Communicating Results

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ATLAS
Accessible Teaching, Learning, and Assessment Systems

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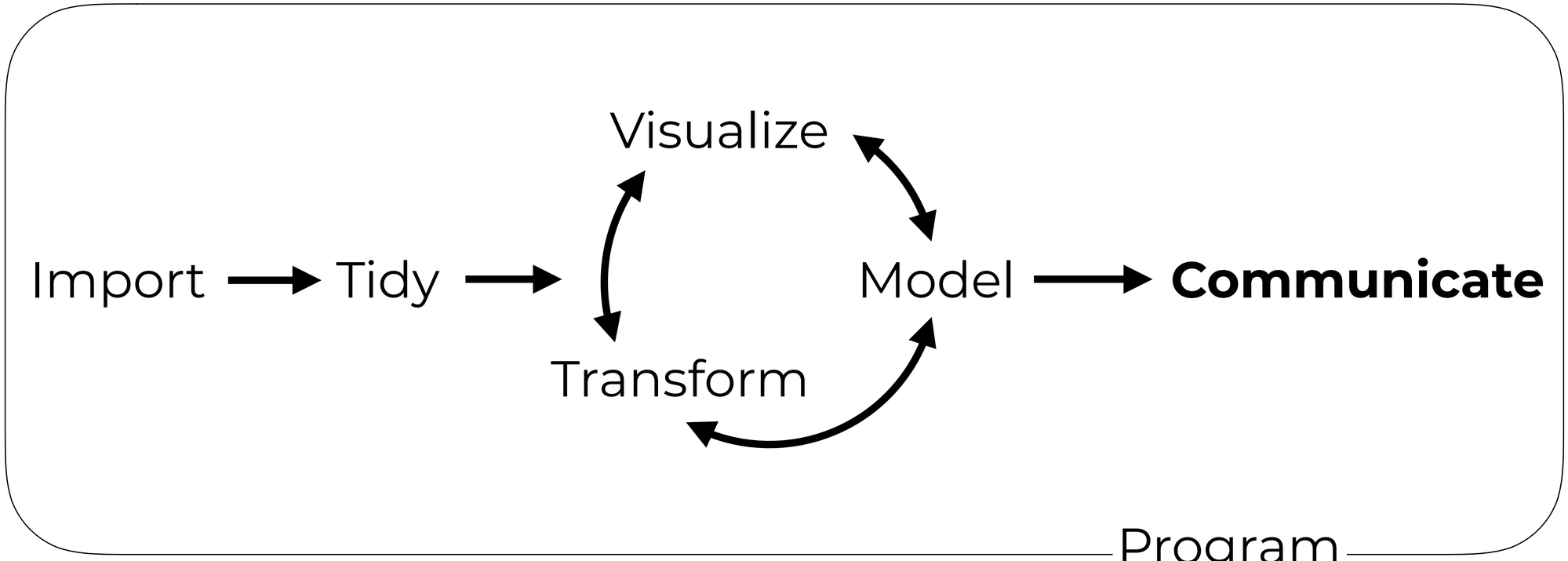

Adapted from Master the Tidyverse, CC BY RStudio

Consider

- What is the definition of a reproducible data analysis?
- What tools can you use to make a data analysis reproducible?

Reproducibility

- Are tables and figures reproducible from the code and data?
- Does the code do what you think it does?
- Is it clear **why** things were done?
- Can the code be used for other data?

From *Steps to Reproducible Research*, Karl Broman

In R4DS

R Markdown

ATLAS

Markdown

- Lightweight markup language with plain text formatting syntax
- Designed to be converted to HTML (and other formats, e.g. PDF)

```
This is the repo for *"Using R and the tidyverse for Data Science"*
given at the 2019 Summer Statistical Institute in May 2019.

## Description

This workshop is designed for those who want to learn how to use R to
analyze data. The material is based on Hadley Wickham and Garrett
Grolemund's [*R for Data Science*](https://r4ds.had.co.nz/index.html).
We'll talk about how to conduct a complete data analysis from data
import to final reporting in R using a suite of packages known as the
[**tidyverse**](https://tidyverse.org). The two goals of this workshop
are: 1) learn how to use R to answer questions about our data; and 2)
write code that is human readable and reproducible. We will also talk
about how to share our code and analyses with others.

## Software Requirements

In order to install the workshop materials (e.g., slides, exercises),
you'll need **a laptop that can access the internet** (wifi will be
available). Before the workshop, install the following:

1.  A recent version of R (~3.6.0), which is available for free at
    [cran.r-project.org](http://www.cran.r-project.org)
2.  A recent version of RStudio IDE (~1.2.1335), available for free at
    [www.rstudio.com/download](http://www.rstudio.com/download)
3.  The set of relevant R packages, which you can install by connecting
    to the internet, opening RStudio, and running the code in `setup.R`.

```

README.md

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Description

This workshop is designed for those who want to learn how to use R to analyze data. The material is based on Hadley Wickham and Garrett Grolemund's *R for Data Science*. We'll talk about how to conduct a complete data analysis from data import to final reporting in R using a suite of packages known as the **tidyverse**. The two goals of this workshop are: 1) learn how to use R to answer questions about our data; and 2) write code that is human readable and reproducible. We will also talk about how to share our code and analyses with others.

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3. The set of relevant R packages, which you can install by connecting to the internet, opening RStudio, and running the code in `setup.R`.

More detailed instructions can be found on the workshop website. Don't forget to bring your power cord!

R Markdown

- Markdown + R
- Text + R code (in chunks) gets converted to text + R code + R output
- 3 types of content:
  - YAML header surrounded by ---
  - R code chunks surrounded by ```
  - Text with markdown formatting

Markdown Formatting

Text and Headers

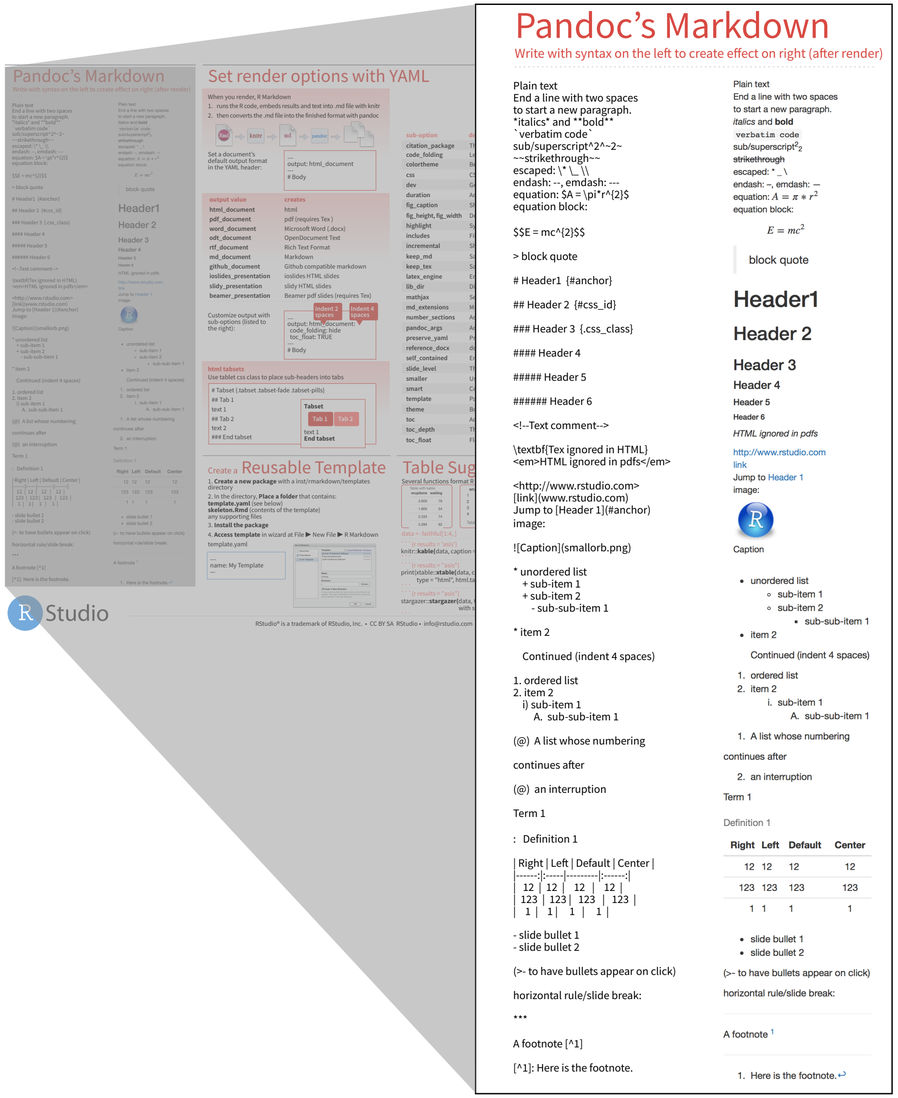
- Text can be `plain`, `*italic*`, `**bold**`, or `` `code` ``
- Headers use #

```
# Header 1
## Header 2
### Header 3
```

Links

- Plain web address, or custom phrase
  - `https://tidy-ds.wjakethompson.com`
  - `[Workshop Website](https://tidy-ds.wjakethompson.com)`
- Images from the web or local
  - `![RStudio logo](https://www.rstudio.com/wp-content/uploads/2018/10/RStudio-Logo-Flat.png)`
  - `![RStudio logo](resources/rstudio-logo.png)`

Alt text



Pandoc's Markdown

Write with syntax on the left to create effect on right (after render)

```
Plain text
End a line with two spaces
to start a new paragraph.
*italics* and **bold**
`verbatim code`
sub/superscript^2^~2~
~~strikethrough~~
escaped: \* \_ \\
endash: --, emdash: ---
equation: $A = \pi*r^{2}$
equation block:

$$E = mc^{2}$$

> block quote

# Header1  {#anchor}

## Header 2  {#css_id}

### Header 3  {.css_class}

#### Header 4

##### Header 5

###### Header 6

<!--Text comment-->

\textbf{Tex ignored in HTML}
<em>HTML ignored in pdfs</em>

<http://www.rstudio.com>
[link](www.rstudio.com)
Jump to [Header 1](#anchor)
image:

![Caption](smallorb.png)

* unordered list
  + sub-item 1
  + sub-item 2
    - sub-sub-item 1

* item 2

  Continued (indent 4 spaces)

1. ordered list
2. item 2
   i) sub-item 1
      A. sub-sub-item 1

(@)  A list whose numbering

continues after

(@)  an interruption

Term 1

:  Definition 1

| Right | Left | Default | Center |
|------:|:-----|---------|:------:|
|  12 |  12 |  12 |  12 |
| 123 | 123 | 123 | 123 |
|   1 |   1 |   1 |   1 |

- slide bullet 1
- slide bullet 2

(>- to have bullets appear on click)

horizontal rule/slide break:

***

A footnote [^1]

[^1]: Here is the footnote.
```

Plain text
End a line with two spaces
to start a new paragraph.
italics and **bold**
`verbatim code`
sub/superscript^2~2~
~~strikethrough~~
escaped: * _ \
endash: –, emdash: —
equation: $A = \pi * r^2$
equation block:

$$E = mc^2$$

> block quote

Header1

Header 2

Header 3

Header 4

Header 5

Header 6

- unordered list
  - sub-item 1
  - sub-item 2
    - sub-sub-item 1
- item 2

  Continued (indent 4 spaces)

1. ordered list
2. item 2
   i. sub-item 1
      A. sub-sub-item 1

(@) A list whose numbering

continues after

(@) an interruption

Term 1

Definition 1

Right	Left	Default	Center
12	12	12	12
123	123	123	123
1	1	1	1

- slide bullet 1
- slide bullet 2

(>- to have bullets appear on click)

horizontal rule/slide break:

A footnote [1]

1. Here is the footnote. ↩

R Markdown Reference Guide

Learn more about R Markdown at rmarkdown.rstudio.com
Learn more about Interactive Docs at shiny.rstudio.com/articles

Contents:
1. **Markdown Syntax**
2. Knitr chunk options
3. Pandoc options

Syntax	Becomes
`Plain text`	Plain text
`End a line with two spaces to start a new paragraph.`	End a line with two spaces to start a new paragraph.
`*italics* and _italics_`	*italics* and *italics*
`**bold** and __bold__`	**bold** and **bold**
`superscript^2^`	superscript^2
`~~strikethrough~~`	~~strikethrough~~
`[link](www.rstudio.com)`	link
`# Header 1`	Header 1
`## Header 2`	Header 2
`### Header 3`	Header 3
`#### Header 4`	Header 4
`##### Header 5`	Header 5
`###### Header 6`	Header 6
`endash: --`	endash: –
`emdash: ---`	emdash: —
`ellipsis: ...`	ellipsis: …
`inline equation: $A = \pi*r^{2}$`	inline equation: $A = \pi * r^2$
`image: ![](path/to/smallorb.png)`	image:
`horizontal rule (or slide break):`	horizontal rule (or slide break):
`***`	
`> block quote`	> block quote

`* unordered list`
`* item 2`
`  + sub-item 1`
`  + sub-item 2`
	• unordered list
	• item 2
	  ◦ sub-item 1
	  ◦ sub-item 2

`1. ordered list`
`2. item 2`
`  + sub-item 1`
`  + sub-item 2`
	1. ordered list
	2. item 2
	  ◦ sub-item 1
	  ◦ sub-item 2

`Table Header | Second Header`
`---|---`
`Table Cell | Cell 2`
`Cell 3 | Cell 4`
	Table Header / Second Header
	Table Cell / Cell 2
	Cell 3 / Cell 4

RStudio Updated 10/30/2014 © 2014 RStudio, Inc. CC BY RStudio.

1

RStudio:

Help → Markdown Quick Reference

Your Turn 1

- Open the **tidyds-2019.Rproj** project
- File > New File > R Markdown...
- Adjust the title, author, ...
- Add an image or equation
- Save your document as **11-Communicate/my-first-rmd.Rmd**
- Compile document to HTML

05 : 00

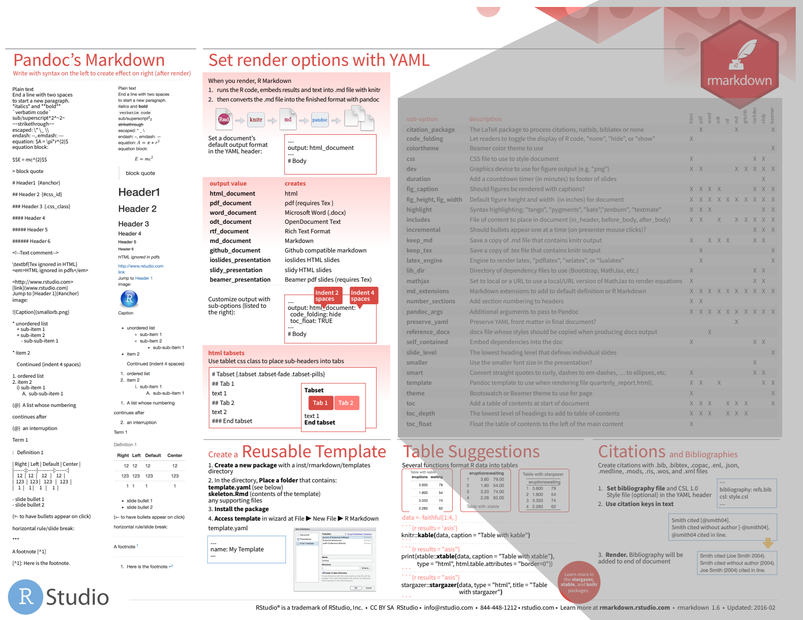
YAML

Customize Output

```
---
title: "Communicate - Solution"
author: "Jake Thompson"
date: "`r Sys.Date()`"
output: html_document
---
```

Customize Output

```
---
title: "Communicate - Solution"
author: "Jake Thompson"
date: "`r Sys.Date()`"
output:
  html_document:
    number_sections: true
    toc: true
---
```



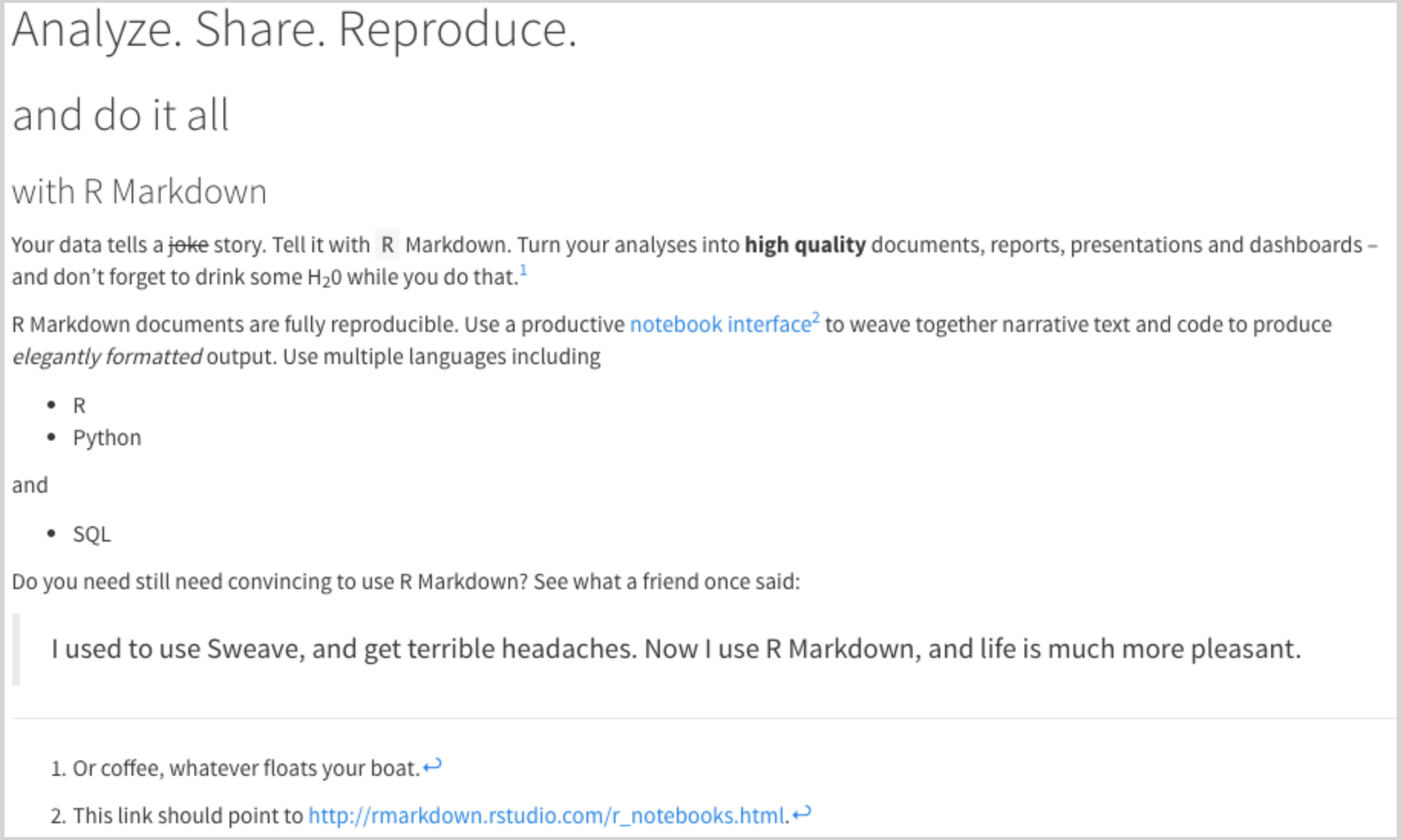
sub-option	description	html	pdf	word	odt	rtf	md	gituhb	ioslides	slidy	beamer
citation_package	The LaTeX package to process citations, natbib, biblatex or none		X				X				X
code_folding	Let readers to toggle the display of R code, "none", "hide", or "show"	X									
colortheme	Beamer color theme to use										X
css	CSS file to use to style document	X							X	X	
dev	Graphics device to use for figure output (e.g. "png")	X	X				X	X	X	X	X
duration	Add a countdown timer (in minutes) to footer of slides									X	
fig_caption	Should figures be rendered with captions?	X	X	X	X				X	X	X
fig_height, fig_width	Default figure height and width (in inches) for document	X	X	X	X	X	X	X	X	X	X
highlight	Syntax highlighting: "tango", "pygments", "kate","zenburn", "textmate"	X	X	X					X	X	
includes	File of content to place in document (in_header, before_body, after_body)	X	X		X		X	X	X	X	X
incremental	Should bullets appear one at a time (on presenter mouse clicks)?								X	X	X
keep_md	Save a copy of .md file that contains knitr output	X		X	X	X			X	X	
keep_tex	Save a copy of .tex file that contains knitr output		X								X
latex_engine	Engine to render latex, "pdflatex", "xelatex", or "lualatex"		X								X
lib_dir	Directory of dependency files to use (Bootstrap, MathJax, etc.)	X							X	X	
mathjax	Set to local or a URL to use a local/URL version of MathJax to render equations	X							X	X	
md_extensions	Markdown extensions to add to default definition or R Markdown	X	X	X	X	X	X	X	X	X	X
number_sections	Add section numbering to headers	X	X						X		
pandoc_args	Additional arguments to pass to Pandoc	X	X	X	X	X	X	X	X	X	X
preserve_yaml	Preserve YAML front matter in final document?						X				
reference_docx	docx file whose styles should be copied when producing docx output			X							
self_contained	Embed dependencies into the doc	X							X	X	
slide_level	The lowest heading level that defines individual slides										X
smaller	Use the smaller font size in the presentation?								X		
smart	Convert straight quotes to curly, dashes to em-dashes, … to ellipses, etc.	X							X	X	
template	Pandoc template to use when rendering file quarterly_report.html).	X	X		X					X	X
theme	Bootswatch or Beamer theme to use for page	X									X
toc	Add a table of contents at start of document	X	X	X		X	X	X			X
toc_depth	The lowest level of headings to add to table of contents	X	X	X		X	X	X			
toc_float	Float the table of contents to the left of the main content	X									

Your Turn 2

- Edit the YAML for **11-Communicate/my-first-rmd.Rmd**
- Add a table of contents
- Change the theme to **darkly**

```
---
...
output:
  html_document:
    toc: true
    theme: "darkly"
---
```

Your Turn 3



Analyze. Share. Reproduce.

and do it all

with R Markdown

Your data tells a ~~joke~~ story. Tell it with `R` Markdown. Turn your analyses into **high quality** documents, reports, presentations and dashboards – and don't forget to drink some H_20 while you do that.[1]

R Markdown documents are fully reproducible. Use a productive notebook interface[2] to weave together narrative text and code to produce *elegantly formatted* output. Use multiple languages including

- R
- Python

and

- SQL

Do you need still need convincing to use R Markdown? See what a friend once said:

> I used to use Sweave, and get terrible headaches. Now I use R Markdown, and life is much more pleasant.

1. Or coffee, whatever floats your boat. ↩
2. This link should point to http://rmarkdown.rstudio.com/r_notebooks.html. ↩

- Open **11-Communicate/analyze-share-repro.Rmd**
- Add styling to the text to create the look on the left.

10 : 00

Putting the R in R Markdown

Run R code inside Markdown

- Code chunks
  - Most powerful
  - Control over computations
  - Handles plots and other non-text output
- Inline code
  - Simple, but only handles text
  - Character strings (including Markdown formatting)
  - Numbers (but not vectors)

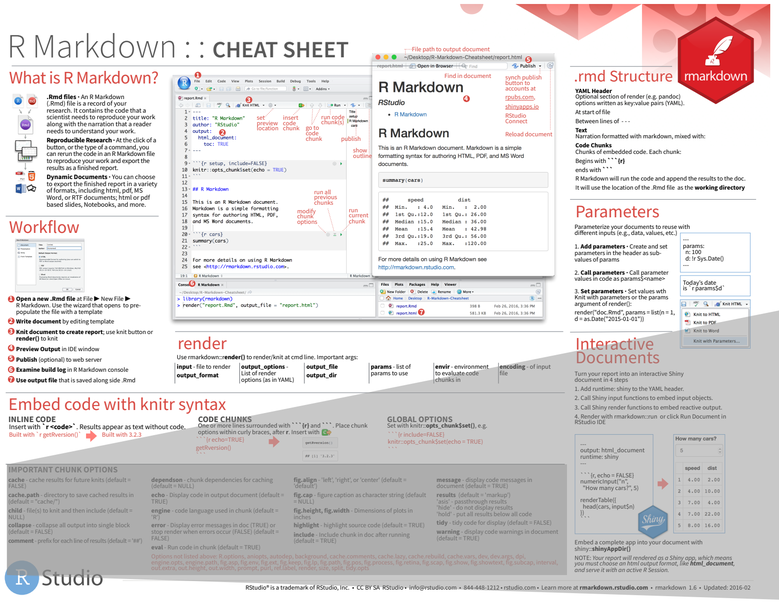
Code chunks

- "Fenced" regions of code
- When report is rendered:
  - Each code chunk is run
  - Output placed directly beneath the code chunk
- Insert new chunks with:
  - *Add Chunk* button in toolbar
  - Keyboard shortcut:
    - Mac: **Cmd** + **option** + **I**
    - Windows: **Ctrl** + **Alt** + **I**

Chunk options

Control how the chunk is displayed

- Should the code display? Or just the output?
- Include errors and warnings?
- How should figures be rendered?



IMPORTANT CHUNK OPTIONS

cache - cache results for future knits (default = FALSE)

cache.path - directory to save cached results in (default = "cache/")

child - file(s) to knit and then include (default = NULL)

collapse - collapse all output into single block (default = FALSE)

comment - prefix for each line of results (default = '##')

dependson - chunk dependencies for caching (default = NULL)

echo - Display code in output document (default = TRUE)

engine - code language used in chunk (default = 'R')

error - Display error messages in doc (TRUE) or stop render when errors occur (FALSE) (default = FALSE)

eval - Run code in chunk (default = TRUE)

fig.align - 'left', 'right', or 'center' (default = 'default')

fig.cap - figure caption as character string (default = NULL)

fig.height, fig.width - Dimensions of plots in inches

highlight - highlight source code (default = TRUE)

include - Include chunk in doc after running (default = TRUE)

message - display code messages in document (default = TRUE)

results (default = 'markup')
'asis' - passthrough results
'hide' - do not display results
'hold' - put all results below all code

tidy - tidy code for display (default = FALSE)

warning - display code warnings in document (default = TRUE)

Options not listed above: R.options, aniopts, autodep, background, cache.comments, cache.lazy, cache.rebuild, cache.vars, dev, dev.args, dpi, engine.opts, engine.path, fig.asp, fig.env, fig.ext, fig.keep, fig.lp, fig.path, fig.pos, fig.process, fig.retina, fig.scap, fig.show, fig.showtext, fig.subcap, interval, out.extra, out.height, out.width, prompt, purl, ref.label, render, size, split, tidy.opts

Some normal text.

```{r make-plot, echo = FALSE, fig.align = "c"}
ggplot(mtcars, aes(mpg, disp)) +
  geom_point()
```

Some more plain text.

````
Some normal text.

```{r make-plot, echo = FALSE, fig.align = "c"}
ggplot(mtcars, aes(mpg, disp)) +
  geom_point()
```

te plain text.
````

Language engine

````
Some normal text.

```{r make-plot, echo = FALSE, fig.align = "c"}
ggplot(mtcars, aes(mpg, disp)) +
  geom_point()
```

Some normal text.
````

Language engine

Chunk label

````
Some normal text.

```{r make-plot, echo = FALSE, fig.align = "c"}
ggplot(mtcars, aes(mpg, disp)) +
  geom_point()
```

Some normal text.
````

Language engine

Chunk label

Chunk options

Inline code

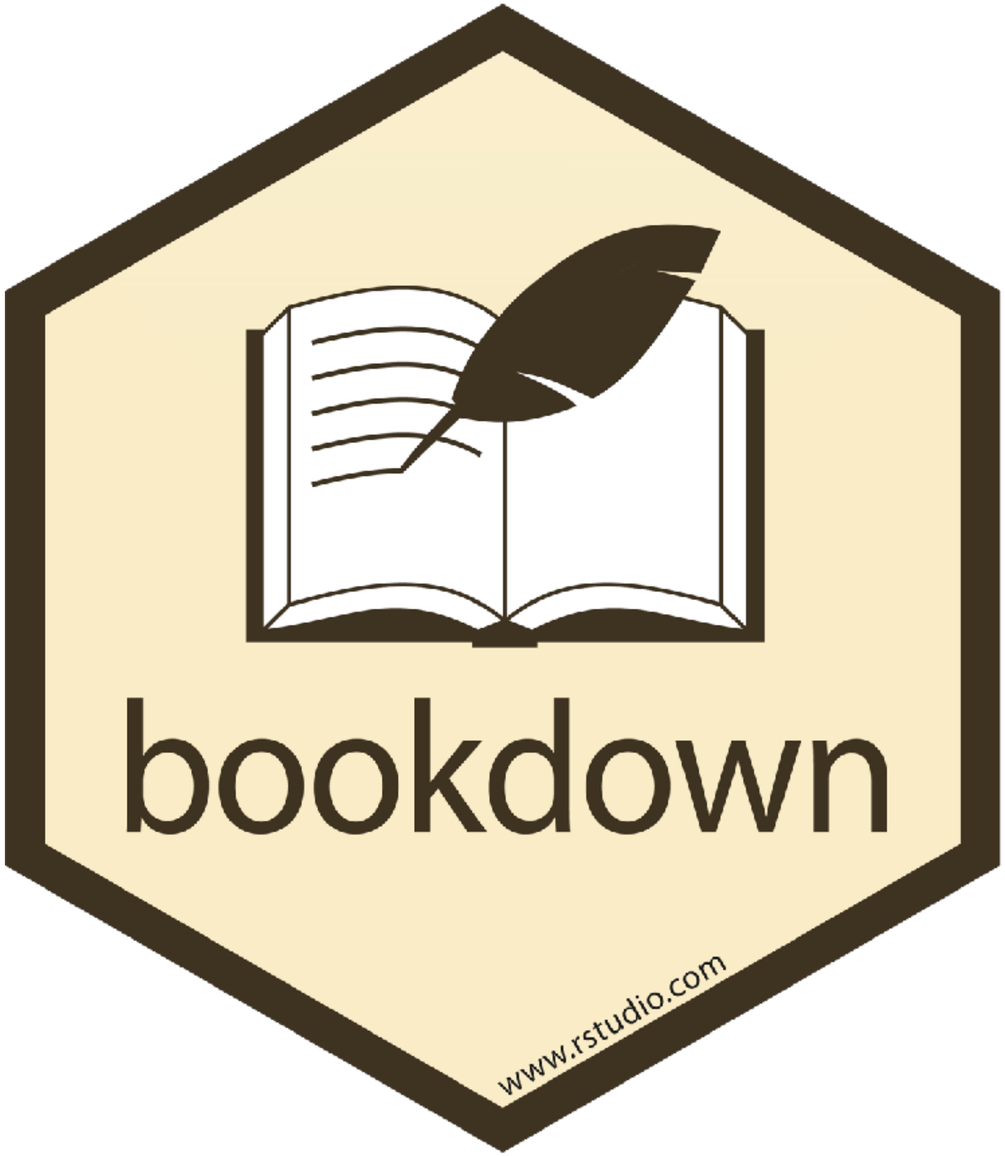
- Can be anywhere in your document... except a chunk
- Fenced with a single back tick `` `r contents` ``
- Uses current workspace

Your Turn 4

- Open **11-Communicate/chunk-basics.Rmd**
- Follow the numbered directions to add and modify code chunks and inline code.

05 : 00

Writing Reports with R Markdown


bookdown
www.rstudio.com

```
---
...
output:
  html_document:
    toc: true
    theme: "darkly"
---
```

```
---
...
output:
  bookdown::html_document2:
    toc: true
    theme: "darkly"
---
```

Case Study 2 Report

Your Turn 5

- Create a new R Markdown document.
- Title it "*Examing the Effect of Gender on Graduate Program Admission*" and add yourself as the author
- Make the date update automatically to today's date
- Change the output to **bookdown::html_document2**
- Save the file as **11-Communicate/case-study-2-report/case-study-2-report.Rmd**

Your Turn 6

Setup global options in the **setup** chunk

- Load the packages that we used in Case Study 2 + **knitr**, **hrbrthemes**, and **colorblindr**
- Set global chunk options inside **knitr::opts_chunk$set()**
  - Don't show code
  - Don't show **messages**, **warnings**, or **errors**
  - Save figure to **figures/**
  - Make all figures **8** inches wide with an aspect ratio of **0.618**
  - Align all pictures in the **center** and use **90%** of the output width

05 : 00

````
```{r setup, include = FALSE}
library(tidyverse)
library(broom)
library(rsample)
library(tidydscompanion)
library(knitr)
library(hrbrthemes)
library(colorblindr)

knitr::opts_chunk$set(
  echo = FALSE,
  message = FALSE,
  warning = FALSE,
  error = FALSE,
  fig.path = "figures/",
  fig.retina = 3,
  fig.width = 8,
  fig.asp = 0.618,
  fig.align = "center",
  out.width = "90%"
)
```
````

Your Turn 7

- Remove the boilerplate text from the document
- Add an introduction that describes the purpose of the report.

05 : 00

Citations and References

Citations are added to a **.bib** file

bib/references.bib

```
@book{gre,
  author = {{Educational Testing Service}},
  year = {2012},
  title = {The official guide to the {GRE} revised general test},
  edition = {2nd},
  address = {New York, NY},
  publisher = {McGraw-Hill},
  isbn = {9780071791236}
}
```

Citation key

```
@book{gre,
  author = {{Educational Testing Service}},
  year = {2012},
  title = {The official guide to the {GRE} revised general test},
  edition = {2nd},
  address = {New York, NY},
  publisher = {McGraw-Hill},
  isbn = {9780071791236}
}
```

syntax	renders as
`Blah blah [@gre].`	Blah blah (Educational Testing Service, 2012).
`ETS say blah [-@gre].`	ETS says blah (2012).
`@gre says blah.`	Educational Testing Service (2012) says blah.

More on citations here:
https://rmarkdown.rstudio.com/authoring_bibliographies_and_citations.html#citations

Example bib entries:
https://www.verbosus.com/bibtex-style-examples.html

```
---
...
bibliography: ["bib/references.bib"]
biblio-style: apalike2
csl: csl/apa.csl
link-citations: true
...
---
```

List of .bib files containing references

Bibliography style

Citation style guide

Citations include hyperlinks

Your Turn 8

- Update the YAML to include **bib/references.bib** as a bibliography
- Set **biblio-style** to "apalike2" and **csl** to "csl/apa.csl"
- Make citations have a hyper link

Where do the references appear?

Add a "References" heading.

Tables

```
kable(x, digits, col.names = NA, align, caption, format.args, ...)
```

- Data frame or matrix
- For numbers, how many digits to round to
- Column names for the table
- Column alignment
- Table caption
- Formatting options
- Additional arguments

```
kable(head(admission), digits = 1, align = "c",
      col.names = c("Decision", "Verbal", "Quant", "Writing", "GPA", "Gender"),
      caption = "A table of data", format.args = list(big.mark = ","),
      booktabs = TRUE)
```

Table 1: A table of data

Decision	Verbal	Quant	Writing	GPA	Gender
0	142	151	2.5	3.1	Female
0	148	140	2.5	3.4	Male
1	156	147	2.5	3.5	Male
0	154	152	4.0	3.3	Male
1	160	164	4.0	2.9	Male
1	154	164	3.5	3.1	Male

Look at those results in Table \@ref(tab:some-table)!

```{r some-table}
kable(head(admission), caption = "Here is a table")
```

It really is incredible!

Your Turn 9

- Add a "Data" section that describes the data and provides summary statistics
- Include a table of the median score on academic measures by gender

05 : 00

Equations

```
Let define the Log Loss in equation below.


$$
\text{LogLoss} = -\frac{1}{n}\sum_{i=1}^n[...]
$$
```

Equations

```
Let define the Log Loss in equation \@ref(eq:logloss).

\begin{equation}
  \text{LogLoss} = -\frac{1}{n}\sum_{i=1}^n[...]
  (\#eq:logloss)
\end{equation}
```

Cite your software!

```
```{r write-packages, include = FALSE}
if (!file.exists("bib/packages.bib")) file.create("bib/packages.bib")
if (!file.exists("bib/knit.bib")) file.create("bib/knit.bib")
suppressWarnings(
  knitr::write_bib(c("rmarkdown", "bookdown"), "bib/knit.bib")
)
suppressWarnings(
  knitr::write_bib(c(.packages()), "bib/packages.bib")
)
```
```

Then cite the package with @R-pkg.

Your Turn 10

- Add a methods section that describes what we did
- Include the equation for the Log Loss

$$\text{LogLoss} = -\frac{1}{n}\sum_{i=1}^{n}[y_i \log(\hat{y}_i) + (1 - y_i)\log(1 - \hat{y}_i)]$$

- Cite the relevant R packages we used

05 : 00

Figures

Include code for figures in their own chunk.

````
```{r figure, fig.cap = "Here is a figure!"}
ggplot() +
  ...
```
````

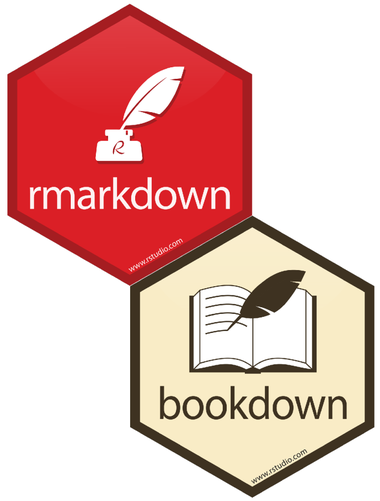
Add a **fig.cap** so the figure can be referenced with **\@ref(fig:figure)**

Your Turn 11

- Add a results section that include the analysis we did in Case Study 2
- Include each figure in its own chunk
- Reference the figures in the text

10 : 00

Communicating Results



ATLAS
Accessible Teaching, Learning, and Assessment Systems

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