

# The Smelly Eight: An Empirical Study on the Prevalence of Code Smells in Quantum Computing - Artifact

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**Abstract**—This abstract summarizes the artifact developed for the research paper “The Smelly Eight: An Empirical Study on the Prevalence of Code Smells in Quantum Computing” accepted for publication in the 45th IEEE/ACM International Conference on Software Engineering (ICSE). The artifact provides all scripts, data, and instructions that would allow others to repeat and reproduce the paper’s study. It is available at <https://doi.org/10.5281/zenodo.7625865>, licensed with the MIT License.

**Index Terms**—Quantum computing, Quantum software engineering, Research artifact

## I. METADATA

- **Associated Paper’s Title:** The Smelly Eight: An Empirical Study on the Prevalence of Code Smells in Quantum Computing
- **Authors:** Qihong Chen, Rúben Câmara, José Campos, André Souto, Iftekhhar Ahmed
- **URL:** <https://doi.org/10.5281/zenodo.7625865>
- **License:** MIT License
- **Status / Badges:** Artifacts Evaluated - Reusable, and Artifacts Available

## II. ARTIFACT’S STRUCTURE

- `README.md`: Provides a bird’s-eye view of the artifact, from where it can be obtained, and how it should be cited.
- `REQUIREMENTS.md`: Describes the software and its required environment (e.g., operating system) by the artifact and the user’s expected skills.
- `INSTALL.md`: Describes the procedures to install the required software and provides usage examples on assessing whether each software installation finished successfully.
- `INSTRUCTIONS.md`: Describes the procedure, accompanied by small examples whenever possible, to repeat and reproduce the results presented in the associated paper.
- `AUTHORS.md`: Contains the name of authors.
- `LICENSE.md`: Describes the distribution rights.
- `STATUS.md`: States what kind of badge(s) the authors are applying for, as well as the reasons why the authors believe that the artifact deserves that badge(s).

Table I: Artifact’s top-level directories.

Directory	Description
<code>experiments/</code>	Study of the prevalence of quantum-specific smells on quantum programs.
<code>samples/</code>	Examples used in Section IV of the associated paper.
<code>subjects/</code>	The subjects (i.e., quantum programs) used in the empirical evaluation.
<code>survey/</code>	Questions asked and answers provided by survey’s participants.
<code>tools/</code>	Local directory that keeps all required tools and environments to run those tools.
<code>utils/</code>	Utility scripts used by more than one experiment/analysis.

Table I lists the top-level directories in the artifact. Each top-level directory provides the required scripts and data to perform a specific analysis or experiment described in the associated paper. Each top-level directory has the following structure:

- `README.md`: Describes the directory and elements found in the directory (data, scripts, etc.) and provides documentation of those elements, e.g., examples on how to run a script, what a script generates, etc.
- `data/`: Data files used as inputs by the scripts and/or automatically generated by the scripts of each analysis to enhance faster processing. `data/FILE-SPECS.md` defines the format of all CSV files in each `data/` directory.
- `scripts/`: Bash or Python scripts for performing the corresponding analysis or experiments.
- `statistics/`: R scripts that process the data and produce numbers, tables, and figures for the associated paper.

## III. STATUS / BADGES

The authors are applying for two badges: Artifacts Evaluated - Reusable, and Artifacts Available. The reasons why the artifact deserves these two badges are explained below.

### A. Artifacts Evaluated - Reusable

The artifact’s quality significantly exceeds minimal functionality. That is, the artifact fulfills all the minimum and

optional criteria recommended for the **Artifacts Evaluated - Reusable** badge. In detail:

- The artifact is well and carefully documented and offers an inventory of the contents and all necessary descriptions to enable the artifact to be exercised.
- The artifact is relevant to the associated paper and contributed to the generation of its main results.
- The artifact is self-contained and exercisable. It includes scripts and/or software used to generate the results described in the associated paper and the data that can be accessed and appropriately manipulated.
- The artifact has a proper license available, explicitly documented in the `LICENSE.md` file.
- The artifact has explicit documentation of the requirements / pre-requisites necessary for potential installations or executions of code in the `REQUIREMENTS.md` file.
- The artifact has an installation script and step-by-step instructions that allow for the automatic installation of necessary tools and environments (see `INSTALL.md` file).
- (Optional criteria) The artifact has an indication of the time needed to run each software, script, or bash command.

#### B. Artifacts Available

The artifact fulfills all the minimum and optional criteria recommended for the **Artifacts Available** badge. In detail:

- The artifact is available for public download from an open-access repository that does not require any registration.
- The artifact is available for public download from a persistent repository with a stable URL: <https://doi.org/10.5281/zenodo.7625865>.
- The artifact is associated with a Digital Object Identifier (DOI): `10.5281/zenodo.7556360`.
- (Optional criteria) The artifact provides explicit documentation on the authors (see `AUTHORS.md`) and a template on how to cite the artifact and the associated paper (see `README.md`).

### IV. REQUIREMENTS

The following subsections briefly list the required knowledge, skills, and software required. Visit the `REQUIREMENTS.md` file for more details, e.g., on how to assess whether a required software is installed and available.

#### A. User

From a user perspective, it is expected the user is capable of navigating between directories on the command line and comfortable running bash commands on the command line. Minimum or basic knowledge of Bash, Python, and R might be required to read and/or modify any script.

#### B. Machine

A Unix-based machine is required to exercise the artifact. Any bash command, tool, or script available or used in the artifact has been tested only on a Unix-based machine and therefore might not work on other operating systems, e.g., Windows.

#### C. Software

The experiments and analyses performed in the associated paper require the following tools to be installed and available: GIT, GNU wget, Perl, GNU Parallel, R, and ImageMagick.

### V. INSTALL

#### A. Docker route

For an easy setup, the artifact provides a Docker container<sup>1</sup> that includes all scripts, data, and instructions required to repeat and reproduce our study. In a nutshell, one should first get the artifact, second pull the docker image

```
docker pull josecarloscampos/qsmells-artifact
and third, connect to the docker image
docker run --interactive --tty \
  --privileged --workdir /qsmells-artifact/ \
  josecarloscampos/qsmells-artifact
```

which should lead one to the root directory of the artifact. Then, one should follow the step-by-step instructions described in the `INSTRUCTIONS.md`.

#### B. Non-Docker route

The top-level directory `tools/` provides a script named `get-tools.sh` which is responsible for automatically assessing whether the requirements described in `REQUIREMENTS.md` file are fulfilled, for configuring an isolated Python environment, and for installing the tool we developed for the associated study, QSmell (`tools/qsmell`). Visit the `INSTALL.md` file for more details on the `get-tools.sh` script and on how to assess whether any script, software, package has been successfully installed. Moreover, visit the `tools/qsmell/README.md` file for more details on QSmell's workflow, installation procedure, and usage examples.

### VI. INSTRUCTIONS

The `INSTRUCTIONS.md` file describes step-by-step instructions, accompanied by small examples, on how to repeat and reproduce the results presented in the associated paper.

### VII. CONCLUSION

We wish, with the artifact, to affirm our commitment to open science which requires open data and open source software to repeat and reproduce prior work. Thus, this artifact provides all elements and step-by-step instructions that would allow others to repeat and reproduce paper's study.

### ACKNOWLEDGMENTS

This work was supported by FCT through the LASIGE Research Unit, ref. UIDB/00408/2020 and ref. UIDP/00408/2020, and by the Instituto de Telecomunicações Research Unit, ref. UIDB/50008/2020 and ref. UIDP/50008/2020.

<sup>1</sup><https://hub.docker.com/r/josecarloscampos/qsmells-artifact>