a href="#">Quarto Article Layout</a>                               |

# Many Quarto formats

| Feature          | R Markdown                                                                                        | Quarto                                                          |
|------------------|---------------------------------------------------------------------------------------------------|-----------------------------------------------------------------|
| Cross References | <a href="#">html_document2</a><br><a href="#">pdf_document2</a><br><a href="#">word_document2</a> | <a href="#">Quarto Crossrefs</a>                                |
| Websites & Blogs | <a href="#">blogdown</a><br><a href="#">distill</a>                                               | <a href="#">Quarto Websites</a><br><a href="#">Quarto Blogs</a> |
| Books            | <a href="#">bookdown</a>                                                                          | <a href="#">Quarto Books</a>                                    |
| Interactivity    | <a href="#">Shiny Documents</a>                                                                   | <a href="#">Quarto Interactive Documents</a>                    |
| Journal Articles | <a href="#">rticles</a>                                                                           | <a href="#">Journal Articles</a>                                |
| Dashboards       | <a href="#">flexdashboard</a>                                                                     | <a href="#">Quarto Dashboards</a>                               |

# Your turn: Create a new Quarto document

In your exercises project in RStudio on Posit Cloud, go to **File > New File > Quarto document** to create a Quarto document with HTML output.

- Render the document, which will ask you to give it a name – you can use `my-first-document.qmd`.

Use the visual editor for the next steps.

- Add a title and your name as the author.
- Create four sections with headings of level 2 (Introduction, Methods, Results, Conclusions).
- **Stretch goal:** Add a table of contents. Note: Watch out for the indentation.
- **Stretch goal:** Change the html theme to `sketchy`. Tipp: Check [quarto.org](https://quarto.org) and use search function  with “HTML theming”

# Take a break

Please get up and move! Let your emails rest in peace.



# Course information

# Weekly Structure

## Monday

---

**Tuesday**      Student hours from 14:00 to 16:00 (CET)

---

**Wednesday**   Assignment submission, latest by 23:59 (CET)

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**Thursday**      Lecture from 12:15 to 15:00 (CET)

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## Friday

# Performance assessment

- End-of-semester exam: 50 points
- Compulsory continuous performance assessment: 50 points, of which
  - Homework assignments: 20 points ( $n = 10$ )
  - Capstone project: 30 points, of which
    - Technical parts of submitted report: 20 points (we will communicate what we expect)
    - Intellectual framing of results: 10 points (we will communicate what we expect)

# Grading scheme

Table [Table 1](#) shows the conversion from points to grades. Grades follow the [ETHZ's Grading System](#). Points are rounded to the nearest grade, for example:

- 97 points = 5.75
- 93 points = 5.75
- 92 points = 5.50
- 45 points = 4.00
- 44 points = 3.50

Table 1: Conversion from points to grades.

| grade | points |
|-------|--------|
| 6.00  | 100    |

## grade points

|      |    |
|------|----|
| 5.75 | 95 |
| 5.50 | 90 |
| 5.25 | 85 |
| 5.00 | 80 |
| 4.75 | 75 |
| 4.50 | 70 |
| 4.25 | 60 |
| 4.00 | 50 |
| 3.50 | 40 |
| 3.00 | 30 |
| 2.50 | 20 |

# grade points

| grade | points |
|-------|--------|
| 2.00  | 10     |
| 1.00  | 0      |

# End-of semester exam

- 2-hour final written exam
- 50 points
- all material allowed (incl. internet)
- for the use of AI tools we expect you to add a link to the prompt
- programming exercises using the R programming language
- success depends on the effort put into the compulsory continuous performance assessment

# Compulsory continuous performance assessment

## Homework assignments:

- 10 assignments
- assessed as pass/fail
- 2 points each
- 20 points in total
- submitted as rendered Quarto documents on GitHub

# Compulsory continuous performance assessment

## Capstone Project

- Data analysis project report with a dataset generated by you
- Method: Survey or Observational Study using Google Forms and Sheets
- 1 project per student, submitted as rendered Quarto document on GitHub
- 30 points in total
  - 20 points for the technical parts of the submitted report
  - 10 points for the intellectual framing of results

# Readings

- Some required for homework assignments
- Additional readings provided to support learning
- Not graded

# Policies

## Class attendance

- Can't attend in person? Inform us before the lecture
- Live streaming recording available
- Missed classes: work through the material using the recording

# Policies

## Use of AI tools

- Use it! (e.g. perplexity.ai has useful free features)
- Refine your prompts to get good outcomes
- Don't trust anything it says
- Include links to your prompts
- Be thoughtful about when this tool is useful

# Policies

## Code of Conduct

- Follow the [ETH Respect Code of Conduct](#)
- If you experience inappropriate behaviour from us or any of your classmates, you will find contact and advice services here: [respekt.ethz.ch/en/contact-and-advice-services.html](#)

# Homework assignments

## module 1

# Module 1 documentation

[rbt-fs24.github.io/website/modules/md-01.html](https://rbt-fs24.github.io/website/modules/md-01.html)

404

There isn't a GitHub Pages site here.

If you're trying to publish one, [read the full documentation](#) to learn how to set up **GitHub Pages** for your repository, organization, or user account.

[GitHub Status](#) — [@githubstatus](#)



# Homework due date

- Homework is a pre-requisite for active participation in Module 2
- Homework assignment due: Wednesday, 28th February

# Wrap-up

Thanks! 🌻

Slides created via revealjs and Quarto:

<https://quarto.org/docs/presentations/revealjs/> Access slides as  
[PDF on GitHub](#)

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