Complex Math documents in Quarto

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This example document shows the right way to write complex Math documents in Quarto.

When I started Quarto, my objective was to port my existing latex files to Quarto. I struggled with these requirements:

- having a single .qmd document to render both HTML and PDF
- using the `equation` and `align environments`
- numbering all equations in HTML
- labelling and refering to a single line of a multi-line equation.
- using macros

This document shows what I believe to be the right solution to these requirements. I hope that this document can make it easy for latex users writing complex math to transition to latex. If you have any feedback, please send me an email

1 An example document

Welcome to this example document. When I started Quarto, my objective was to port my existing latex (Knuth 1986; Lamport 1994; Mittelbach et al. 2004) files to Quarto. I struggled with these requirements:

- having a single .qmd document to render both HTML and PDF
- using the `equation` and `align environments`
- numbering all equations in HTML
- labelling and refering to a single line of a multi-line equation.
- using macros

I wrote this document to illustrate what I believe to be the right solution to these issues. This document does not aim to illustrate all of Quarto's syntax. Please refer to the Quarto documentation instead. In Section 1.1, I present a simple example of a math theorem and proof. In Section 1.2, I explain how to solve the issues I encountered.

1.1 Empirical mean and variance

Let x_i be a dataset of values of $\mathbb{R}$. The empirical mean m and variance v are defined as:

$$m = \frac{1}{n}\sum_{i=1}^{n} x_i \tag{1}$$

$$v = \frac{1}{n}\sum_{i=1}^{n} (x_i - m)^2 \tag{2}$$

Theorem 1.1 (Alternative form)**.** *The empirical variance can also be written as:*

$$v = (\frac{1}{n}\sum_{i=1}^{n} x_i^2) - m^2 \tag{3}$$

Proof. The proof is straightforward: we start from the original definition in eq.(2) and expand the square.

$$v = \frac{1}{n}\sum_{i=1}^{n} (x_i - m)^2 \tag{4}$$

$$= \frac{1}{n}\sum_{i=1}^{n} (x_i^2 - 2x_i m + m^2) \tag{5}$$

$$= (\frac{1}{n}\sum_{i=1}^{n} x_i^2) - 2(\frac{1}{n}\sum_{i=1}^{n} x_i)m + (\frac{1}{n}\sum_{i=1}^{n} 1)m^2 \tag{6}$$

$$= (\frac{1}{n}\sum_{i=1}^{n} x_i^2) - 2mm + 1m^2 \tag{7}$$

$$= (\frac{1}{n}\sum_{i=1}^{n} x_i^2) - m^2 \tag{8}$$

This concludes the proof: we have indeed established the correctness of eq.(3).

□

1.2 Explanations

1.2.1 Numbering equations in HTML

In a HTML document, equations are rendered by MathJax. By default, MathJax does not number equations. In order to number equations, we need to modify the MathJax configuration. A simple self-contained solution is to modify the yaml preamble of the qmd file. Please see the example below for the corresponding code.

Please note, if your preamble becomes too complex, you can export it to a separate file.

```
---
format:
  html:
        - text: |
            <script>
            MathJax = {
                tex: {
                    tags: 'ams'  // should be 'ams', 'none', or 'all'
                }
            };
            </script>
---
```

1.2.2 Macros

Macros are necessary when writing complex math, both to simplify the source code and improve writing speed. It is tricky to define macros in Quarto. My solution (see example below) is to define macros in the yaml preamble, hard-coding them in the premable of the html and tex file.

Please note that macros need to be written twice: once for html, once for tex. This approach also makes the macros invisible for Quarto.

```
---
format:
    pdf:
        include-in-header:
            - text: |
                \def\sumi{{\frac{1}{n} \sum_{i=1}^n}}
    html:
        include-before-body:
```

```
            - text: |
                $$
                    \def\sumi{{\frac{1}{n} \sum_{i=1}^n}}
                $$

---
```

1.2.3 Equation cross-references

For equation cross-referencing, it is necessary to use the Latex `\label{label}` and `\eqref{label}` syntax, instead of the Quarto `@label` syntax. For example:

```
\begin{equation}
    1 + 1 = 2
\label{the_equation}
\end{equation}

Eq.\eqref{the_equation} is much deeper than it appears.
```

Please note that figure and section cross-referencing should use Quarto syntax.

Also note that, if you do not number all equations, then you need to further add a `\tag` command. Otherwise, in HTML output, MathJax does not label the equation. The eqref then produces a `???` hyperlink to the correct equation. For example:

```
\begin{equation}
    1 + 1 = 2
\tag \label{the_equation}
\end{equation}

Eq.\eqref{the_equation} is much deeper than it appears.
```

1.2.4 Citations

Citations of the relevant litterature can either be:

- separated from the text.

  ```
  Latex is a typesetting system [@texbook; @latex2e; @latex:companion].
  ```

  > Latex is a powerful typesetting system (Knuth 1986; Lamport 1994; Mittelbach et al. 2004).

- integrated in the text:

```
@latex2e provides detailed information about Latex.
```

Lamport (1994) provides detailed information about Latex.

Knuth, Donald E. 1986. *The TeX Book*. Addison-Wesley Professional.

Lamport, Leslie. 1994. *LaTeX: A Document Preparation System*. 2nd ed. Massachusetts: Addison Wesley.

Mittelbach, Frank, Michel Gossens, Johannes Braams, David Carlisle, and Chris Rowley. 2004. *The LaTeX Companion*. 2nd ed. Addison-Wesley Professional.