Reproducibility starts with methods

Building a culture of openness and reuse

Tracey L Weissgerber

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ReproducibiliTeach, Meta-research Methods

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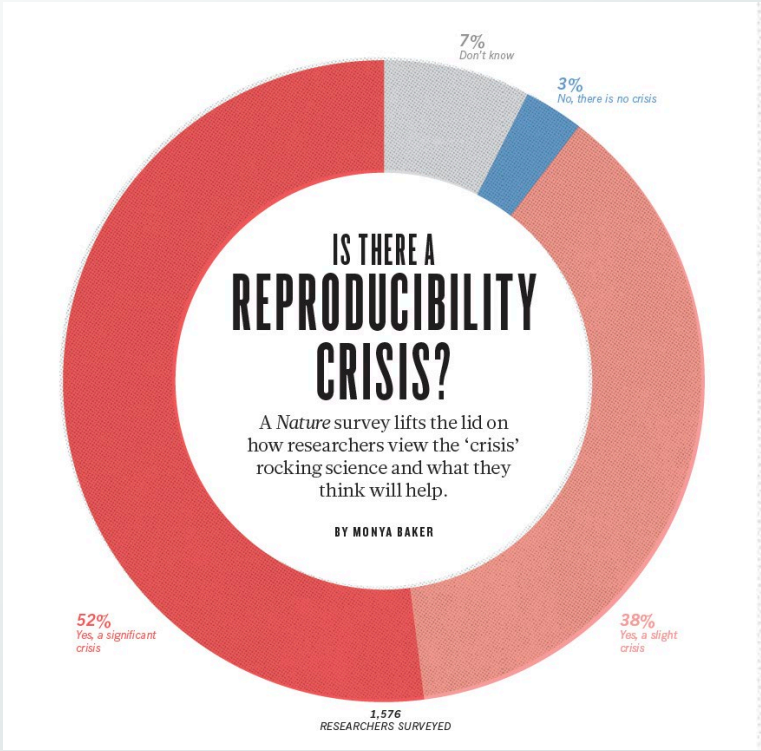
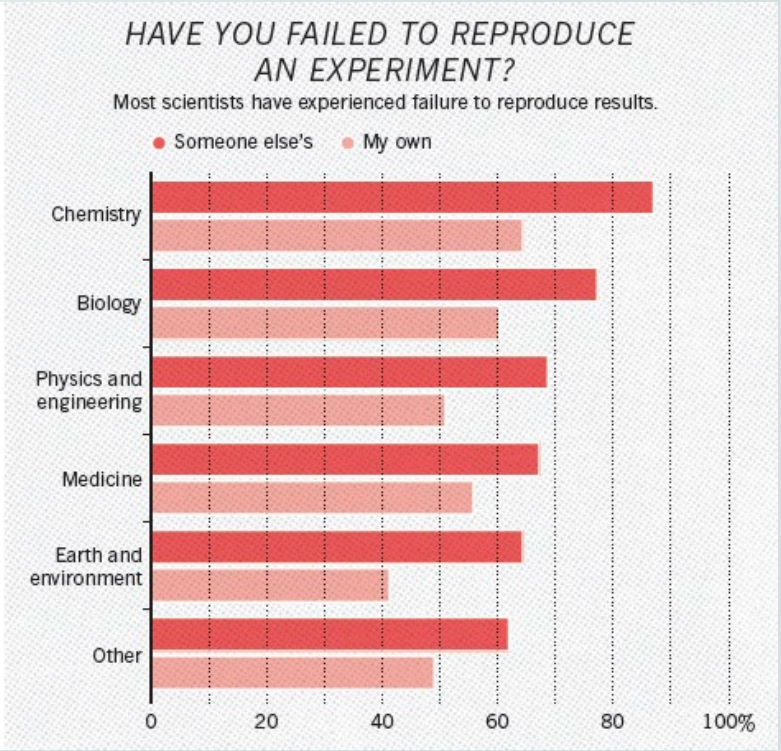
Many biomedical research results are not reproducible or replicable

Raise standards for preclinical cancer research

C. Glenn Begley and Lee M. Ellis propose how methods, publications and incentives must change if patients are to benefit.





https://doi.org/10.1038/533452a

EXCELSciOR

DAVIDE BONAZZI

Plan to replicate 50 high-impact cancer papers shrinks to just 18

By Jocelyn Kaiser | Jul. 31, 2018 , 5:45 PM

2%
experiments with open data

70%
of experiments required asking for key reagents

69%
of experiments needing a key reagent original authors were willing to share

0%
of protocols completely described

32%
of experiments the original authors were not helpful (or unresponsive)

41%
of experiments the original authors were very helpful

Scientific research provides the evidence base for addressing societal needs, such as improving patient care. We need reproducible and replicable results to benefit patients and society.

Why isn’t research reproducible or replicable?

3 classes of reasons

Informative

Neutral or unknown

Problematic

Why isn’t research reproducible or replicable?

3 classes of reasons

Informative

Neutral or unknown

Problematic

The reproducibility crisis is a manifestation of larger underlying problems affecting research quality

The evolution of open research

Open access

(papers)

Reproducibility and replication are inextricably connected to openness and transparency. Data (and code) are crucial to determine whether a finding is reproducible.

The evolution of open research

Open code, software

Open data

Open access (papers)

Results & conclusions -> Reproducibility

The evolution of open research

Comment: The FAIR Guiding Principles for scientific data management and stewardship

Mark D. Wilkinson *et al.*[#]

Open code, software

Open data

Open access (papers)

Results & conclusions -> Reproducibility

Reusability

A though experiment

- I share FAIR data from a poorly designed study with a high risk of bias that is unlikely to yield trustworthy or reproducible findings
- Each of you re-use that data
- Success: Data were reused many times!
- But…if the re-users didn't (or couldn't) account for the design problems in the analysis, the findings are unlikely to be trustworthy and replicable. This does not benefit science or society and may cause harm.

Openess and FAIRness are not markers of rigorousness, trustworthiness or risk of bias.

Researchers can't simply determine whether a dataset is open and FAIR. They must also consider:

- The quality of the study design used to generate or collect the data
- Whether the data are appropriate to answer the research question

https://doi.org/10.1038/s41591-024-02879-x

Understanding the provenance and quality of methods is essential for responsible reuse of FAIR data

We need to expand our approach by considering the data reuser's responsibilities

What we have: FAIR principles

- Outlines dataset properties that facilitate re-use -> responsibilities of the data depositor
- Answers the question "Can I reuse these data?"

What we need: Guiding principles for responsible data reuse

- Outline the responsibilities of the data reuser
- Answer the questions "Should I reuse this data?" and "How should I reuse this data responsibly?"

The evolution of open research

Open methods

Open code, software

Open data

Open access (papers)

Results & conclusions -> Reproducibility

Research processes and outputs -> Reusability

Why do we need a culture of open, reusable methods sharing?

Reproducibility starts with methods: We can't reproduce or critically evaluate findings if we don't know what was done.

Reuse: Researchers may be more likely to reuse or adapt methods than data.

FAIR data: We can't reuse data responsibly if we don't know how they were generated.

There are large communities for open data and open code, but open methods have attracted comparatively little attention.

How can researchers and organizations create a culture of methods sharing?

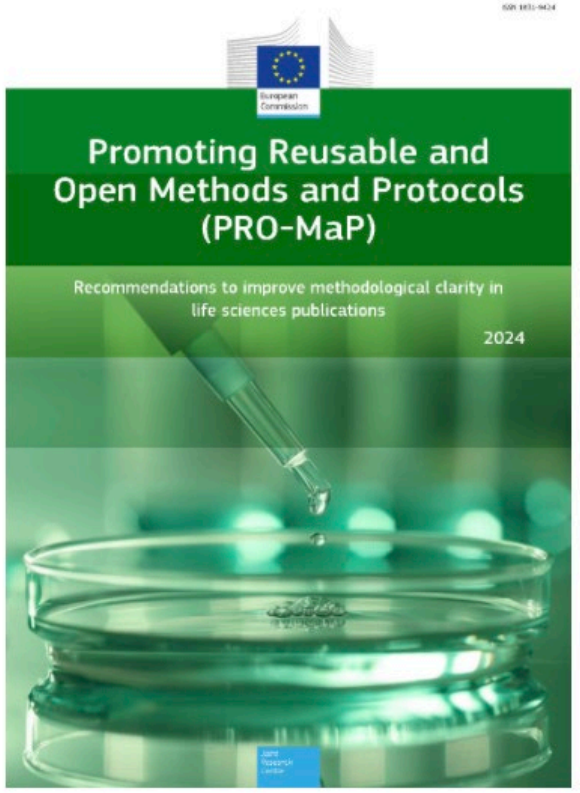
Promoting **R**eusable and **O**pen **M**ethods **a**nd **P**rotocols

Objective: Improve the clarity of methods and reusable step-by-step protocols in life sciences preprints and papers

Approach: Recommends actions for 4 stakeholder groups

- Researchers
- Research institutions and departments
- Funders
- Publishers & editors

PRO-MaP
PROMOTING REUSABLE
OPEN METHODS & PROTOCOLS



Principle 1: Cultural change

We need a cultural shift to reward and incentivize methods development, and sharing of reusable, open methods and protocols.

Principle 2: Share reusable step-by-step protocols and cite them in publications

Reusable step-by-step protocols are much more useful for implementing a method and the general overviews found in methods sections.

Crème Brûlée:
An example

The methods section: The contents of one vanilla bean was added to a sugared heavy whipping cream solution (400 ml), which was was briefly heated and stirred into 5-7 egg yolks, from which residues were subsequently removed before adding 80 ml of the final solution into eight 100 ml flat glass dishes. Dishes were heated at 91°C using a standard household oven until the surface was firm. Dishes were allowed to cool down before being caramelized by adding white sugar to cover the surface and melting using a small blow torch.

Which would you rather use?

Example created by René Bernard

The protocol

Principle 3: Protocols should be citable and shared on dynamic platforms (e.g., protocols.io)

Each protocol object (with a DOI) represents that static version of the protocol used in a specific experiment or study. Versioning and forking allow investigators to create new versions that more accurately reflect procedures used in current studies.

Principle 4: Use methodological shortcut citations responsibly

Authors use methodological shortcut citations when they cite another resource that may, or may not, fully describe the method instead of fully describing the method in their paper.

Criteria for using shortcut citations responsibly

The cited resource:

1. Contains a very detailed description of how to implement the method
2. Describes the method that you used. Any modifications can be briefly described in your paper.
3. Is open access

We argue that shortcut citations should meet higher standards then resources cited for other reasons, as they replace a part of the methods. If the information in the citation is inadequate, then part of the methods is missing.

Selected recommendations for publishers and editors: The basics

Recommendation	Actions
P1. Ensure that methods are described **in enough detail to enable others to reproduce the experiment.** Details may be presented in the methods section or through responsible use of shortcut citations (see **recommendation P3**).	P1.1. **Eliminate word limits for methods sections**
	P1.2. **Encourage authors to describe exactly what they did**, even if there is overlap with previously published methods. If a shortcut citation is used to replace a detailed description, the authors should follow criteria for responsible use of shortcut citations (Standvoss et al., 2024) (see **recommendation P3** and **Box 2**).
	P1.3. **Allow authors to re-use text describing detailed methods, with attribution. Raise awareness about policies permitting this among authors.** Clearly specify that it is acceptable to copy or quote exact methods from a previous work, with attribution. Plagiarism screening may still be performed on methods sections to ensure that duplications are attributed to the source paper or identify plagiarism of methods written by a separate team of authors. Plagiarism screening software should allow users to evaluate screening results from methods sections separately.

Selected recommendations for publishers and editors: The basics

P2. Encourage authors to strengthen static methods sections by linking to reusable step-by-step protocols uploaded to dynamic platforms	P2.1. **Encourage authors to upload protocols to open access protocol repositories that allow versioning and forking, provide DOIs, and have a long-term preservation strategy** (**Annex 3**). Repositories that do not currently allow versioning and forking should be encouraged to add these capabilities. Specifically state that authors are permitted to deposit protocols, even if they partially duplicate information contained in the methods section of the original research article.
	P2.2. **Do not ask authors to upload the same protocol to different repositories** (e.g. if authors have already shared their protocol on a repository of their choice, do not ask them to upload it to a repository affiliated with the publisher).
	P2.3. **Ask authors to avoid publishing detailed methods information in supplemental files or on lab or project websites.** Encourage authors to deposit methods in an open access repository that has a robust long-term preservation strategy instead.

Selected recommendations for publishers & editors: More challenging

P4. Move methods sections in front of the paywall	P4.1. **Ensure that all readers can access the methods section, free of charge and without a subscription.**

We argue that shortcut citations should meet higher standards then resources cited for other reasons, as they replace a part of the methods. If the information in the citation is inadequate, then part of the methods is missing.

Help needed: publishers and those working on meta-data standards

P5. Require methods and materials availability statements	P5.1. **Require machine-readable methods availability statements in front of any paywall.** These statements should specify where detailed protocols are openly available and include links to and citations of protocols published in repositories.
	P5.2. **Do not allow the statement 'Methods are available upon reasonable request'.**
	P5.3. **Require a materials availability statement** as mandated by the MDAR guidelines (Macleod et al., 2021). This statement should provide details on the availability of newly created materials and the procedure to follow to access those materials if they are not openly available in a materials repository.

The evolution of open research

Selecting research questions

Open methods

Open code, software

Open data

Open access (papers)

Results & conclusions -> Reproducibility

Research processes and outputs -> Reusability

Potential impact, trustworthiness, usefulness

Research quality is more than reproducibility

Research quality has many intersecting dimensions

- Reproducibility
- Reusability
- Openness, transparency
- Rigor
- Innovation
- Impact
- Ethics & integrity

When we focus one dimension, we miss opportunities to improve quality overall, and we weaken our ability to collaborate with other disciplines that might prioritize other aspects of quality.

Is working backwards the best way to move forwards?

Fundamental decisions that effect many dimensions of research quality occur in the topic selection and study design phases, before any data are collected. If we want to improve research quality, perhaps we should start from the beginning and adopt a holistic approach.

Changing rewards & incentives

We need to incentivize and reward researchers for sharing open methods, open materials, open data, open code, open software, and other open outputs on par with publications.

Until we do this, researchers who share these materials are doing more work for the same unit of credit. This is not sustainable.

Why should we modularize our research outputs?

- Provide essential details for reuse or replication
- Make it easier to find other outputs
- Making other outputs visible is essential to change rewards and incentives
- Adjust authorship to give credit to those who led or created other outputs
- Offer more than one path to be a successful researcher

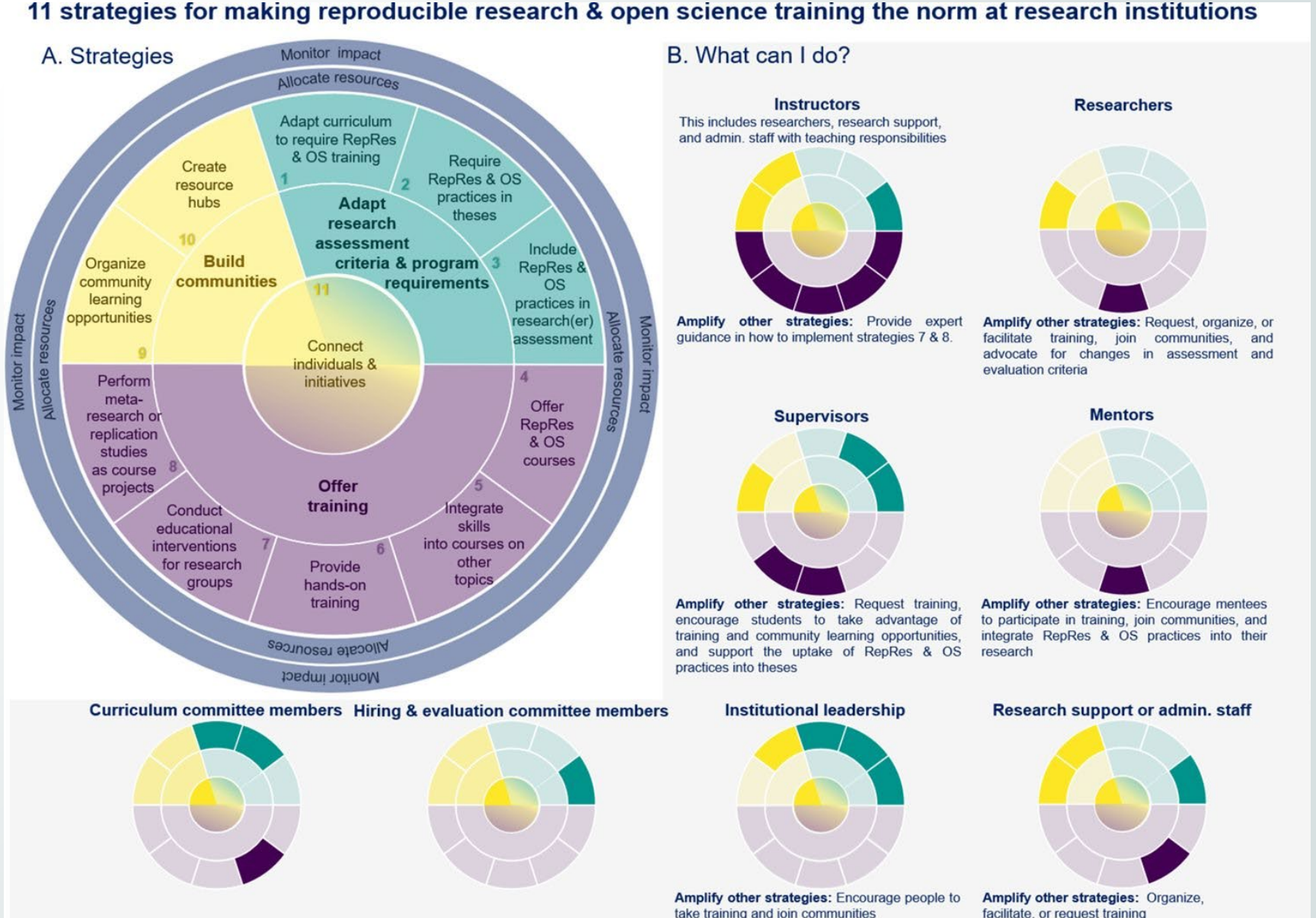
How can we normalize open research practices?

Convincing individual researches to adopt new practices is not scalable. We need to identify levers that organizations can use to introduce systemic change across research groups, departments and fields.

Eleven strategies for making reproducible research and open science training the norm at research institutions

Friederike E Kohrs[1], Susann Auer[2], Alexandra Bannach-Brown[1], Susann Fiedler[3], Tamarinde Laura Haven[4], Verena Heise[5], Constance Holman[1], Flavio Azevedo[6,7], René Bernard[8], Armin Bleier[9], Nicole Bössel[10], Brian Patrick Cahill[11], Leyla Jael Castro[12], Adrian Ehrenhofer[13], Kristina Eichel[14], Maximillian Frank[15], Claudia Frick[16], Malte Friese[17], Anne Gärtner[18], Kerstin Gierend[19], David Joachim Grüning[20,21], Lena Hahn[22], Maren Hülsemann[1], Malika Ihle[23], Sabrina Illius[24], Laura König[25], Matthias König[26], Louisa Kulke[27], Anton Kutlin[28], Fritjof Lammers[29], David MA Mehler[30], Christoph Miehl[31], Anett Müller-Alcazar[24], Claudia Neuendorf[32], Helen Niemeyer[33], Florian Pargent[15], Aaron Peikert[34], Christina U Pfeuffer[35], Robert Reinecke[36], Jan Philipp Röer[37], Jessica L Rohmann[38], Alfredo Sánchez-Tójar[39], Stefan Scherbaum[18], Elena Sixtus[40], Lisa Spitzer[41], Vera Maren Straßburger[42,43], Marcel Weber[17], Clarissa J Whitmire[44,45], Josephine Zerna[18], Dilara Zorbek[46], Philipp Zumstein[47], Tracey L Weissgerber[1]*

Normalizing practices requires coordinated action across stakeholders



TREASURE

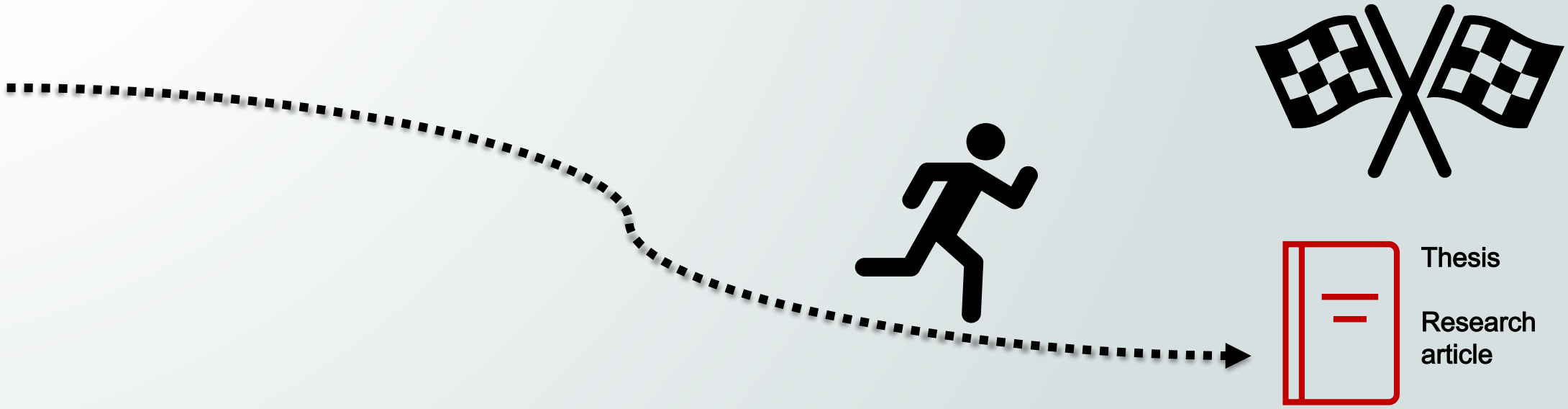
Transforming Research Assessment through Responsible Research training of Early-Stage Researchers: An institutional pilot project

treasure@uc.pt
www.uc.pt/iii/treasure

Inês Almeida
Junior researcher

Funded by the European Union

Why we need to change incentives and rewards



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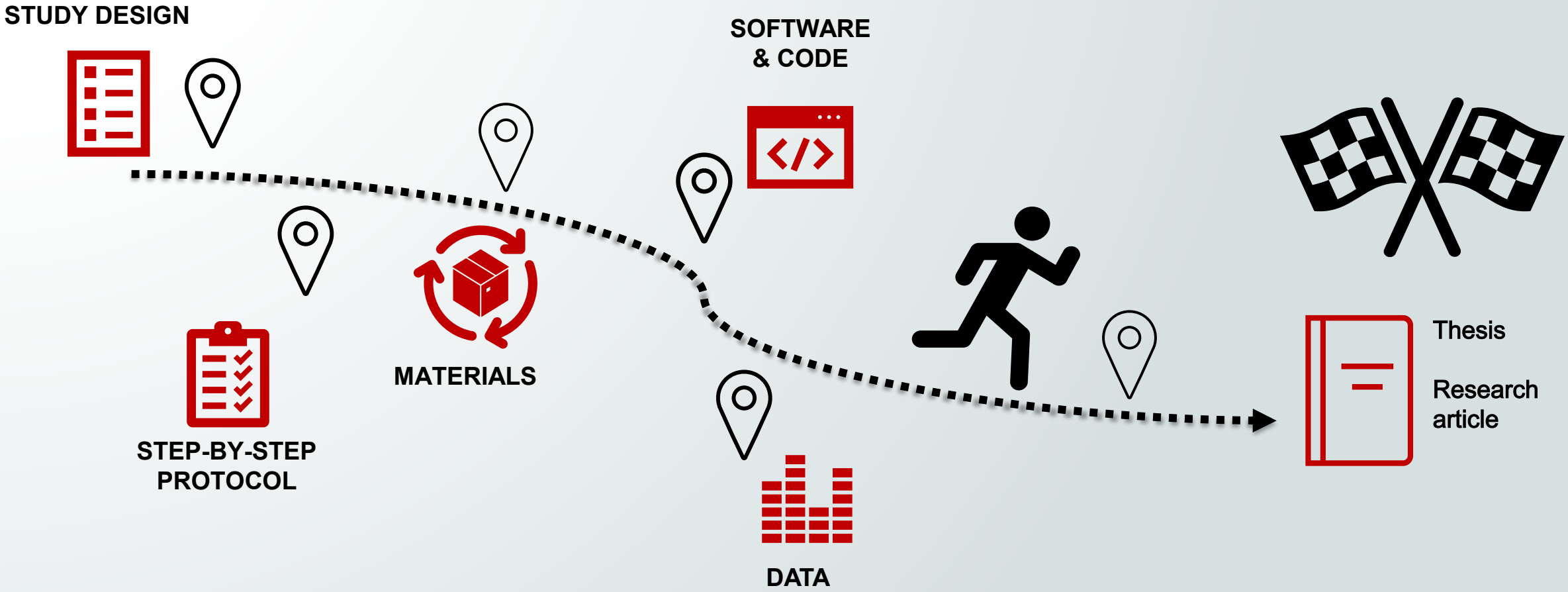

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What are we doing?

Piloting a new recognition and reward student for **graduate students**

- Develop an opt-in program, **interdisciplinary** & **transversal** to the university
- Train, support & reward actual **implementation** of reproducible, reusable and open research **in master and doctoral research theses**
- Value a **diverse** set of practices and outputs, assessed based on **quality**
- Attribute a **badge (formal recognition)** additional to the MSC / PhD degree

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What for: desired impact

Our aims

- Promote knowledge & skills in the **future generation of researchers** on reproducible, reusable and open research activities, practices and outputs
- Encourage **supervisors and other researchers within host research units** to adopt new practices, and to recognize and value new activities and outputs
- Long-term: transform the badge award into **hiring & promotion criteria**

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What is rewarded?

Practices - *may include or result in Outputs*

- Author contribution statements
- Unique Identifiers for research materials/resources
- Stakeholder engagement, Citizen science or Participatory research
- Science communication, dissemination, policy recommendations [activities, materials, policy briefs]
- Using evidence synthesis techniques to assess the quality of evidence & identify research gaps
- Reporting of null results
- Reporting guidelines
- Preregistered reproducibility or replication studies

Outputs – *have an identifier; accessible in a trusted repository*

- Preregistration or study design plans
- Registered reports
- Open step-by-step methods and protocols
- Data sharing
- Open-source code and software
- Open/reusable materials/resources
- Preprints
- Open educational materials

Practices and outputs **assessed** based on **quality**: set process-focused minimum standards

Program delivery

- **Course 1**: Select practices and outputs, develop an implementation plan
- **Course 2**: Students peer review each others work, address feedback from peers and instructors
- **Thesis check**

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Engaging the next generation of researchers to enhance the future of scholarly communication

Learned Publishing

LEARNED PUBLISHING Open Access

ORIGINAL ARTICLE OPEN ACCESS

Collaborating With Early Career Researchers to Enhance the Future of Scholarly Publication: A Guide for Publishers

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Thank you

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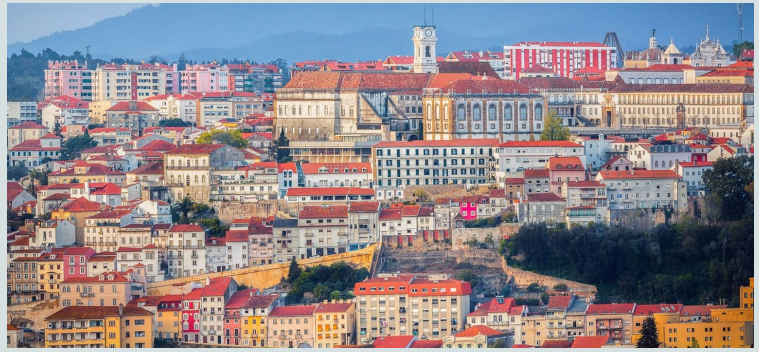
Questions…?
Comments…?
Emotional outbursts…?

Tracey Weissgerber

ReproducibiliTeach, Meta-research Methods



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