

# Open, reproducible, and replicable (PhD) research

Based on AGILE PhD school 2022

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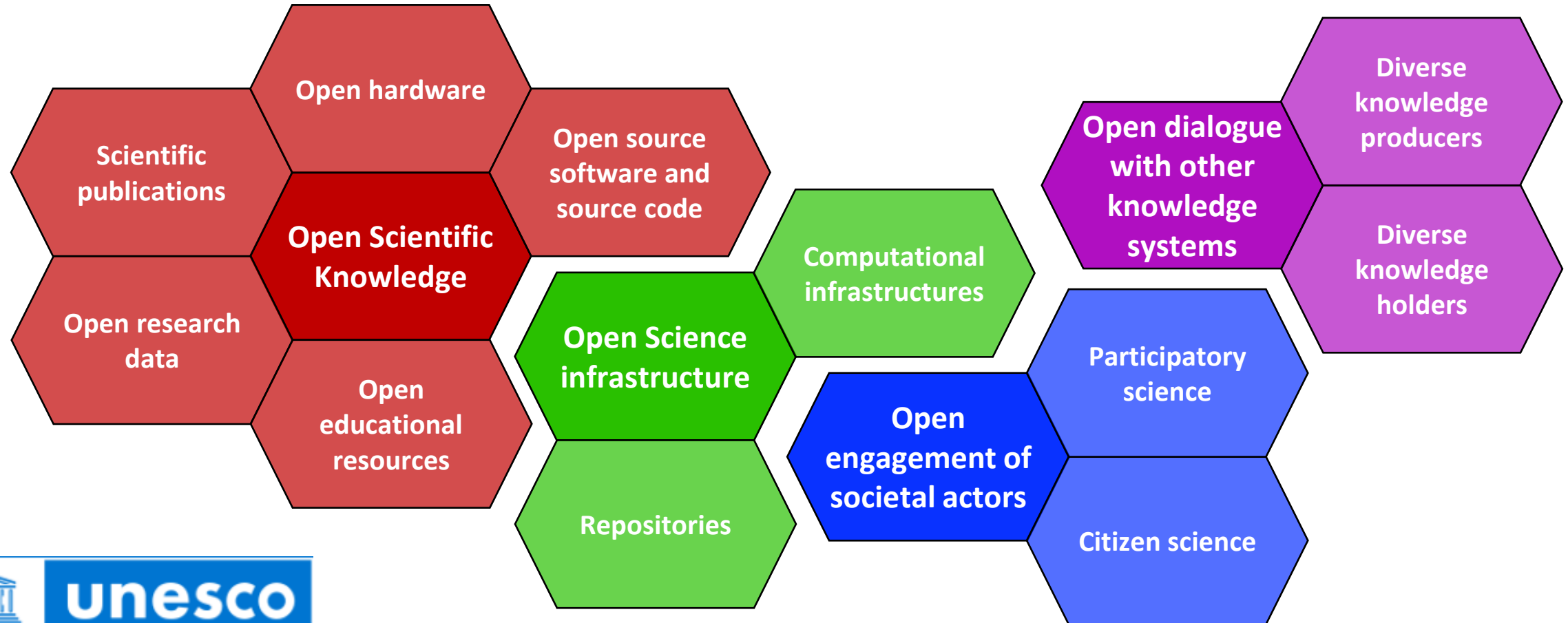
# What does Science mean?

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- Discover laws, axioms, rules, etc. and describe under which conditions they apply
- Conduct case studies to prove a general principle or theory
- Transfer/publish results to prove validity, veracity, trust in findings
  - Scientists confirm the validity of a new finding or discovery by **repeating** the research.
  - Observed inconsistency may be an important precursor to new discovery while others fear it may be a symptom of a lack of rigor in science

# What does Open Science mean?

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# Reproducible Research

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|          |           | Data         |               |
|----------|-----------|--------------|---------------|
|          |           | Same         | Different     |
| Analysis | Same      | Reproducible | Replicable    |
|          | Different | Robust       | Generalisable |

# What are reproducibility and replicability?

**Reproducibility** is whether you can get the **same results** using

- the **same analysis** (applying the same methods and code, libraries, programs, etc.) and
- **same original data**

If outcomes are identical or within the expected margin of error: great, the original hypothesis has not been falsified, and research design is sound

# What are reproducibility and replicability?

**Replicability** is whether you can get **similar results** changing

- input data (time, geographic area, means of collections, etc.) and/or
- methods (different libraries or completely different algorithm)

If outcomes are similar, original hypothesis is supported

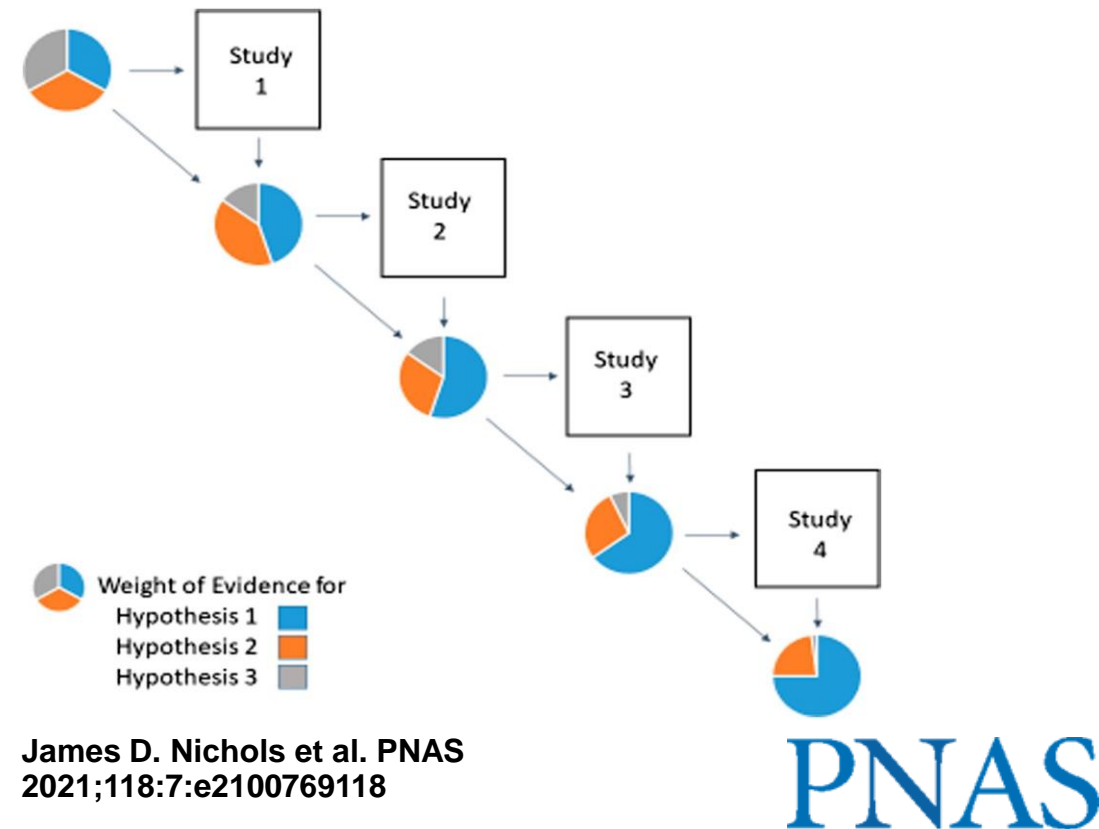
If not, original hypothesis is not automatically falsified, but at least of limited generalizability (and if multiple replications fail, probably just an idiographic observation)



# Why do they matter?

For (open) science: Discover laws, axioms, rules, etc. and describe them and under which condition they apply

- Without reproducibility, replication is difficult (if you don't know which factors you changed, how can you interpret the new results?)
- Without replication, limited new knowledge (how do you know which observations are generalizable under which conditions?)



# Open != reproducible

“Openness and Open Science (data sharing, code sharing, open access, etc.) are enablers of reproducibility, but do not necessarily guarantee it” <https://zenodo.org/record/5521077>)

What does open and reproducible science for PhD (MSc) research?

By default

- Open != good (of high academic quality)
- Reproducible != Good (of high academic quality)
- Open != reproducible

What does open and reproducible science mean for PhD (MSc) research?

# Start early....

.. And don't ask for permission to document your analysis (or data, if possible), just make this part of your manuscript/thesis

## **Reproducible analysis**

- R or Python script is best as any one can reproduce your analysis
- If you had to re-do your analysis changing one variable, could you do this quickly?

## **Make data open**

- Complex if privacy considerations applied
- If you cannot, synthetic/simulated datasets are an option

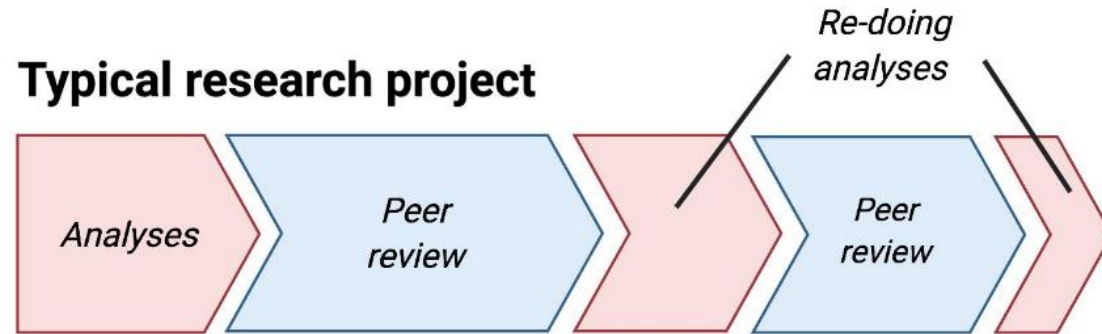
## **Posting preprints and postprints**

# You don't need to adopt all these practices at once

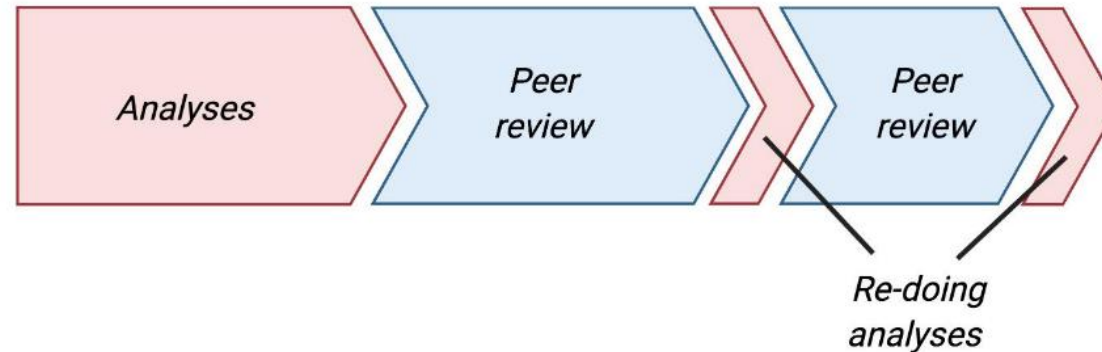
- It's not all or nothing
- Start applying practices paper-by-paper. It becomes easier every paper
- Even if no one checks your data and scripts (so far), the very practice of making data and code available builds your credibility (and your open science/data science skills!)

# You don't spend more time doing reproducible science

- You just **reallocate** where you spend it



## Research project using reproducible practices



Quintana, D. S. (2020, November 28). Five things about open and reproducible science that every early career researcher should know. <https://doi.org/10.17605/OSF.IO/DZTVQ>

# But I've completely ignored qualitative research?!?

- So qualitative research is not good science, because much of it is irreproducible?
- Of course not! I've done qualitative research myself and I know how valuable and difficult it is.
- Remember: Reproducibility is a spectrum. Let's try to make qualitative research as reproducible as possible!

# WHAT ARE THE MAIN REPRODUCIBILITY CHALLENGES FOR USING CROWDSOURCED OR VOLUNTEERED GI?

## REPRODUCIBILITY

### 1. Platform (API) Black boxes:

You can't guarantee that others will retrieve the same data

### 2. Volatility of content and access:

You can't guarantee that the content will remain the same, nor that others will continue to be able to access it (licenses, ToS)

### 3. Variance in human behavior (inter- and intra-rater agreement):

You can't guarantee that volunteer data is consistent, even from one participant



# Qualitative (GIScience) research

## Replication across space and time must be weak in the social and environmental sciences

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Edited by Alan T. Murray, University of California, Santa Barbara, CA, and accepted by Editorial Board Member B. L. Turner June 24, 2021 (received for review November 30, 2020)

**Replicability takes on special meaning when researching phenomena that are embedded in space and time, including phenomena distributed on the surface and near surface of the Earth. Two principles, spatial dependence and spatial heterogeneity, are generally characteristic of such phenomena. Various practices have evolved in dealing with spatial heterogeneity, including the use of place-based models. We review the rapidly emerging applications of artificial intelligence to phenomena distributed in space and time and speculate on how the principle of spatial heterogeneity might be addressed. We introduce a concept of weak replicability and discuss possible approaches to its measurement.**

replicability | artificial intelligence | spatial heterogeneity | place-based analysis

<https://www.pnas.org/doi/10.1073/pnas.2015759118>

# Qualitative (GIScience) research – considerations

- Privacy often even more of a concern, because more in-depth information of individual participants is collected
- Many steps are inherently irreproducible (participants, setting, etc.)
- BUT: replication is certainly an option!
- Provide
  - As much information (demographics) on participants as possible
  - Share anonymized transcripts
  - Maybe document laboratory setting with a video