

Reproducibility Literature Review

Among statisticians at large, there is a reproducibility crisis.¹ In published articles from reputable journals, reviewers intending to reproduce the results of study face obstacles that authors fail to clear.² The availability of good data to reviewers creates one of the biggest challenges in reproducibility.³ Authors may not share data sets (even upon reasonable request) or reviewers may struggle to recreate/recover the data.^{3,4} From there, many data sets have incorrect or inconsistent data reporting which can further complicate the replication process.³ Without identical data to those of the study, it is less likely that the published results can be achieved, harming the credibility of the work. As such, whether due to data inconsistency or simply poor statistical practices, some studies' claims of significance fail upon further review.² While much of the literature studying the validity of these claims are in psychological research, it stands to reason that these issues are relevant in all fields of research.²

One of the greatest ways to address this is in the classroom. Training statisticians in reproducibility from the start of their work can create better practice in the field. With properly trained researchers, the effort into properly reporting methods can maximize the reproducibility of published research studies in the future.¹ As teaching reproducibility earlier in statistics education is becoming standard, it is important to understand the current ways it is addressed and areas to expand upon.¹

A three pronged approach advocated in Dogucu & Centinkaya-Rundel (2022) proposes teaching reproducibility with reproducible research, teaching reproducibility, and reproducible teaching.^{1,5} This pedagogy involves expanding upon each of the workflows for research, learning, and teaching.⁵ Research and learning reproducibility is somewhat integrated already, with opportunities for research in labs or faculty-advised projects as well as instructors introducing students to technology and resources used to create a reproducible workflow.¹

The idea of teaching reproducibility is less standard in practice than the other two. However, it can have great impact on student success. Teaching reproducibility provides an opportunity to teach by example, exposing students to the instructor's own best practices in reproducibility which they might not otherwise witness.⁵ It furthermore seeks to improve collaboration between instructors to learn and advance statistics education.⁵ The core pillars of this principle are computational reproducibility, documentation, and openness. Computational reproducibility entails integrating plain text with code (literate programming), keeping raw data and tracking steps taken, file organization, and version control.⁵ For documentation, instructors should write plain text files to track the software (and versions), steps for file reproduction, codebook (explaining data structure), and a style guide to aid in

organization.⁵ Finally, materials should be shared as openly as possible; instructors should provide clear licensing and a site host to share with the public.⁵

To facilitate teaching and learning reproducibility, tools like R Markdown/Quarto or Jupyter notebooks effectively unify notes with R code.¹ Using these notebook files allows students to bypass struggles with pure coding and computational environments (some difficulties running R packages on different operating systems).⁶ By allowing instructors to integrate step-by-step instructions with working code, students can better step through code and see how to replicate solutions.⁶ Much of the research done on these sort of technologies uses R, but identical products exist for a wide range of programming languages, and the impacts they bring to education are likely similar.

Integrating GitHub, either on its own or through GitHub Classroom can further teach students the necessity of a reproducible workflow. Version control systems like Git allow researchers to track their workflow and trace errors, while maintaining the openness and clarity needed in a reproducible workflow.⁷ Given the importance of GitHub as an online host for open source projects and data sharing, it is a crucial platform to be familiar with in research. The study of interest links a GitHub repository of all data and code used in their project, allowing for easy access to attempt to reproduce their work. Broader adoption of such a practice will benefit statisticians at large, and the greatest way to start is with integration at the educational, training level.⁸

Educating students on reproducibility early in their statistical studies is important to begin correcting the irreproducibility of many published studies in the future. By making all aspects of the classroom reproducible, students can learn by example and gain a broader understanding of how and why to maintain a fully reproducible workflow.

References:

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