Introduction to Literate Programming with Quarto

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Credit statement and licence

Possible roles using the CRediT contribition system:

- **Conceptualization**: Ideas; formulation or evolution of overarching research goals and aims
- **Methodology**: Development or design of methodology; creation of models
- **Software** : Programming, software development; designing computer programs; implementation of the computer code and supporting algorithms; testing of existing code components
- **Validation**: Verification, whether as a part of the activity or separate, of the overall replication/ reproducibility of results/experiments and other research outputs
- **Formal analysis**: Application of statistical, mathematical, computational, or other formal techniques to analyze or synthesize study data
- **Investigation**: Conducting a research and investigation process, specifically performing the experiments, or data/evidence collection
- **Resources**: Provision of study materials, reagents, materials, patients, laboratory samples, animals, instrumentation, computing resources, or other analysis tools
- **Data Curation**: Management activities to annotate (produce metadata), scrub data and maintain research data (including software code, where it is necessary for interpreting the data itself) for initial use and later reuse
- **Writing - Original Draft**: Preparation, creation and/or presentation of the published work, specifically writing the initial draft (including substantive translation)
- **Writing - Review & Editing**: Preparation, creation and/or presentation of the published work by those from the original research group, specifically critical review, commentary or revision – including pre-or postpublication stages

- **Visualization**: Preparation, creation and/or presentation of the published work, specifically visualization/ data presentation
- **Supervision**: Oversight and leadership responsibility for the research activity planning and execution, including mentorship external to the core team
- **Project administration**: Management and coordination responsibility for the research activity planning and execution
- **Funding acquisition**: Acquisition of the financial support for the project leading to this publication

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Prerequisites

> **!** Prerequisites
>
> Before completing this submodule, please carefully read about the necessary prerequisites.

Prerequisite	Description	Link/Where to find it
Topic Name	Basic intro to X	Module + Submodule
Software Name	Configuring the environment	Download Link

Questions from previous submodule

Questions from previous submodule

- **Aim**: This first slide is dedicated to clarifying questions from the previous submodule and/or to discuss assignments.
- Additional slides may need to be added depending on the nature of the homework assignments.
- Critical for the learning process to ensure that students are on the same page and have been able to achieve the learning goals of the previous workshop.
- Not applicable if this set of slides corresponds to the first submodule of a new module.

Before we start: Survey time!

Take this survey to test your prior Quarto knowledge

Quarto Survey link

- **Aim**: The pre-submodule survey serves to examine students' prior knowledge about the sumodule's topic.
- Use free survey software such as or other survey software (Menti, particify, formR) to establish this. You can use the example survey, edit it or create your own!

Discussion of survey results

- **Aim**: Briefly examine the answers given to each question interactively with the group.
- Use visuals from the survey to highlight specific answers.

Make it clear to the group that there will be a similar post-submodule survey to examine understanding and learning progress.

Where are we at?

- **Aim**: Place the topic of the current submodule within a broader context.
- Remind students what you are working towards and what the bigger picture is.

Quarto

Quarto makes it easy to analyze, share and reproduce. It's a powerful tool for producing transparent, reproducible, and accessible work that can be freely shared, viewed, and reused by others.

- **Aim**: Place the topic of the current submodule within a broader context.
- Remind students what you are working towards and what the bigger picture is.

Quarto Learning Goals

- Participants will **learn** how to create, edit, and render Quarto documents
- Participants will **understand** how to use key Quarto features (code chunks, YAML headers, citations, and output formatting)
- Participants will **gain confidence** in preparing and teaching Quarto effectively to students

- **Aim**: Formulate specific, action-oriented goals learning goals which are measurable and observable in line with Bloom's taxonomy (Anderson et al., 2001; Bloom et al., 1956)

- Place an emphasis on the **verbs** of the learning goals and choose verbs that align with the skills you want to develop or assess.

- Examples:

  - Students will **describe** the process of photosynthesis or
  - Students will **construct** a diagram illustrating the process of photosynthesis

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Key Terms and Definitions

- **What is Quarto?** An open-source scientific and publishing system that combines text, code and media to create easily shareable documents such as websites, slides, reports, and much more.
- **What is Rendering?** The process where Quarto runs the code, combines it with the text, and creates a final output.
- A Quarto Markdown document is saved as a **.qmd file**

Aim: Introduce key terms and definitions that students will come across throughout the session.

Components of a .qmd file

- **YAML header**- the section at the top of the Quarto document that controls settings like the title, output format, and author.
- **code chunks**- sections of the document that contains code (from R or Python, for example) that are used for showing results such as tables, plots, or calculations
- **Quarto Markdown**- combines text, codes, and formatting to create the actual content of the document

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Components of a .qmd file

- You can write Quarto documents in **Visual mode** or **Source mode** in RStudio.
- This is part of the **authoring process**, and it allows you to format the text, add code, and build your document using either buttons (WYSIWYM-style) or markdown syntax.

Base yourself on conceptual change theory and examine exisiting concepts in relation to some key terms. Re-examine formation of new concepts at the end of the lesson.

Covered in this Session

- Setting up a Quarto Document
- Authoring
- Code Chunks
- Adding Citations
- Publishing

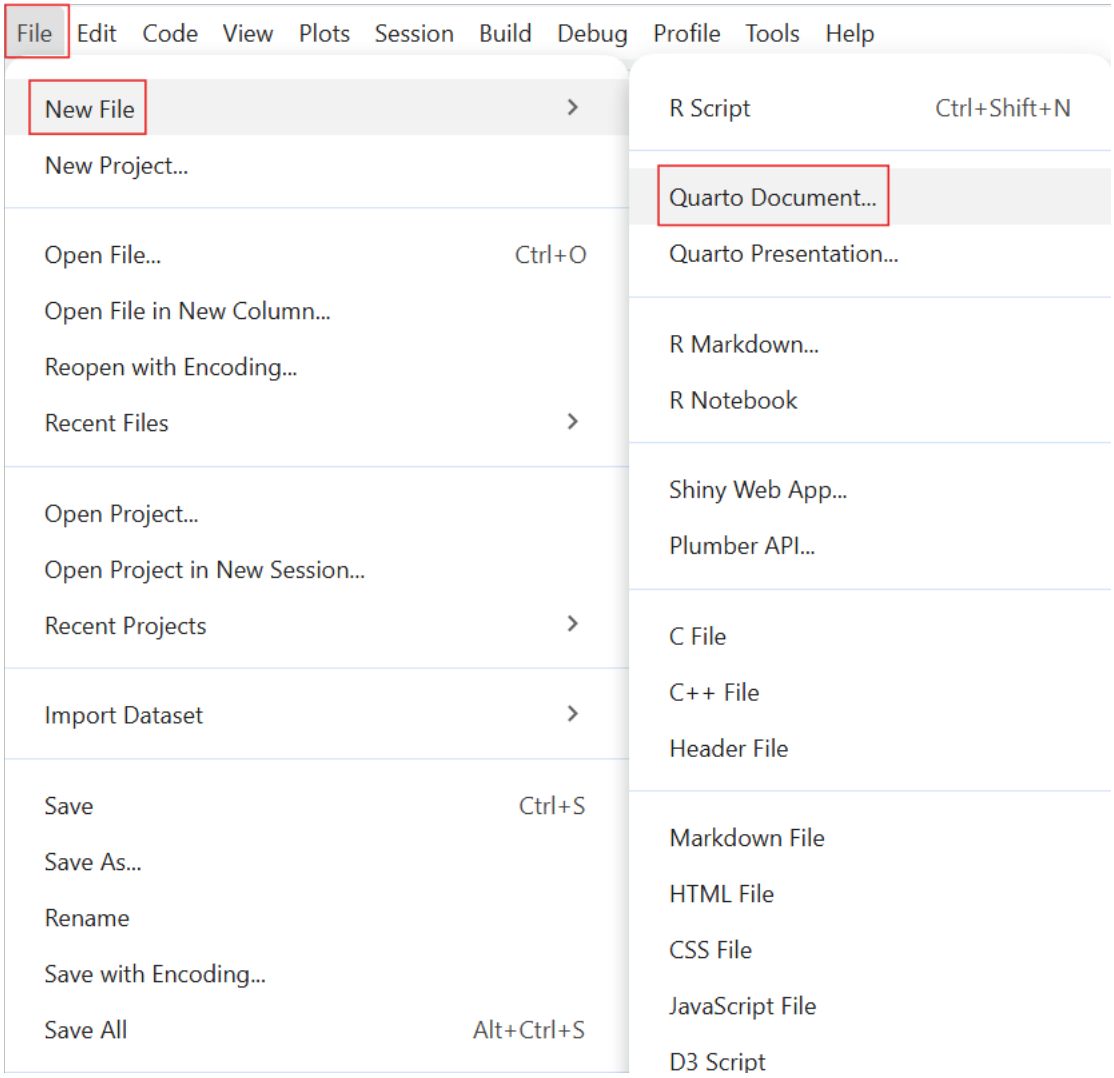
Introduction of submodule topic - **Aim**: Core theoretical introduction of submodule topic. - Pair theoretical aspects with practical exercises and group discussions according to the Think-Pair-Share style and according to Cognitive Load Theory (Sweller, 1980). - Use multiple slides for this part.

For a 90-minute lesson, the instructor should try to "lecture" for only 20 minutes, students should work in groups/pairs/on their own for at least 55 minutes of the lesson (+ a 15 minute break).

Practical exercises on topic - **Aim**: Design practical exercises for students to apply the new skills in practise. - Depending on the topic, the exercises should be in accordance with the learning objective(s). - It's useful to have exercises directly after a topic is taught to reinforce what was learnt.

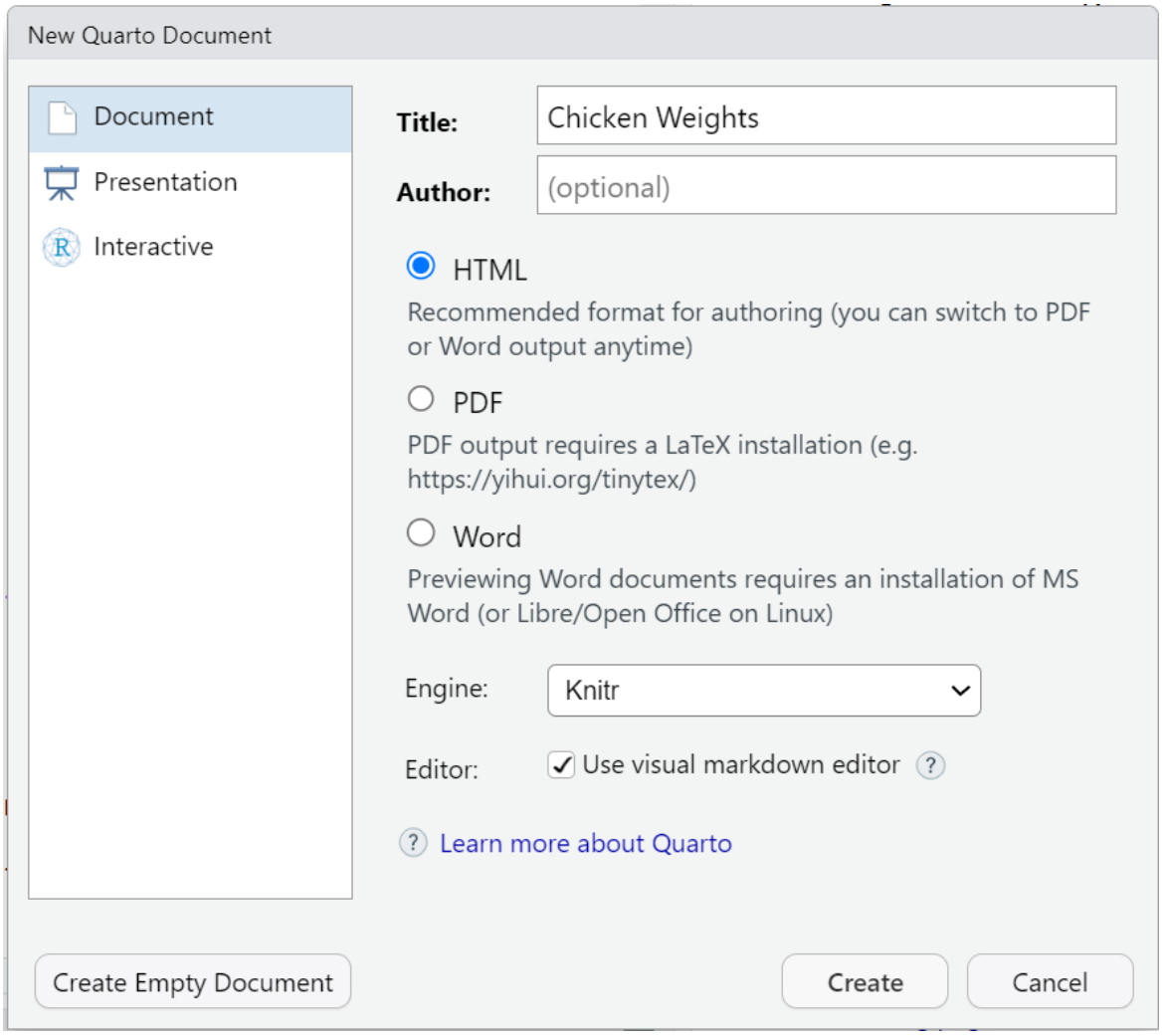
For students who advance faster: Prepare extra exercises.

Setting up a Quarto Document using RStudio



- Select **File**
- → Select **New File**
- → Select **Quarto Document**

Setting up a Quarto Document using RStudio



- The default format is html
- The output format can also be changed by editing the YAML header

Task 1

☐ Follow the steps to create a new Quarto Document

Rendering

There are two ways to render in Quarto

- **Manual rendering**: having to click on the "Render" each time you want to see the output
- **Render on Save**: Quarto will automatically re-render the document each time you click "Save"

Where are these rendering options in RStudio?

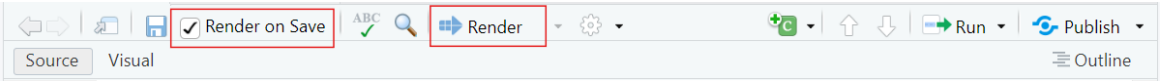


Figure 1: You can find both Manual Render and Render on Save at the top of your workspace

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Authoring

This is the process of writing and structuring the Quarto document.

YAML Header + Markdown = Authoring

To practice authoring in Quarto, let's start with setting the YAML header and adding text in **Source** mode.

Authoring

Task 2

☐ copy & paste this into the YAML header of your document

```
---
title: "ChickWeight Analysis"
author: "Your Name"
format:
  html:
    code-fold: false
    toc: true
---
```

> **i** output format
>
> You can replace "html" to render the document to a different format.
> Here is a link to a list of the different output formats.

Markdown Text

Basic Text Formatting

- **Bold:** `**bold**` → **bold**
- *Italic:* `*italic*` → *italic*
- ~~Strikethrough:~~ `~~text~~` → ~~text~~
- `Inline code: \`code\`` → `code`

> **markdown shortcuts**
>
> Here is a link for the full list of markdown shortcuts for formatting!

Formatting Markdown Text

```
Have you ever been curious about what affects a chick's weight?
This document explores the ChickWeight dataset using R.
The goal is to compare chick weight across different diets and time points.
Key steps include:

- Loading the dataset
- Visualizing growth trends
- Summarizing results
```

Task 3

- ☐ Copy this text and paste it to your document
- ☐ Bold the word *"ChickWeight"*
- ☐ Italicize the phrase *"growth trends"*

Adding a Callout Box

Highlight particularly important aspects with Quarto callout boxes, for example:

! Important with Title

This is an example of a callout box to highlight particularly important information using `callout-important`

Tip with Title

This is an example of a callout box to give important tips using `callout-tip`

Note with Title

This is an example of a callout box to include an additional note using `callout-note`

Adding a Callout Box

Here is the markdown text for inserting a callout note box.

```
::: callout-note
## Based on Real Data

The ChickWeight dataset in R is based on real experimental data.
:::
```

Task 4

☐ Copy & paste into your Quarto document to add this callout note box.

Code Chunks

Inserting Code

Two ways to insert code chunks:

- Manually type 3 back ticks “‘ then {r} to start a coding chunk and end it with 3 back ticks

OR

- Use the keyboard shortcut Ctrl + Alt + I (Windows/Linux) or Cmd + Option + I (Mac) to insert a code chunk

---

Inserting Code

```
summary(ChickWeight)
```

```
library(ggplot2)
ggplot(ChickWeight, aes(x = Time, y = weight, color = Diet)) +
  geom_line(aes(group = Chick)) +
  labs(title = "Chick Growth Over Time")
```

Task 5

- ☐ Insert the code in **two separate code chunks**
- ☐ Render the output and see what you get

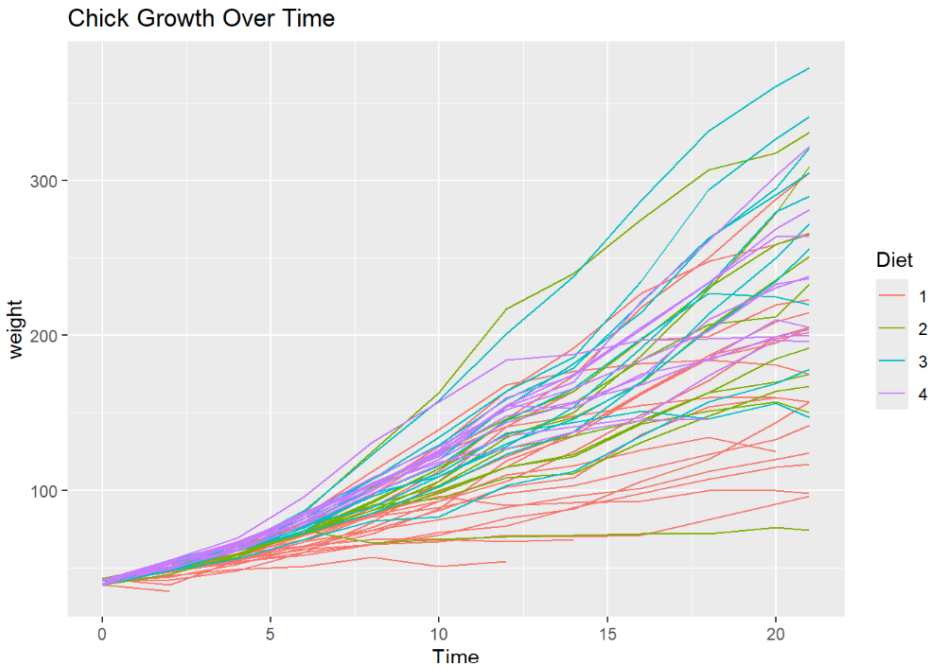
Code Chunks

Adjust how the code is portrayed by editing the YAML header

```r
summary(ChickWeight)
```

```
     weight           Time           Chick     Diet
 Min.   : 35.0   Min.   : 0.00   13     : 12   1:220
 1st Qu.: 63.0   1st Qu.: 4.00   9      : 12   2:120
 Median :103.0   Median :10.00   20     : 12   3:120
 Mean   :121.8   Mean   :10.72   10     : 12   4:118
 3rd Qu.:163.8   3rd Qu.:16.00   17     : 12
 Max.   :373.0   Max.   :21.00   19     : 12
                                 (Other):506
```

```r
library(ggplot2)
ggplot(ChickWeight, aes(x = Time, y = weight, color = Diet)) +
  geom_line(aes(group = Chick)) +
  labs(title = "Chick Growth Over Time")
```



- `code-fold: false` - the code is visible and not collapsible (as seen here)
- `code-fold: true` - collapses the code so the reader can expand it

Code Chunks

Adjust how the code is portrayed by editing the YAML header

```r
summary(ChickWeight)
```

```
     weight           Time           Chick     Diet
 Min.   : 35.0   Min.   : 0.00   13     : 12   1:220
 1st Qu.: 63.0   1st Qu.: 4.00   9      : 12   2:120
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```r
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  geom_line(aes(group = Chick)) +
  labs(title = "Chick Growth Over Time")
```

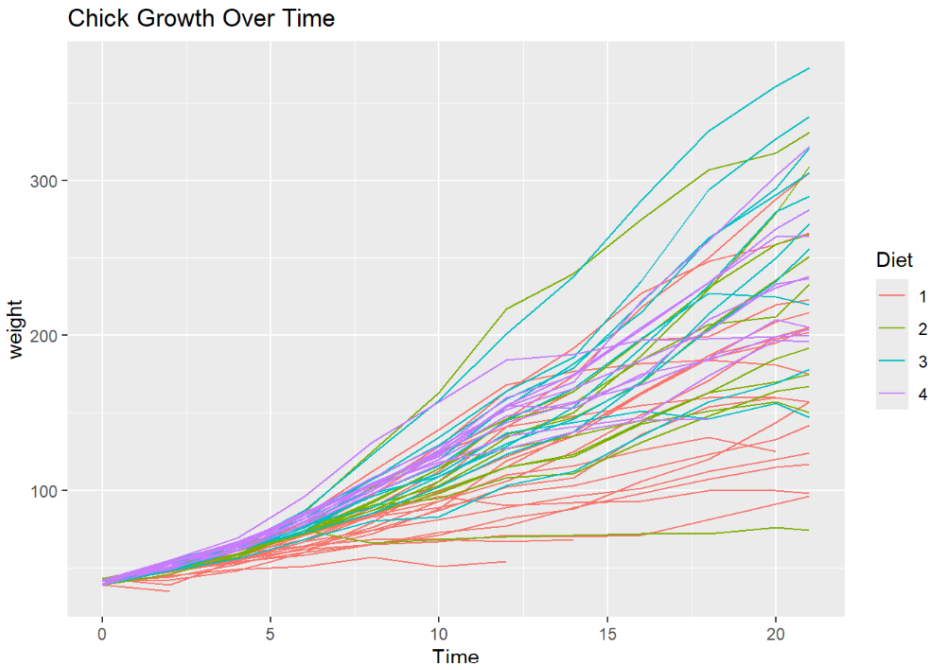

- `code-tools: true` - adds the functions "show code" at the top of the page and "copy" next to the chunks
- `echo: true` - both the code and the output is visible

Code Chunks

Let's edit the YAML header to make the code chunks collapsible and add code tools.

Task 6

- ☐ change `code-fold: false` to `code-fold: true`
- ☐ add `code-tools: true`
- ☐ render the document to see the changes

Pre-break survey

- **Aim**: This pre-break survey serves to examine students' current understanding of key concepts of the submodule
- Use free survey software such as or other survey software (Menti, particify, formR) to establish the following questions (shown on separate slides).

What's the name of Quarto Markdown document?

a. .png file

b. .qmd file

c. .doc file

d. .mp3 file

What is the YAML header?

a. summarizes the document into a single line

b. this is where you store notes and reminders

c. it's like the "settings" of the document

d. just the title of the document

Which of the following is used to format content (like paragraphs and bullet points)?

a. Code chunks

b. YAML header

c. Markdown text

d. All of the above

Break! 10 minutes

Post-break survey discussion

- **Aim**: To clarify concepts and aspects that are not yet understood
- Highlight specific answers given during the survey

Additional Authoring Features

Quarto offers additional authoring features that make it more versatile and comprehensive. These include:

- adding links and hyperlinking text,
- embedding media,
- creating multi-column layouts,

and more.

> **i** commonly used authoring features
>
> Here is a link for commonly used markdown syntax for additional authoring features!

Inserting Links

link with title: [title] (link)

- [Quarto Website] (https://quarto.org/) → Quarto Website
- [Reveal.js Documentation] (https://revealjs.com/) → Reveal.js Documentation

link without title: < https:// link >

- < https://www.markdownguide.org/ > → https://www.markdownguide.org/
- < https://github.com/ > → https://github.com/

Inserting Images

- A benefit of using Quarto is the ability to easily add media, such as images, to your documents
- It's a good practice to save these files in the same main folder as your Quarto document (ideally in a dedicated subfolder named images—to keep paths organized and easy to manage)

Inserting Images

- no caption: ! [ ] (path/image.png)

Inserting Images

- with caption: ! [caption] (path/image.png)

Figure 2: This is a caption about three yellow chicks in the grass.

Inserting Images

- with link: [! [caption] (path/image.png)] (link)

Figure 3: Click to see a study on Chick Weights

Inserting Images

```
![No chicks were harmed in the making of this lesson.](images/chickpic1.png)
```

Task 7

- ☐ Click this link to download the image
- ☐ Save the image to the main folder of the Quarto document files
- ☐ Copy & paste the markdown text to insert an image with a caption (edit path if needed)

Creating Columns

You can change the layout of a section using columns.

- Start the column layout by writing "::::: columns"
- Begin the first column with "::: column"
- Add content and end it with ":::"
- Begin second coloumn with "::: column"
- Add content and end it with ":::"
- End section with a final ":::::"

> **i** list of page layout options
>
> Here is a link for page layout options to author how content looks on your document!

Creating Columns

Let's use columns to add bullet points next to an image.

Task 8

- ☐ Click this link to download the image
- ☐ Save the image to the main folder of the Quarto document files

---

Creating Columns

Task 8

```
:::::: columns
::: column

![](images/chickpic2.png)

:::

::: column

-   Monitor growth trends over time
-   Compare diets and weight gain

:::
::::::
```

☐ Copy & paste the markdown text to add an image with bullet points using columns (edit path if needed)

Adding Citations with Zotero

- **Zotero** is a free reference management tool to collect, organize, cite, and share research sources.
- You can use **Zotero** in RStudio to easily insert citations into your Quarto document

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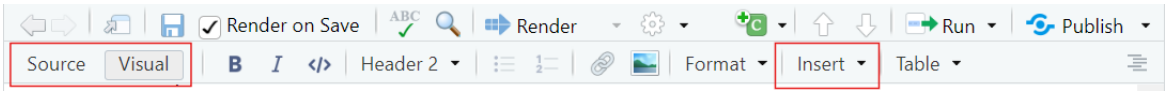
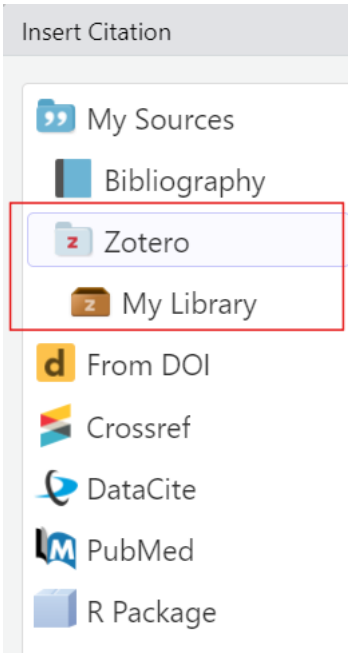
Adding Citations with Zotero



To insert a citation:

- Switch to the "Visual Editor" mode
- In the YAML header, add `bibliography: references.bib`
- Press the "Insert" button in the toolbar and select "Citation"

Adding Citations with Zotero



- You can select citations straight from your library and folders in Zotero
- Each citation is assigned a short citation key based on the author and year (e.g., Zimmerman2002).
- You can quickly cite it in your document by typing @ followed by the citation key.

Adding Citations with Zotero

Follow this link to an article on diets and broiler chicks

Task 9

☐ add the citation to your Zotero Library

Publishing

What is **Publishing** with Quarto? It's the process of sharing the rendered documents or projects online so it can become accessible to others.

You can publish to:

- GitHub Pages
- Quarto Pub
- personal website

> **i** list of publishing services
>
> Here is a link for a list of publishing services and more information!

Publishing to GitHub

A great option to share your document is publishing to GitHub.

- **GitHub** is a platform for hosting and sharing code and projects online
- An advantage of GitHub is it allows for **version control**- the ability to track and manage changes over time
- One of the ways Quarto can publish your document to GitHub is by using **GitHub Pages**

Publishing to GitHub

GitHub Pages enables you to publish content based on source code managed within a GitHub repository.

3 ways to publish a Quarto document to GitHub Pages:

- Render to the `docs` directory and checking it into your repository
- Use the `quarto publish` command
- Use GitHub Actions to auto-render and publish whenever you push changes

Let's take a closer look at the first method: **Render to `docs`**

Publishing to GitHub

Render to `docs`

- Edit the YAML header and add `output-dir: docs` at the end
- In the root of your GitHub repo, create an empty file named `.nojekyll` by running the following in the terminal for Mac/Linux:

```
touch .nojekyll
```

OR the following for Windows command prompt:

```
copy NUL .nojekyll
```

Publishing to GitHub

Render to `docs`

- Enter the following in the Terminal to render and push your site to GitHub

```
quarto render
git add docs
git commit -m "Publish site to docs/"
git push
```

Publishing to GitHub

Task 10

Recap

Relevance and implications

- **Aim**: To work out the relevance of the topic to your students.
- In an interactive setting, discuss how the new skills could be applied in practise with specific examples.
- Examine downfalls and practical obstacles.

What is the take-home message?

Aim: End lesson on clear take-home message that are interactively compiled by students.

Assignment

- **Aim**: Explain the homework assignment and the rationale behind the homework.
- Examine whether/how it will be assessed
- Mention scoring rubrics, if applicable
- Design a peer-review system for assignments to place students in role of reviewer and author

---

To conclude: Survey time!

- **Aim**: This post-submodule survey serves to examine students' current knowledge about the sumodule's topic.
- Use free survey software such as or other survey software (particify, formR) to establish the following questions (shown on separate slides):

What is your level of familiarity with [Topic] (e.g., basic concepts, terminology, or tools)?

a. I have never heard of it before.

b. I have heard of it but have never worked with it.

c. I have basic understanding and experience with it.

d. I am very familiar and have worked with it extensively.

Which of the following concepts or skills do you feel most confident about in relation to [Topic]? (Select all that apply)

a. Concept 1

b. Concept 2

c. Concept 3

d. Concept 4

e. I am not sure about any of these concepts.

On a scale of 1 to 5, how comfortable are you with using [specific tool/technology] related to [Topic]? (1 = Not comfortable at all, 5 = Very comfortable)

a. 1

b. 2

c. 3

d. 4

e. 5

Discussion of survey results

- **Aim**: Briefly examine the answers given to each question interactively with the group.
- Compare and highlight specific differences in answers between pre- and post-survey answers

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References

- Provide literature you refer to throughout this lesson.

Thanks!

See you next class :)

Pedagogical add-on tools for instructors

- This section is dedicated to ideas on how to incorporate pedagogical tools into teaching for this specific submodule topic. This could mean:
  - Information about the scientific evidence on the theory of the pedagogical add-on tool and the evidence for its efficacy.
  - Discussion/reflection on how tools can be incorporated into the teaching for this particular content.
  - Extra exercises for faster students.

Additional literature for instructors

- References for content
- References for pedagogical add-on tools

- Other resources (videos etc.)

Figure with caption

- Centered image and caption below in italics

This is a Penguin.

Figure with bullet points

- First bullet point
- Second bullet point
- Third bullet point

Side-by-side figures

Stacked figures with text

- First bullet point
- Second bullet point
- Third bullet point

Two-column text slide

Column 1

Lorem ipsum dolor sit amet, consectetur adipiscing elit.
Vivamus lacinia odio vitae vestibulum vestibulum.
Cras venenatis euismod malesuada.

Column 2

Sed do eiusmod tempor incididunt ut labore et dolore magna aliqua.
Ut enim ad minim veniam, quis nostrud exercitation ullamco laboris.

Three-column text slide

Column 1

Lorem ipsum dolor sit amet, consectetur adipiscing elit.
Vivamus lacinia odio vitae vestibulum vestibulum.

Column 2

Sed do eiusmod tempor incididunt ut labore et dolore magna aliqua.
Ut enim ad minim veniam, quis nostrud exercitation ullamco laboris.

Column 3

Duis aute irure dolor in reprehenderit in voluptate velit esse cillum dolore eu fugiat nulla pariatur.

Simple table

Column 1	Column 2	Column 3
Row 1 Cell	Row 1 Cell	Row 1 Cell
Row 2 Cell	Row 2 Cell	Row 2 Cell
Row 3 Cell	Row 3 Cell	Row 3 Cell
Row 4 Cell	Row 4 Cell	Row 4 Cell

Complex table

Column 1	Column 2	Column 3
Row 1 Cell	Row 1 Cell	Row 1 Cell
Row 2 Cell	Row 2 Cell	Row 2 Cell
Row 3 Cell	Row 3 Cell	Row 3 Cell
Row 4 Cell	Row 4 Cell	Row 4 Cell

Task list

- ☒ Done
- ☐ To do

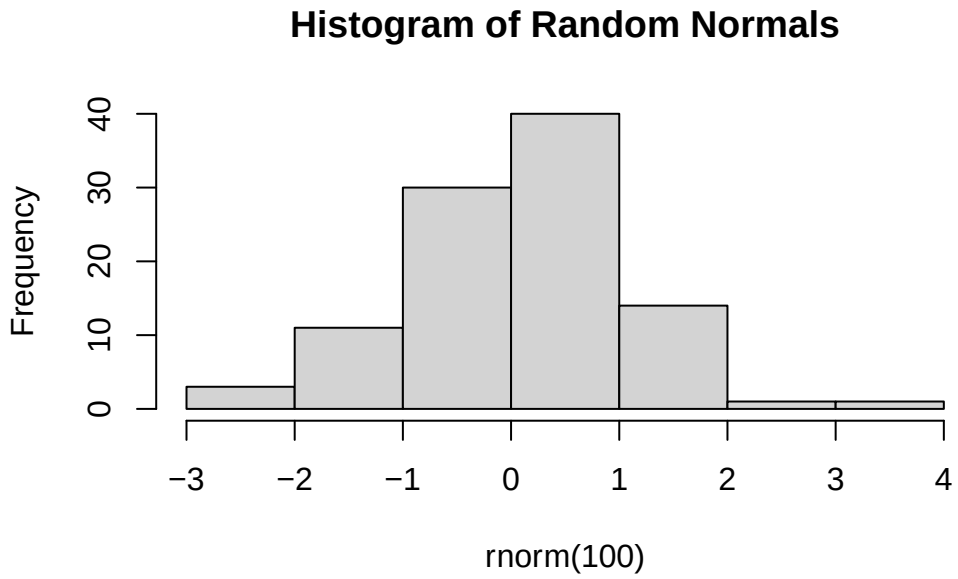
Embedding videos

Code blocks

```r
# A basic R code chunk
x <- 1:10
mean(x)
```

```
[1] 5.5
```

```r
# A simple plot
hist(rnorm(100), main = "Histogram of Random Normals")
```



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  - **only** if they attribute the creator and also share their new work under the **same terms**
  - allows for both **commercial and non-commercial** use of the licensed material
- Components of attributions:
  - `Title`
  - `Author`
  - `Source`

```
- License
```

Example attribution (for previous slide)

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