ARTE

Article Reproducibility Template & Environment

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Abstract

This document is a deployment of the **ARTE: Article Reproducibility Template & Environment**. It serves as an example of how the template can be used and showcases its features. This template provides a structured framework for creating **dynamic and fully reproducible research articles** using **Quarto**, integrated with **RStudio**, **Git/GitHub**, and designed for sharing on platforms like **OSF** and **GitHub Pages**.

The template is organized according to the **TIER Protocol 4.0**, ensuring clarity and reproducibility. It is pre-configured for environment management using **renv** and **Docker**, guaranteeing that the computational environment is consistent and reproducible both locally and in the cloud via **MyBinder**. This example demonstrates the integration of narrative text, executable R code, and outputs (like tables and figures) within a single, cohesive document.

This deployment illustrates the project structure and the use of **Quarto's book format**. It is not a research article on a specific topic but a guide on how to use the template itself.

Key-words: Open Science, Reproducibility, Quarto, TIER Protocol 4.0, R language, RStudio, Git, GitHub, renv package, Docker, **MyBinder**, GitHub Pages, OSF.

How cite this template?

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We also recommend reading:

Limongi, R., & Rogers, P. (2025). Open Science in Three Acts: Foundations, Practice, and Implementation - Second Act. *BAR - Brazilian Administration Review*, *22*(2), e250116. https://doi.org/10.1590/1807-7692bar2025250116

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1 Introduction

This section introduces the **ARTE: Article Reproducibility Template & Environment**. This is not an introduction to a research topic, but rather an explanation of the template's purpose and structure.

This template is designed for researchers, particularly in the applied social sciences, who want to create **dynamic and reproducible research articles**. It aims to make the principles of reproducible research more accessible by providing a pre-structured project environment.

ARTE also provides cloud-based reproducibility verification via MyBinder, allowing anyone to verify the computational workflow without local installation.

The template integrates several key tools and practices:

- **Quarto's book:** For authoring dynamic documents that seamlessly blend narrative text, executable code (R), and the resulting outputs (tables, figures). *This document you are reading is an example of a Quarto book.*
- **TIER Protocol 4.0:** Provides a standardized folder structure (`Data/`, `Scripts/`, `Output/`) to organize your project logically and transparently, making it easier for others (and your future self) to understand and reproduce your work.
- **Git/GitHub:** Built-in version control allows you to track changes to your project over time, facilitating collaboration and providing a history of your work.
- **Environment Control:** The template supports three levels of environment management:
  - **Proper Reproducibility:** Using the R `renv` package to snapshot and restore specific versions of R packages.
  - **Full Reproducibility (Recommended):** Using **Docker** (see `docker/` folder) to containerize the entire computational environment (R, RStudio, Quarto, packages, LaTeX). This ensures that your project runs identically on any machine with Docker installed, eliminating "it works on my machine" issues.
- **GitHub Pages:** Pre-configured for publishing your dynamic article using GitHub Actions (`.github/workflows/deploy.yml`) and designed for sharing on the **Open Science Framework (OSF)**.

This example document demonstrates how these components work together. Gain some additional knowledge regarding Open Science and Reproducible Research (Kathawalla et al., 2021; Klein et al., 2018; Limongi & Rogers, 2025a, 2025b; Rogers & Limongi, 2025).

This is an example of how to integrate an external document into your article (Figure 1), showcasing the **TIER Protocol 4.0** folder structure.

For more details about **TIER Protocol 4.0**, visit the page: https://www.projecttier.org/ and/or read the Domingos & Batista (2021) article.

Read the README files for the project root and explore the repository structure to learn more about how this protocol works with this template.

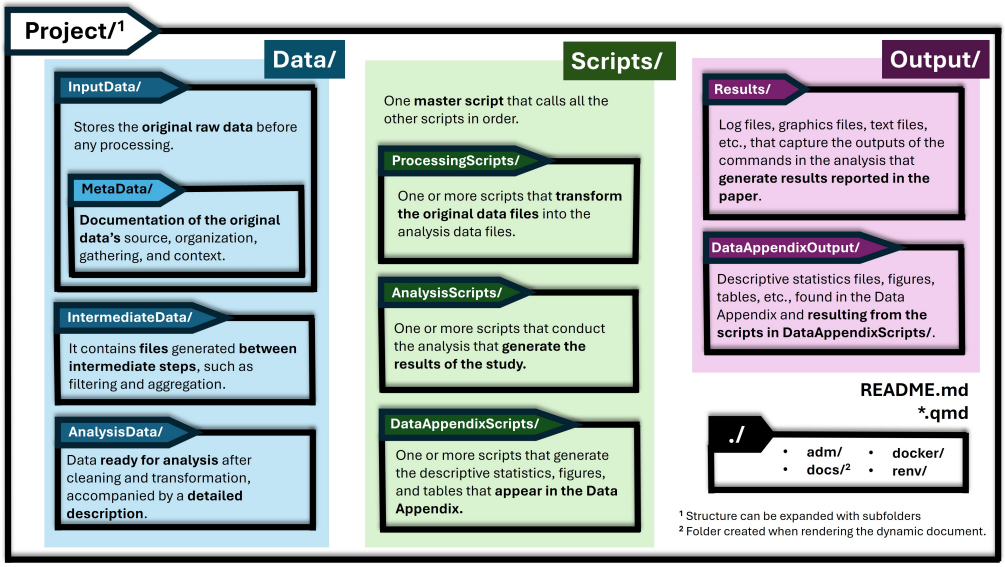

Figure 1: ARTE (Article Reproducibility Template & Environment) workflow folder structure. Illustration available at: https://doi.org/10.5281/zenodo.17496183

2 Background

This section provides background on the concepts of reproducibility and the tools integrated into this template.

Reproducible research is a cornerstone of good scientific practice. It ensures that findings are reliable and that the scientific process is transparent. The tools and structure provided by this template are designed to support these principles.

Make sure to look into the thought of reproducible research practice (Dogucu & Çetinkaya-Rundel, 2022; Gilroy & Kaplan, 2019; Limongi & Rogers, 2025a, 2025b; Rogers & Limongi, 2025; Sullivan et al., 2019; Vuorre & Curley, 2018; Wiebels & Moreau, 2021; Wilson et al., 2017).

2.1 Reproducibility Levels

The template is designed to support different levels of reproducibility, as illustrated in the Figure 2. The levels are:

- **Minimal Reproducibility:** Using the template structure, editing READMEs, and sharing on OSF.
- **Proper Reproducibility:** Adding Quarto narrative (with RStudio and Git/GitHub) development and using renv package for R package management.
- **Full Reproducibility (This Template's Strength):** Incorporating Docker to containerize the entire computational environment, ensuring maximum consistency and ease of replication. This is achieved using the files in the `docker/` folder.

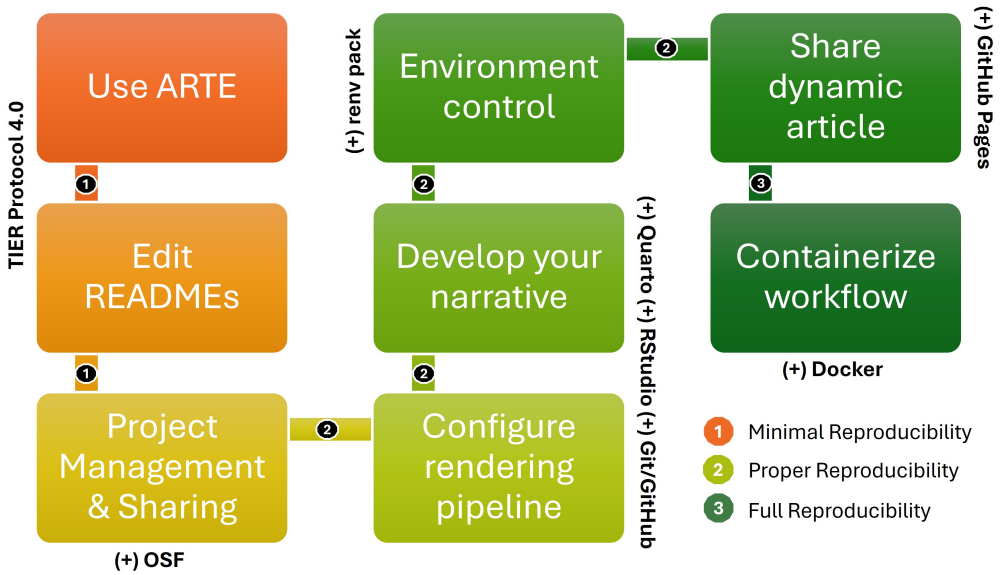

Figure 2: Roadmap for Developing a Dynamic and Reproducible Research Article with ARTE workflow. Illustration available at: https://doi.org/10.5281/zenodo.17509258

2.1.1 Cloud-Based Reproducibility Verification

Beyond local reproducibility tools, ARTE integrates MyBinder for cloud-based verification. MyBinder creates executable environments from GitHub repositories, allowing reviewers and readers to:

- Launch a complete R environment in their web browser
- Execute the full computational pipeline without any installation
- Verify results independently across different systems
- Explore and interact with the analysis interactively

This addresses a critical barrier in reproducibility: while many researchers share code and data, technical difficulties often prevent independent verification. MyBinder removes this friction by providing one-click access to a working environment.

2.2 The Role of Dynamic Documents

Dynamic documents, like the ones created with Quarto (`.qmd` files), play a crucial role. They allow the narrative of your research to be directly linked to the analysis code. When you render the document, the code is executed, and the results (tables, figures, numbers) are automatically inserted into the text. This reduces manual errors and ensures that your narrative always reflects the latest analysis.

2.3 TIER Protocol 4.0 Structure

The folder structure adheres to the TIER Protocol 4.0:

- `Data/`: Stores raw, intermediate, and final data files.
- `Scripts/`: Contains R scripts for data processing, analysis, and visualization. Complex analyses are best kept here.
- `Output/`: Stores generated results like tables, figures, and intermediate data files.
- `docs/` (Root): Contains the final rendered output (HTML, PDF) for web publication.
- **Root**: Contains main narrative files (`index.qmd`, `01-intro.qmd`, etc.), project configuration (`_quarto.yml`), bibliography (`references.bib`), and CSL style file (`apa7ed.csl`).

This structure promotes clarity and makes it easier for others to navigate your project.

3 Methods

This section describes the tools and methods used to create and utilize this template.

This template itself is the "method". It prescribes a specific way to organize and execute a reproducible research project.

3.1 Core Technologies

1. **Quarto:** The primary authoring tool. It uses Markdown syntax for text and integrates executable code chunks (primarily R, but also Python, Julia, etc.). Key features used:
    - **Book Format:** Organizes the article into chapters/sections.
    - **Code Chunks:** Embed R code directly (`{r}`) for analysis and visualization.
    - **Citations:** Managed via `references.bib` (BibTeX) and formatted using `apa7ed.csl`. You can use Zotero in RStudio for this.
    - **Embedding Outputs:** Results from scripts in `Scripts/` can be embedded into the narrative using `{{< embed >}}` (see Results section).
2. **R & RStudio:** The computational engine and integrated development environment (IDE). R/RStudio is used for statistical analysis, data manipulation, and creating visualizations within Quarto documents.
3. **Git & GitHub:**
    - **Git:** Provides version control locally. Every significant change to your project files is tracked.
    - **GitHub:** Hosts the repository online, enabling collaboration, sharing, backup, and to publish the dynamic document (Github Pages). It also integrates with GitHub Actions.
4. **Environment Management:**

- **renv:** (Proper Reproducibility) Tracks and restores specific R package versions used in the project. The `renv.lock` file is the key component.
- **Docker:** (Full Reproducibility) Packages the entire software environment (R, RStudio, Quarto, packages, LaTeX) into a container. This guarantees that the environment is identical for anyone running the project. The `docker/` folder contains the necessary configuration (`Dockerfile`, `docker-compose.yml`, `start/stop` scripts).
- **MyBinder**: Cloud platform for reproducibility verification. Provides one-click browser-based access to a complete computational environment, enabling verification without local installation (`.binder/Dockerfile`)

5. **Sharing & Publication:**
    - **OSF:** A platform for registering, storing, and sharing research materials openly.
    - **GitHub Pages:** A free service to host the rendered HTML version of your Quarto book/article directly from your GitHub repository. The `.github/workflows/deploy.yml` file automates this process.

3.2 Workflow Integration

If you need to learn a little more about Reproducible Research with R/RStudio, there are excellent free e-books:

- R for Data Science
- Building reproducible analytical pipelines with R
- The Open Science Manual: Make Your Scientific Research Accessible and Reproducible

The typical workflow using this template for Full Reproducibility involves:

1. Setting up the environment using Docker (`docker/start.sh` or `start.bat`).
2. Working within the RStudio container to edit `.qmd` files, run code chunks, and manage R packages (tracked by `renv`).
3. Rendering the document using `quarto render` in the RStudio Terminal.
4. Stopping the Docker environment when done (`docker/stop.sh` or `stop.bat`).
5. Using Git locally to commit and push changes to your GitHub repository.
6. Optionally, pushing to the `main` branch triggers the GitHub Actions workflow to automatically publish the updated HTML site to GitHub Pages.

4 Results

This section demonstrates how results generated by your analysis can be integrated into the narrative. It showcases the use of Quarto's `embed` feature to include outputs from separate analysis scripts.

Remember that the dynamic document's (`.qmd`) primary role is to present the narrative and key findings. Complex or exploratory analyses are best kept in separate scripts

within the `Scripts/` directory. This separation keeps the main narrative document focused and clean.

The `Scripts/AnalysisScripts/data_visualization.qmd` file contains example R code for generating plots and tables. Below, we embed the outputs from specific code chunks within that script directly into this narrative.

I've included two examples of how to include results from your analytic scripts into your story below: Figure 3 and Table 1. These are generated by running the code in `Scripts/AnalysisScripts/data_visualization.qmd`.

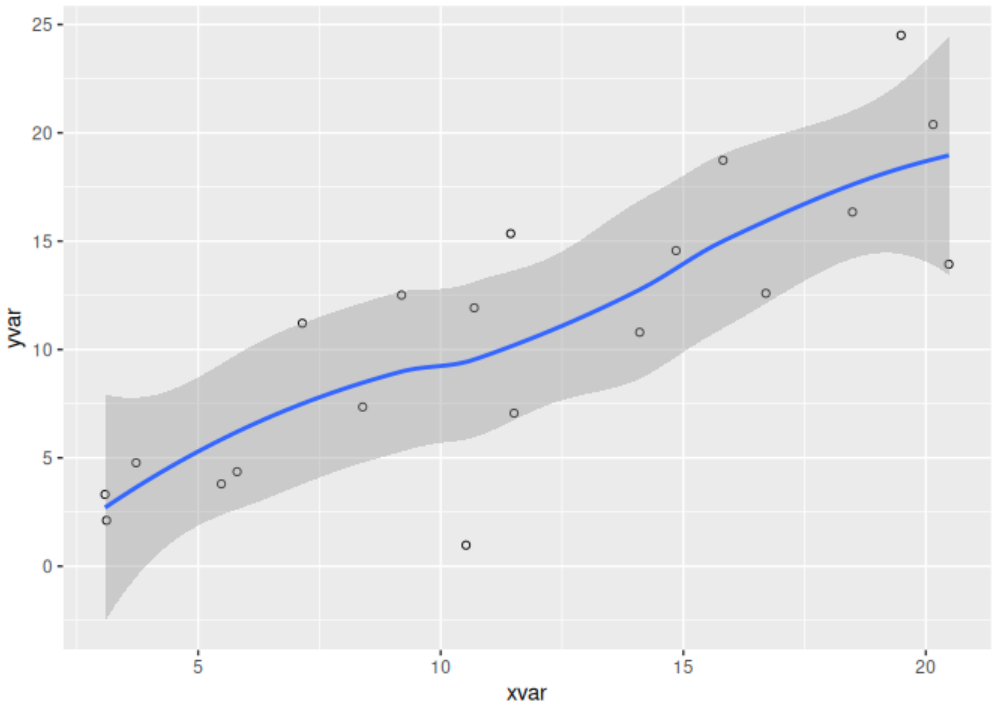

Figure 3: Pressure

Table 1: Diamonds characteristics

carat	cut	color	clarity	depth	table	price	x	y	z
0.23	Ideal	E	SI2	61.5	55	326	3.95	3.98	2.43
0.21	Premium	E	SI1	59.8	61	326	3.89	3.84	2.31
0.23	Good	E	VS1	56.9	65	327	4.05	4.07	2.31
0.29	Premium	I	VS2	62.4	58	334	4.20	4.23	2.63
0.31	Good	J	SI2	63.3	58	335	4.34	4.35	2.75
0.24	Very Good	J	VVS2	62.8	57	336	3.94	3.96	2.48

To learn how it was done, follow the code in `Scripts/AnalysisScripts/data_visualization.qmd`! Please take note that we are only referring to the *output* (the figure and table) generated

by the code chunks labeled `fig-pressure` and `tbl-diamonds` in that script. The underlying R code is executed when that script is run or when this document embeds its output, ensuring reproducibility.

This approach allows you to develop complex analyses in dedicated script files while selectively presenting the most relevant results in your main article narrative.

> To learn more about the embedding process discussed here, see the Quarto embedding documentation.

5 Conclusion

This section summarizes the purpose and benefits of the ARTE: Article Reproducibility Template & Envorinment.

This template provides a comprehensive and structured pathway for researchers to create dynamic, reproducible research articles. By integrating tools like Quarto, TIER Protocol 4.0, Git/GitHub, and Docker, it addresses the core requirements for modern, transparent, and robust scientific communication.

Although your project must be auditable and replicable by your scripts and data, keep in mind that not everything in your scripts needs to be explicitly shown in your main narrative document. You can maintain detailed analysis workflows in the `Scripts/` folder. The main narrative (`.qmd` files) should focus on the story you are trying to tell, embedding only the most critical results and insights.

The key advantages of using this template are:

1. **Enhanced Reproducibility:** The combination of renv package and Docker ensures that your work can be replicated exactly by others. MyBinder eliminates technical barriers to reproducibility verification.
2. **Improved Organization:** The predefined folder structure (TIER Protocol 4.0) makes projects easier to navigate and understand.
3. **Streamlined Workflow:** Integration with RStudio and Quarto provides a smooth environment for writing, coding, and publishing.
4. **Easy Sharing and Publishing:** Built-in support for GitHub Pages and OSF facilitates open science practices.
5. **Reduced Setup Time:** Researchers can start new projects quickly with a preconfigured environment.

This template is a practical tool for implementing the principles of reproducible research and open science. It lowers the technical barriers, allowing researchers to focus on their core research questions while ensuring best practices for transparency and replication are followed.

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