Design of Data Analysis

January, 2023

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# About this Course

The concept of reproducibility of a scientific investigation is most directly connected to the analysis of the data. Therefore, this course provides an overview of the structure of a data analysis and how to design an analysis to maximize the potential for reproducibility by research team members and by others. A key premise of this course is that reproducibility failure is often a consequence of poorly specified data analyses and a lack of understanding of the primary goal of the analysis by key stakeholders. The idea that “prevention is the best medicine” underlies this module, as proper design, structure, and execution of data analyses can prevent problems further downstream. We will therefore cover key analytic design concepts such as analytic iteration, analysis requirements and expectation setting, and unexpected outcomes and root causes.

## 0.1 Learning Objectives

1. Implement the basic analytic cycle of the sense-making process: setting expectations about the data, comparing results to expectations, diagnosing unexpected outcomes, hypothesizing explanations and alternatives, and revising our understanding of the data.
2. Given a problem statement, characterize the stakeholders for a data analysis and what they hope to obtain/learn from the analysis
3. Write a high-level description of final/key/primary outputs and measures of uncertainty to be produced by the analysis
4. Develop a summary of key assumptions or constraints concerning inputs, data, or other factors.
5. Develop a set of requirements/expectations for the analysis regarding the outputs
6. Identify key analytic and data processing choices in an analysis that may significantly affect outputs
7. Identify any unexpected outcomes for a given analysis plan
8. Apply techniques for identifying root causes of any unexpected outcomes produced by the analysis

## 0.2 References

## 0.3 Available course formats

This course is available in multiple formats which allows you to take it in the way that best suites your needs. You can take it for certificate which can be for free or fee.

* The material for this course can be viewed without login requirement on this [Bookdown website](LINK%20HERE). This format might be most appropriate for you if you rely on screen-reader technology.
* This course can be taken for [free certification through Leanpub](LINK%20HERE).
* This course can be taken on [Coursera for certification here](LINK%20HERE) (but it is not available for free on Coursera).
* Our courses are open source, you can find the [source material for this course on GitHub](LINK%20HERE).

# 1 Introduction

## 1.1 Motivation

## 1.2 Target Audience

The course is intended for …

## 1.3 Curriculum

The course covers…

devtools::session\_info()

## ─ Session info ───────────────────────────────────────────────────────────────  
## setting value   
## version R version 4.0.2 (2020-06-22)  
## os Ubuntu 20.04.3 LTS   
## system x86\_64, linux-gnu   
## ui X11   
## language (EN)   
## collate en\_US.UTF-8   
## ctype en\_US.UTF-8   
## tz Etc/UTC   
## date 2023-01-25   
##   
## ─ Packages ───────────────────────────────────────────────────────────────────  
## package \* version date lib source   
## assertthat 0.2.1 2019-03-21 [1] RSPM (R 4.0.3)   
## bookdown 0.24 2022-02-15 [1] Github (rstudio/bookdown@88bc4ea)   
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## yaml 2.2.1 2020-02-01 [1] RSPM (R 4.0.3)   
##   
## [1] /usr/local/lib/R/site-library  
## [2] /usr/local/lib/R/library

# 2 A new chapter

If you haven’t yet read the getting started Wiki pages; [start there](https://www.ottrproject.org/getting_started.html).

To see the rendered version of this chapter and the rest of the template, see here: <https://jhudatascience.org/OTTR_Template/>.

Every chapter needs to start out with this chunk of code:

## 2.1 Learning Objectives

Every chapter also needs Learning objectives that will look like this:

This chapter will cover:

* {You can use <https://tips.uark.edu/using-blooms-taxonomy/> to define some learning objectives here}
* {Another learning objective}

## 2.2 Libraries

For this chapter, we’ll need the following packages attached:

\*Remember to add [any additional packages you need to your course’s own docker image](https://github.com/jhudsl/OTTR_Template/wiki/Using-Docker#starting-a-new-docker-image).

library(magrittr)

## 2.3 Topic of Section

You can write all your text in sections like this, using ## to indicate a new header. you can use additional pound symbols to create lower levels of headers.

See [here](https://www.rstudio.com/wp-content/uploads/2015/02/rmarkdown-cheatsheet.pdf) for additional general information about how you can format text within R Markdown files. In addition, see [here](https://pandoc.org/MANUAL.html#pandocs-markdown) for more in depth and advanced options.

### 2.3.1 Subtopic

Here’s a subheading (using three pound symbols) and some text in this subsection!

## 2.4 Code examples

You can demonstrate code like this:

output\_dir <- file.path("resources", "code\_output")  
if (!dir.exists(output\_dir)) {  
 dir.create(output\_dir)  
}

And make plots too:

hist\_plot <- hist(iris$Sepal.Length)



You can also save these plots to file:

png(file.path(output\_dir, "test\_plot.png"))  
hist\_plot

## $breaks  
## [1] 4.0 4.5 5.0 5.5 6.0 6.5 7.0 7.5 8.0  
##   
## $counts  
## [1] 5 27 27 30 31 18 6 6  
##   
## $density  
## [1] 0.06666667 0.36000000 0.36000000 0.40000000 0.41333333 0.24000000 0.08000000  
## [8] 0.08000000  
##   
## $mids  
## [1] 4.25 4.75 5.25 5.75 6.25 6.75 7.25 7.75  
##   
## $xname  
## [1] "iris$Sepal.Length"  
##   
## $equidist  
## [1] TRUE  
##   
## attr(,"class")  
## [1] "histogram"

dev.off()

## png   
## 2

## 2.5 Image example

How to include a Google slide. It’s simplest to use the ottrpal package:



But if you have the slide or some other image locally downloaded you can also use HTML like this:

## 2.6 Video examples

You may also want to embed videos in your course. If alternatively, you just want to include a link you can do so like this:

Check out this [link to a video](https://www.youtube.com/embed/VOCYL-FNbr0) using markdown syntax.

### 2.6.1 Using knitr

To embed videos in your course, you can use knitr::include\_url() like this: Note that you should use echo=FALSE in the code chunk because we don’t want the code part of this to show up. If you are unfamiliar with [how R Markdown code chunks work, read this](https://rmarkdown.rstudio.com/lesson-3.html).

## PhantomJS not found. You can install it with webshot::install\_phantomjs(). If it is installed, please make sure the phantomjs executable can be found via the PATH variable.

### 2.6.2 Using HTML

## 2.7 File examples

You can again use simple markdown syntax to just include a link to a file like so:

[A file](https://www.bgsu.edu/content/dam/BGSU/center-for-faculty-excellence/docs/TLGuides/TLGuide-Learning-Objectives.pdf).

Alternatively you can embed files like PDFs.

### 2.7.1 Using knitr

### 2.7.2 Using HTML

## 2.8 Website Examples

Yet again you can use a link to a website like so:

[A Website](https://yihui.org)

You might want to have users open a website in a new tab by default, especially if they need to reference both the course and a resource at once.

[A Website](https://yihui.org)

Or, you can embed some websites.

### 2.8.1 Using knitr

This works:

### 2.8.2 Using HTML

If you’d like the URL to show up in a new tab you can do this:

<a href="https://www.linkedin.com" target="\_blank">LinkedIn</a>

## 2.9 Citation examples

We can put citations at the end of a sentence like this ([Allaire et al. 2021](#ref-rmarkdown2021)). Or multiple citations Xie, Allaire, and Grolemund ([2018](#ref-Xie2018)).

but they need a ; separator ([Allaire et al. 2021](#ref-rmarkdown2021); [Xie, Allaire, and Grolemund 2018](#ref-Xie2018)).

In text, we can put citations like this Allaire et al. ([2021](#ref-rmarkdown2021)).

## 2.10 Stylized boxes

Occasionally, you might find it useful to emphasize a particular piece of information. To help you do so, we have provided css code and images (no need for you to worry about that!) to create the following stylized boxes.

You can use these boxes in your course with either of two options: using HTML code or Pandoc syntax.

### 2.10.1 Using rmarkdown container syntax

The rmarkdown package allows for a different syntax to be converted to the HTML that you just saw and also allows for conversion to LaTeX. See the [Bookdown](https://bookdown.org/yihui/rmarkdown-cookbook/custom-blocks.html) documentation for more information ([Xie, Dervieux, and Riederer 2020](#ref-Xie2020)). Note that Bookdown uses Pandoc.

::: {.notice}  
Note using rmarkdown syntax.  
  
:::

Note using rmarkdown syntax.

As an example you might do something like this:

Please click on the subsection headers in the left hand navigation bar (e.g., 2.1, 4.3) a second time to expand the table of contents and enable the scroll\_highlight feature ([see more](introduction.html#scroll-highlight))

### 2.10.2 Using HTML

To add a warning box like the following use:

<div class = "notice">  
Followed by the text you want inside  
</div>

This will create the following:

Followed by the text you want inside

Here is a <div class = "warning"> box:

Note text

Here is a <div class = "github"> box:

GitHub text

Here is a <div class = "dictionary"> box:

dictionary text

Here is a <div class = "reflection"> box:

reflection text

## 2.11 Dropdown summaries

You can hide additional information in a dropdown menu

Here’s more words that are hidden.

## 2.12 Print out session info

You should print out session info when you have code for [reproducibility purposes](https://jhudatascience.org/Reproducibility_in_Cancer_Informatics/managing-package-versions.html).

devtools::session\_info()

## ─ Session info ───────────────────────────────────────────────────────────────  
## setting value   
## version R version 4.0.2 (2020-06-22)  
## os Ubuntu 20.04.3 LTS   
## system x86\_64, linux-gnu   
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## language (EN)   
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## curl 4.3 2019-12-02 [1] RSPM (R 4.0.3)   
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## fs 1.5.0 2020-07-31 [1] RSPM (R 4.0.3)   
## glue 1.6.1 2022-01-22 [1] CRAN (R 4.0.2)   
## highr 0.8 2019-03-20 [1] RSPM (R 4.0.3)   
## hms 0.5.3 2020-01-08 [1] RSPM (R 4.0.0)   
## htmltools 0.5.0 2020-06-16 [1] RSPM (R 4.0.1)   
## httr 1.4.2 2020-07-20 [1] RSPM (R 4.0.3)   
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## lifecycle 1.0.0 2021-02-15 [1] CRAN (R 4.0.2)   
## magrittr \* 2.0.2 2022-01-26 [1] CRAN (R 4.0.2)   
## memoise 1.1.0 2017-04-21 [1] RSPM (R 4.0.0)   
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## pkgload 1.1.0 2020-05-29 [1] RSPM (R 4.0.3)   
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## vctrs 0.3.4 2020-08-29 [1] RSPM (R 4.0.2)   
## webshot 0.5.2 2019-11-22 [1] RSPM (R 4.0.3)   
## withr 2.3.0 2020-09-22 [1] RSPM (R 4.0.2)   
## xfun 0.26 2022-02-15 [1] Github (yihui/xfun@74c2a66)   
## yaml 2.2.1 2020-02-01 [1] RSPM (R 4.0.3)   
##   
## [1] /usr/local/lib/R/site-library  
## [2] /usr/local/lib/R/library

# About the Authors

These credits are based on our [course contributors table guidelines](https://www.ottrproject.org/more_features.html#giving-credits-to-contributors).

| Credits | Names |
| --- | --- |
| **Pedagogy** |  |
| Lead Content Instructor(s) | [Roger Peng] |
| Lecturer(s) (include chapter name/link in parentheses if only for specific chapters) - make new line if more than one chapter involved | Delivered the course in some way - video or audio |
| Content Author(s) (include chapter name/link in parentheses if only for specific chapters) - make new line if more than one chapter involved | If any other authors besides lead instructor |
| Content Contributor(s) (include section name/link in parentheses) - make new line if more than one section involved | Wrote less than a chapter |
| Content Editor(s)/Reviewer(s) | Checked your content |
| Content Director(s) | Helped guide the content direction |
| Content Consultants (include chapter name/link in parentheses or word “General”) - make new line if more than one chapter involved | Gave high level advice on content |
| Acknowledgments | Gave small assistance to content but not to the level of consulting |
| **Production** |  |
| Content Publisher(s) | Helped with publishing platform |
| Content Publishing Reviewer(s) | Reviewed overall content and aesthetics on publishing platform |
| **Technical** |  |
| Course Publishing Engineer(s) | Helped with the code for the technical aspects related to the specific course generation |
| Template Publishing Engineers | [Candace Savonen](https://www.cansavvy.com/), [Carrie Wright](https://carriewright11.github.io/) |
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| Technical Publishing Stylists | [Carrie Wright](https://carriewright11.github.io/), [Candace Savonen](https://www.cansavvy.com/) |
| Package Developers ([ottrpal](https://github.com/jhudsl/ottrpal)) [Candace Savonen](https://www.cansavvy.com/), [John Muschelli](https://johnmuschelli.com/), [Carrie Wright](https://carriewright11.github.io/) |  |
| **Art and Design** |  |
| Illustrator(s) | Created graphics for the course |
| Figure Artist(s) | Created figures/plots for course |
| Videographer(s) | Filmed videos |
| Videography Editor(s) | Edited film |
| Audiographer(s) | Recorded audio |
| Audiography Editor(s) | Edited audio recordings |
| **Funding** |  |
| Funder(s) | Institution/individual who funded course including grant number |
| Funding Staff | Staff members who help with funding |

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# 3 References

Allaire, JJ, Yihui Xie, Jonathan McPherson, Javier Luraschi, Kevin Ushey, Aron Atkins, Hadley Wickham, Joe Cheng, Winston Chang, and Richard Iannone. 2021. *Rmarkdown: Dynamic Documents for r*. <https://github.com/rstudio/rmarkdown>.

Xie, Yihui, J. J. Allaire, and Garrett Grolemund. 2018. *R Markdown: The Definitive Guide*. Boca Raton, Florida: Chapman; Hall/CRC. <https://bookdown.org/yihui/rmarkdown>.

Xie, Yihui, Christophe Dervieux, and Emily Riederer. 2020. *R Markdown Cookbook*. Boca Raton, Florida: Chapman; Hall/CRC. <https://bookdown.org/yihui/rmarkdown-cookbook>.