Failure to Reproduce: The Replication Crisis in Research – Can Librarians Help?

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1. The Reproducibility Crisis

2. Reproducible Workflows

3. Introduction to the
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The Reproducibility Crisis

“It can be proven that most claimed research findings are false.”

— John P. A. Ioannidis, 2005

“Reproducibility crisis” (aka “replication crisis”)

“A methodological crisis in science in which scientists have found that the results of many scientific experiments are difficult or impossible to replicate on subsequent investigation, either by independent researchers or by the original researchers themselves.”

— Wikipedia

Psychology

91.5% of all published studies in psychology found positive results.

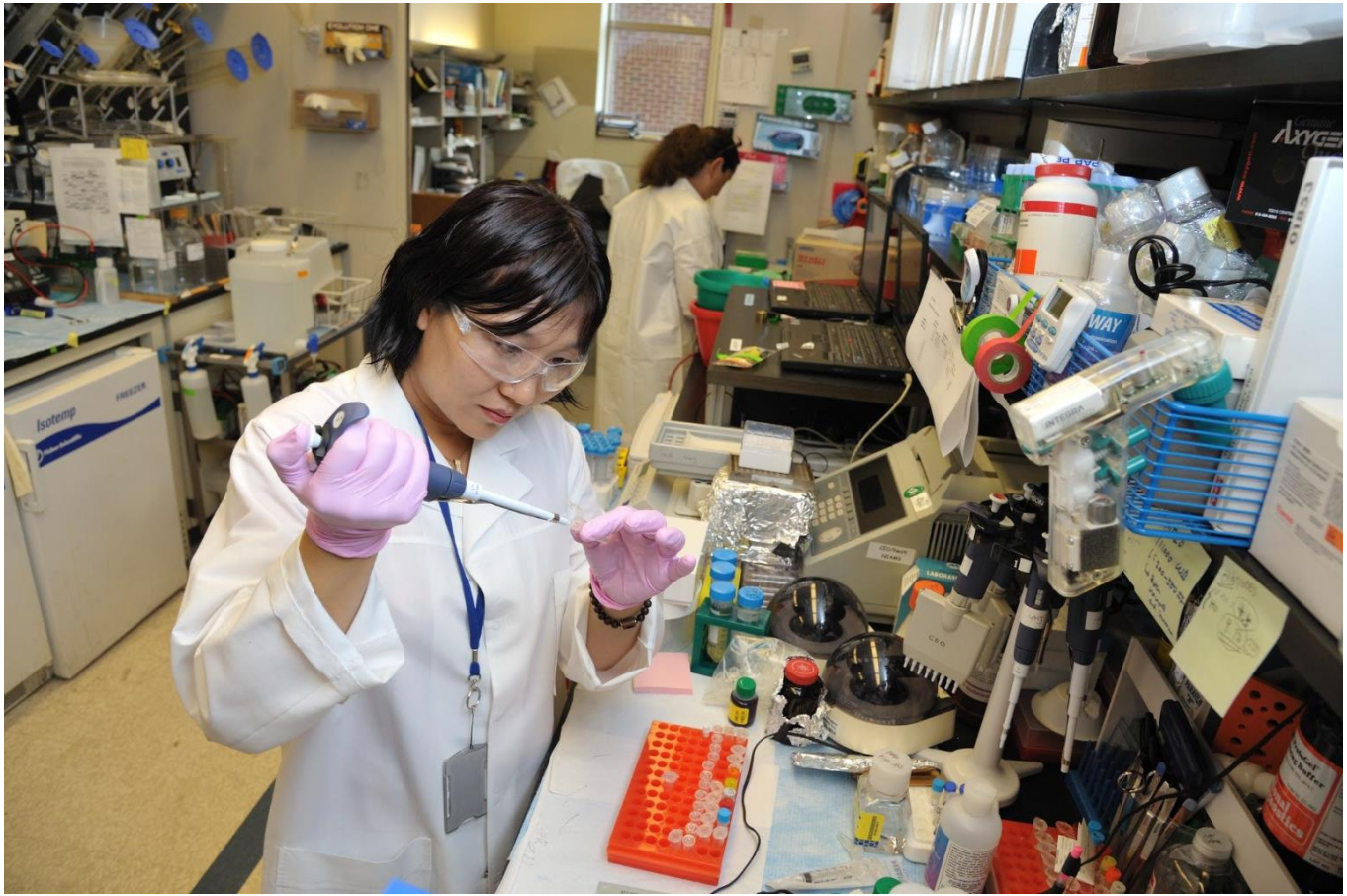
"EEG Experiment" from Dr. Hirt's Psychology Lab, Indiana University

Economics

"...We assert that economics research is usually not replicable."

— Andrew C. Chang and Phillip Li, 2015

Biomedical research

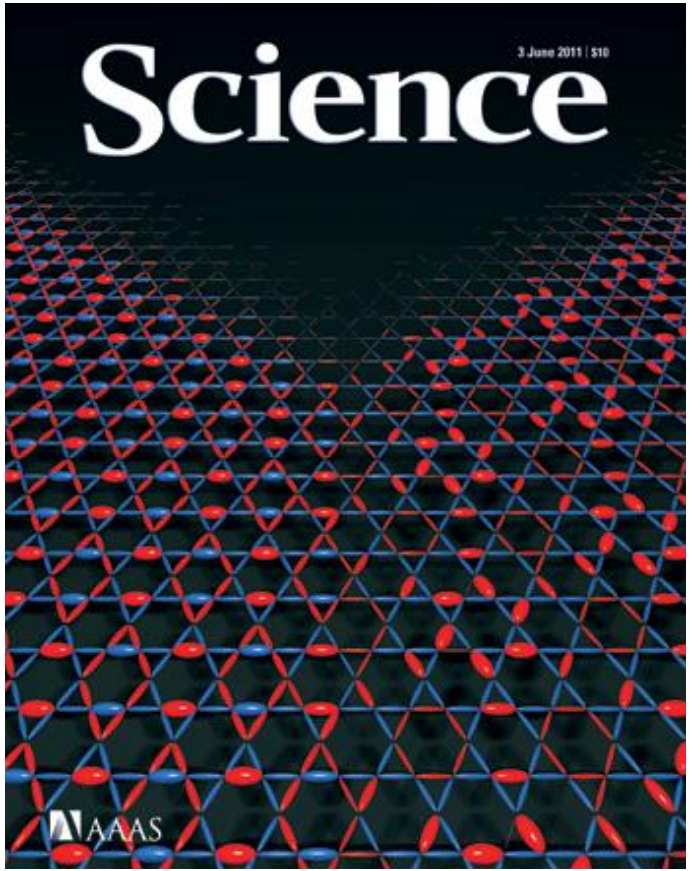


Why? *“File-drawer problem”*

Researchers do not bother to write up experiments with negative / null results or the results of replication studies.

Instead of submitting them to journals, they file them away.

Why? *Publication bias*

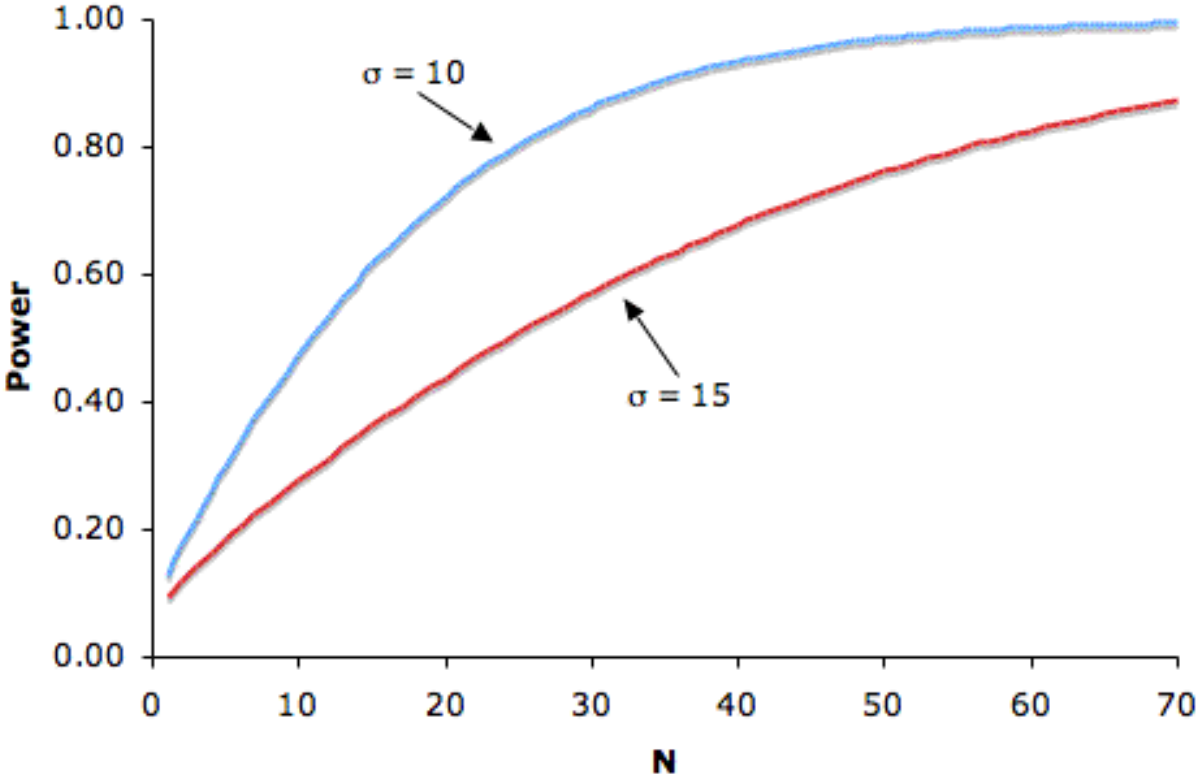


"...the small proportion of results chosen for publication are unrepresentative of scientists' repeated samplings of the real world."

– Neal S. Young, John P. A. Iaonnidis, and Omar Al-Ubaydli, 2008

Cover of Science v. 332, no. 6034 by the American Association for the Advancement of Science. Image by Stephen R. White.

Why? *Bad experimental design & analysis*



"If you torture the data long enough, it will confess."

– Ronald Coase, recipient of the 1991 Nobel Prize in Economics

"The Relationship Between Sample Size and Power" by Online Statistics Education: A Multimedia Course of Study is in the public domain.

Why? *Incentive structure*

"Today I wouldn't get an academic job. It's as simple as that. I don't think I would be regarded as productive enough."

— Peter Higgs, 2013 (winner of the 2013 Nobel Prize in Physics)

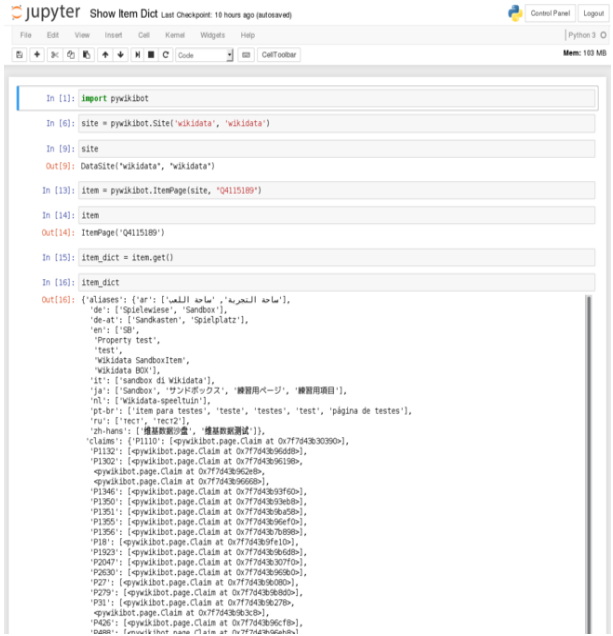
What about peer review?

"We need to get away from the notion, proven wrong on a daily basis, that peer review of any kind at any journal means that a work of science is correct."

— Michael Eisen, 2014

Reproducible Workflows

Communicating computational results



Modern data analysis typically involves dozens, if not hundreds of steps, each of which can be performed by numerous algorithms that are nominally identical but differ in detail, and each of which involves at least some ad hoc choices. If researchers do not make their code available, there is little hope of ever knowing what was done to the data, much less assessing whether it was the right thing to do.

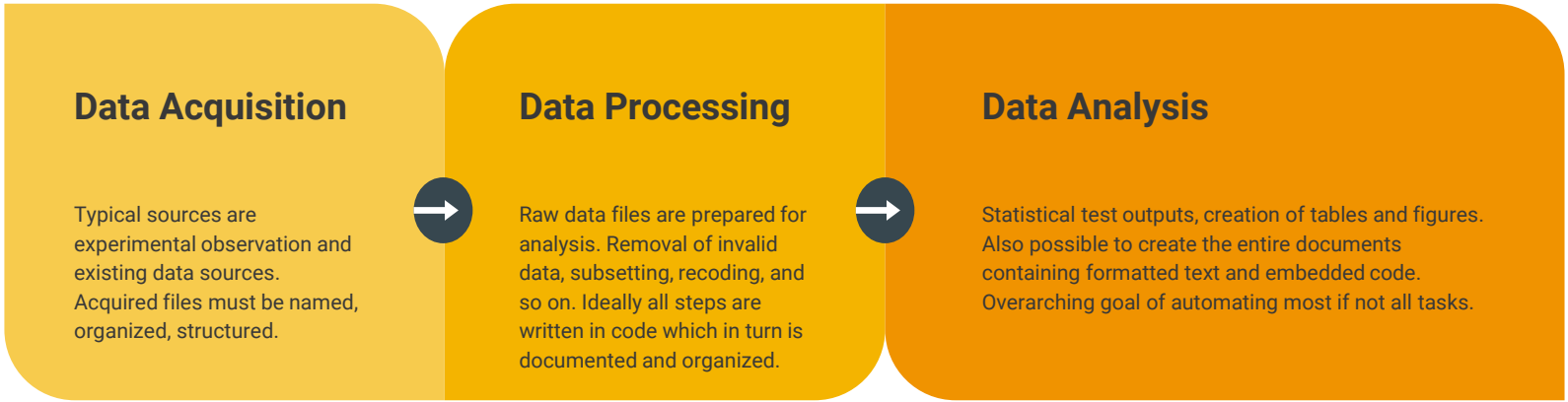
Stark, 2018

Scholarship or advertising?

An article about computational science in a scientific publication is not the scholarship itself, it is merely advertising of the scholarship. The actual scholarship is the complete software development environment and the complete set of instructions which generate the figures.

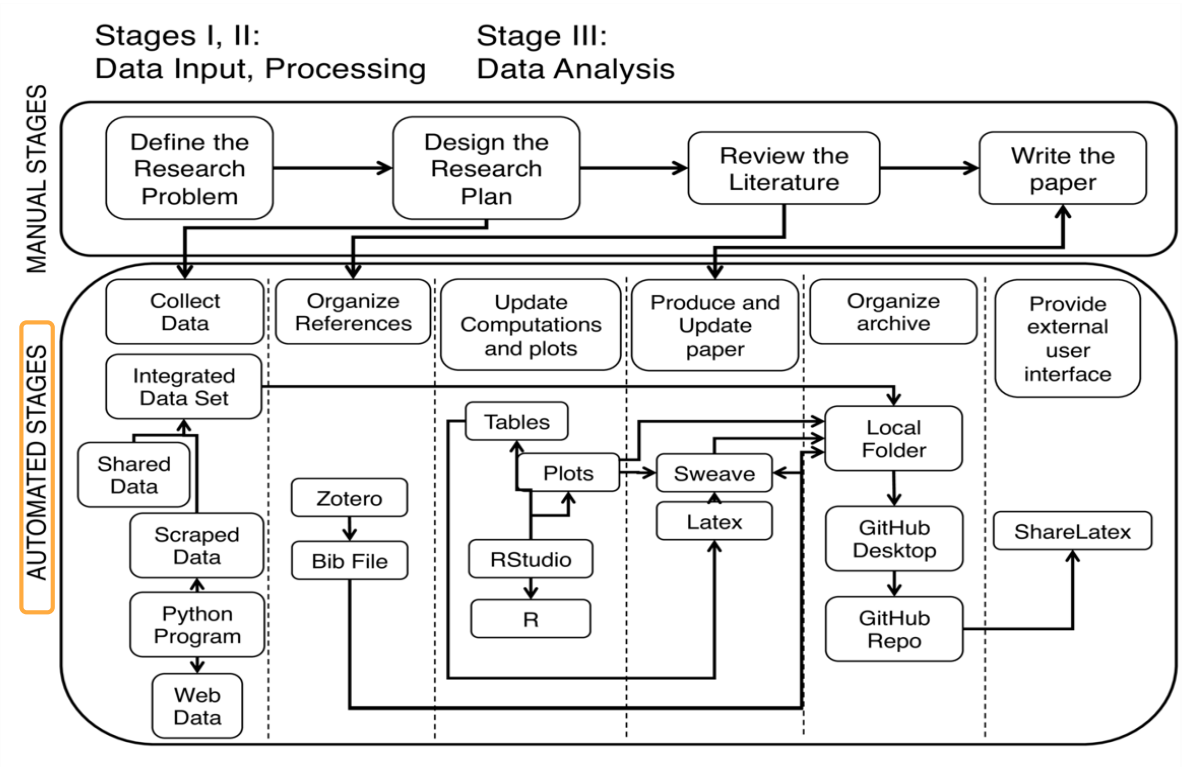
- Jonathan Buckheit and David Donoho, 1995

General workflow model



Kitzes, 2018

Detailed workflow example



Magallanes, 2018

Workflow skills and tools

Skill type	Description	Tools
Literate computing	Enable writing self-contained documents combining text and code	Rstudio : Markdown : LaTeX : Jupyter
Version control	Track file changes over time. Revert to earlier versions. Branch/fork	Git : GitHub : BitBucket
Tracking provenance	Capture complex workflows involving multiple research objects/tools	VisTrails : Kepler : Taverna
Automation	Automate workflows using time-tested and ubiquitous command line tools	Unix command line : shell scripts : make
Virtual environments	Capture complex computation environments and configurations	VirtualBox : VMWare : Docker

https://ropensci.github.io/reproducibility-guide/sections/introduction/, 2018

Learning incentives

The first step to making science reproducible is to build good habits. Your most important collaborator is your future self. It’s important to make a workflow that you can use time and time again, and even pass on to others in such a way that you don’t have to be there to walk them through it.

Culich, 2014

More information

Training:
Data/Software Carpentry -- https://carpentries.org/
Library Carpentry -- https://librarycarpentry.github.io/

Case Studies:
Kitzes, J., Turek, D., & Deniz, F. (Eds.). (2018). *The Practice of Reproducible Research: Case Studies and Lessons from the Data-Intensive Sciences*. Oakland, CA: University of California Press. (A free pre-print edition is available)

Teaching materials:
Project TIER -- https://www.projecttier.org/
ROpenSci -- https://ropensci.github.io/reproducibility-guide/
BITSS -- https://www.bitss.org/resources/

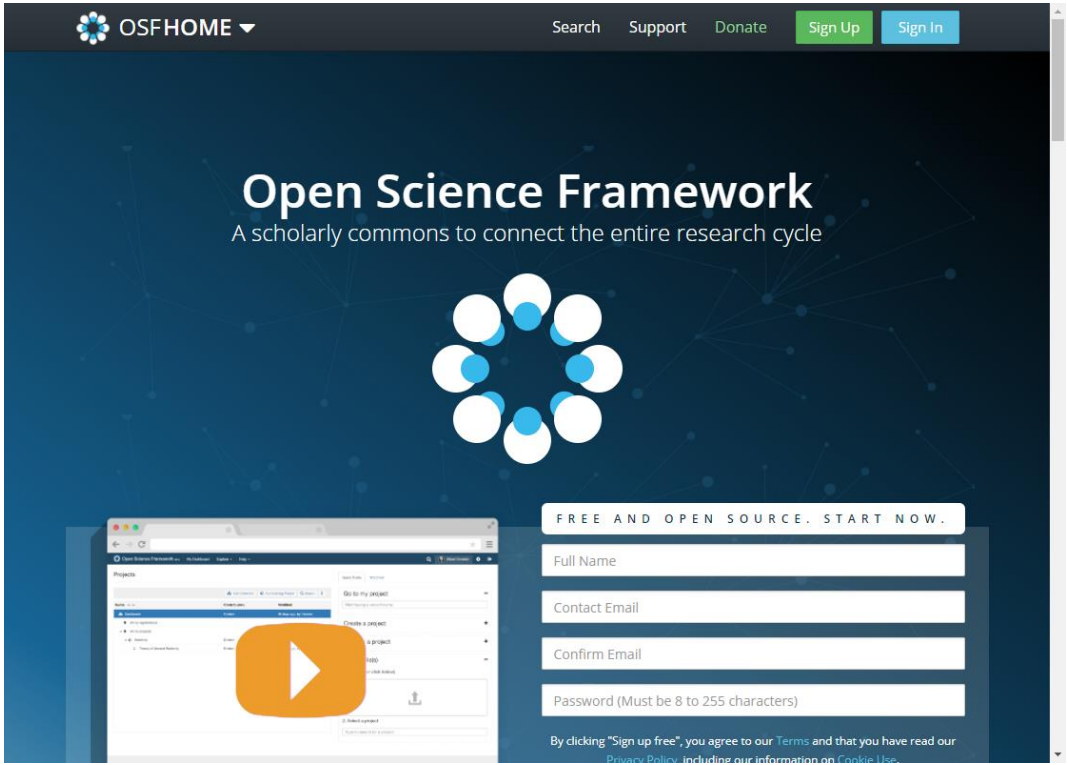
Introduction to
The Open Science Framework

Why the Open Science Framework?

Project of the
Center for Open Science,
a nonprofit based in
Charlottesville, VA

Funded by a variety of
grants and sponsors,
including DARPA, the
NSF, NIH, and others.

https://osf.io/

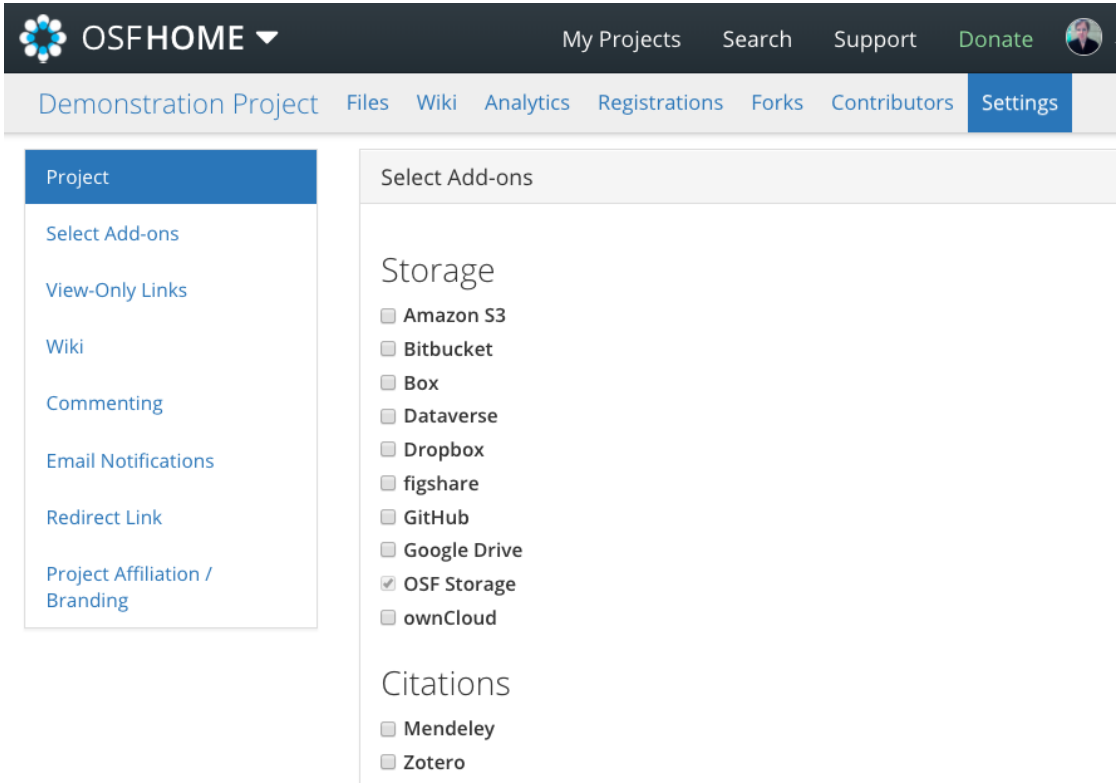


What it does

Connects various parts of your workflow, *wherever* they are

- Google Drive
- Dropbox
- Mendeley
- FigShare
- GitHub...

Share other non-project files individually as well (new feature)

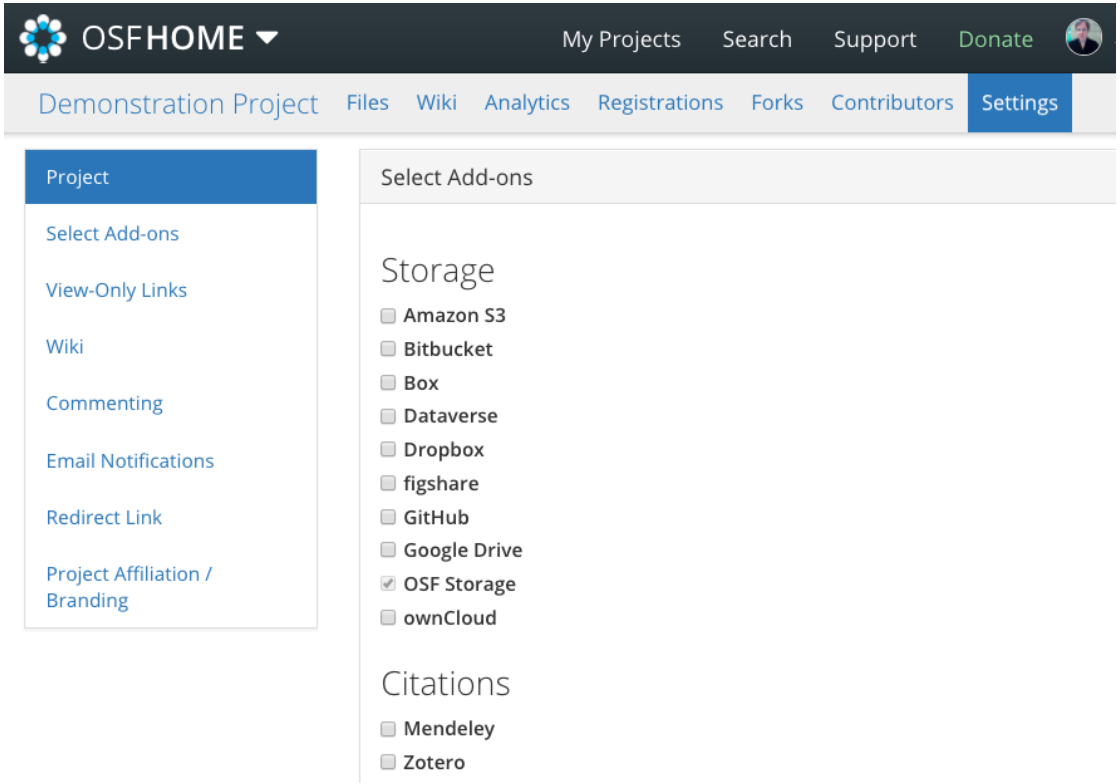


What it does

Supports versioning

Allows date-stamped registration of research projects

Provides an additional backup of research materials

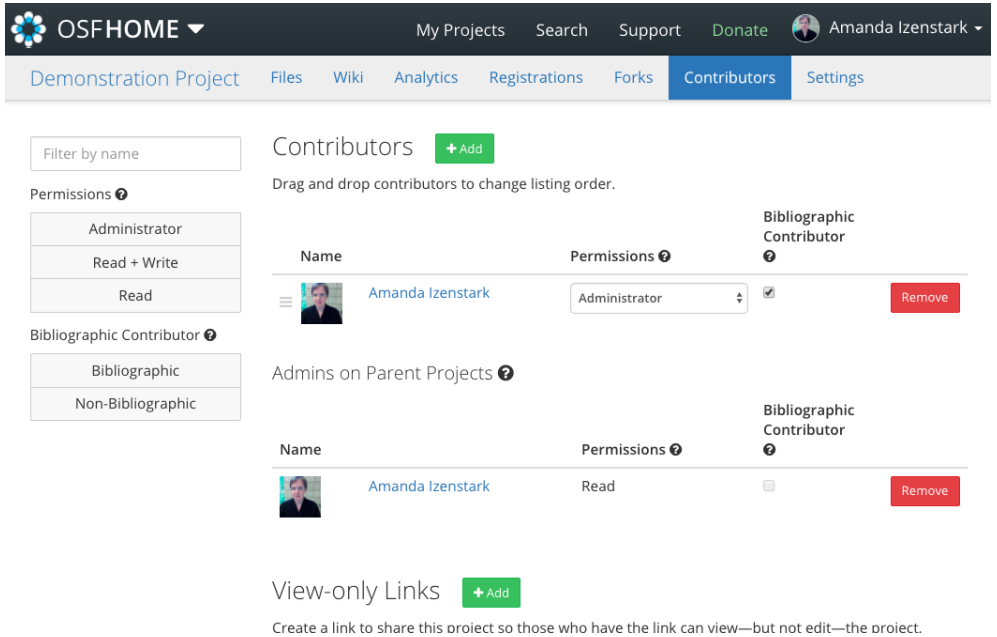


What it does

Centralizes access to research information

Provides granular sharing of elements with collaborators

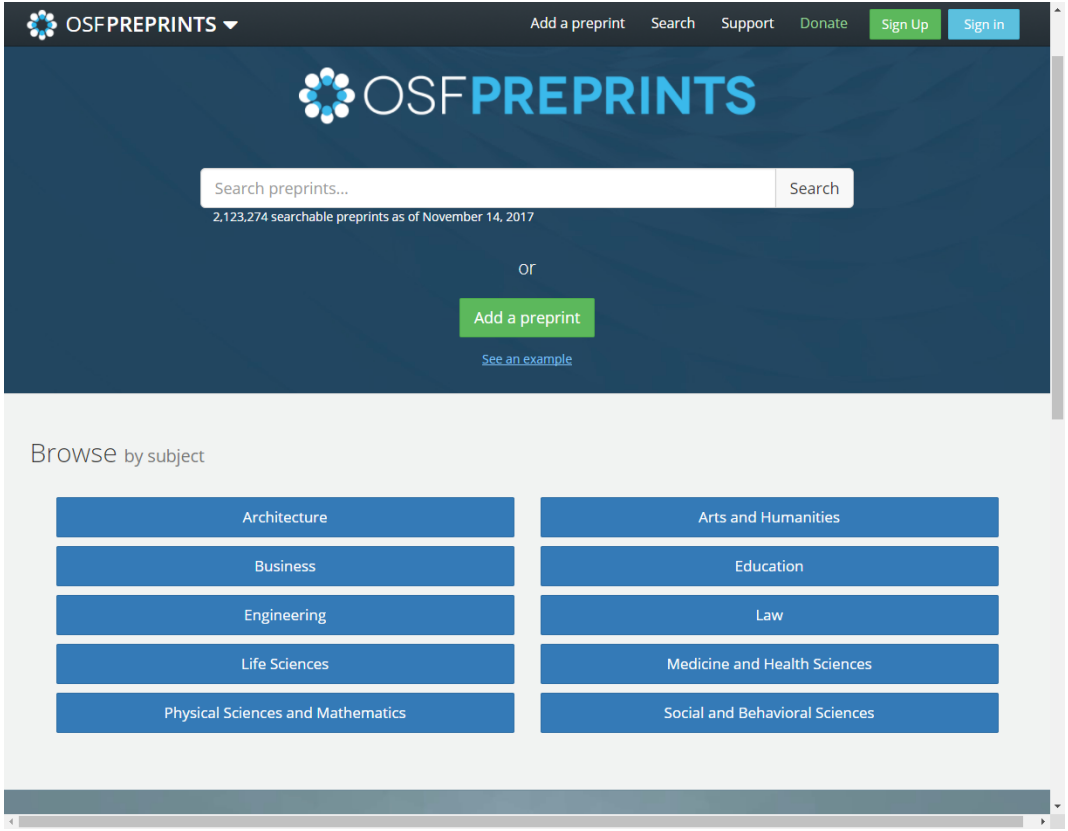
Provides access for others who can provide feedback at any stage of the research process



Additional Related Project - OSF Preprints

Not just for science - includes the Arts & Humanities, Business, Education, Law, and more.

* Once research is published, encourage researchers to post their final manuscripts your institutional repository for increased visibility!



Closing thoughts

“As readers of scientific work, all we can do is be more skeptical of everything that is published.”

> – Cristobal Young, Assistant Professor of Sociology, Stanford University, 2015

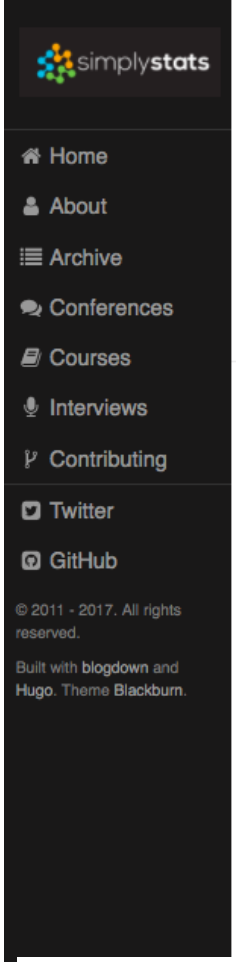
“I want to adopt a stance of humility and assume that there are errors and that’s why I need to be cautious in my conclusions.”

> – Brian Nosek, Professor of Psychology, University of Virginia and co-founder and director of the Center for Open Science, 2016

Closing thoughts

Sharing research at various stages of the process for feedback and input from others can improve researchers’ visibility, the actual research, and the final product.

(and in case you need additional talking points…)



A few things that would reduce stress around reproducibility/replicability in science

Jeff Leek 2017/11/21

I was listening to the Effort Report Episode on The Messy Execution of Reproducible Research where they were discussing the piece about Amy Cuddy in the New York Times. I think both the article and the podcast did a good job of discussing the nuances of the importance of reproducibility and the challenges of the social interactions around this topic. After listening to the podcast I realized that I see a lot of posts about reproducibility/replicability, but many of them are focused on the technical side. So I started to think about compiling a list of more cultural things we can do to reduce the stress/pressure around the reproducibility crisis.

I'm sure others have pointed these out in other places but I am procrastinating writing something else so I'm writing these down while I'm thinking about them :).

1. **We can define what we mean by "reproduce" and "replicate"** Different fields have different definitions of the words *reproduce* and *replicate*. If you are publishing a new study we now have an R package that you can use to create figures that show what changed and what was the same betweeen the original study and your new work. Defining concretely what was the same and different will reduce some of the miscommunication about what a reproducibility/replicability study means.

https://simplystatistics.org/2017/11/21/rr-sress/

From “A few things…”

2. We can remember that replication is statistical, not deterministic

3. We can remember that there is a difference between exploratory and confirmatory research

6. We can be persistent and private as long as possible

7. We can make the realization that data is valuable but in science you don’t own it

Thank you!

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