# Best Practices for Teaching R

## A Randomized Controlled Trial

Lucy D'Agostino McGowan
@LucyStats

lucymcgowan.com/#talks

# Follow Along!

# learnr modules

participants will access 6 modules to teach data manipulation techniques. There will a pre-assessment mid-assessment, and post-assessment

1

# Goals

What are we trying to acheive? What are we trying to measure?

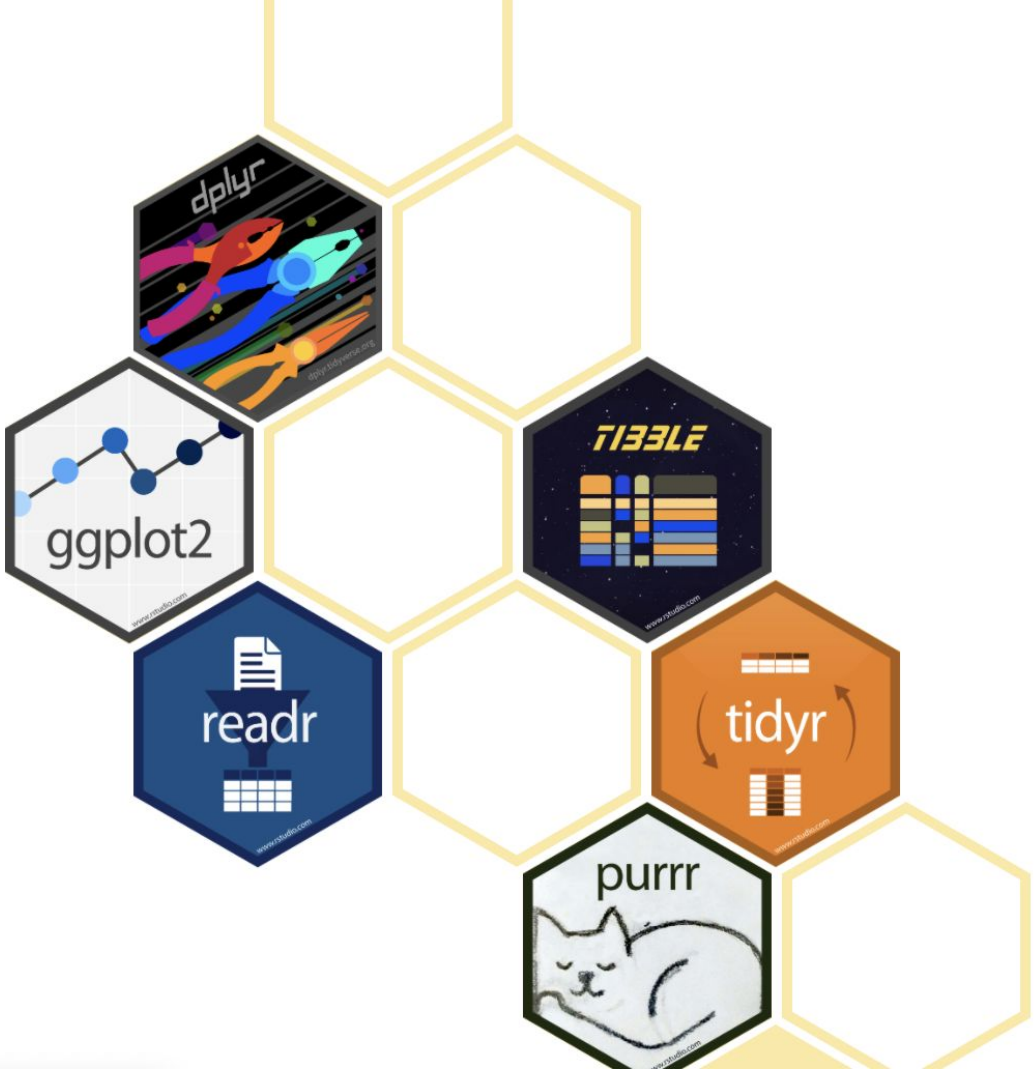
Assess whether there is a relationship between the **order** students learn R tools and their ability to complete common **data manipulation** tasks

Assess whether there is a relationship between the **order** students learn R tools and their ability to complete common **data manipulation** tasks

# Students will be randomized to learn

- ✓ tidyverse first
- ✓ base first

And then will **crossover** to see the other modality



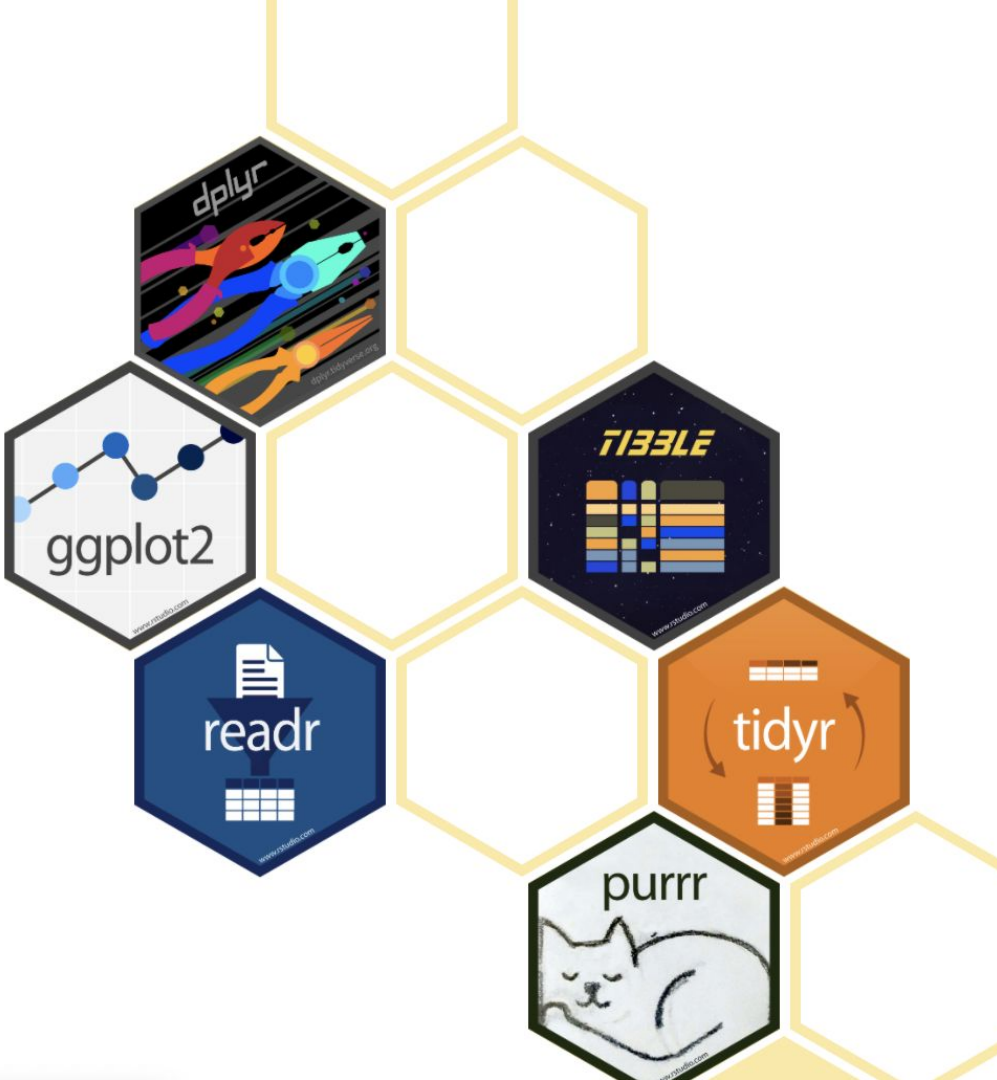

# tidyverse

a language for solving data science challenges with R code.

Wickham et al., (2019). Welcome to the Tidyverse. Journal of Open Source Software, 4(43), 1686, https://doi.org/10.21105/joss.01686

# tidyverse first

- ✓ tidy data frames and column types
- ✓ reading data into R
- ✓ data manipulation using **dplyr**



# The R Base Package

## base

the basic functions which let R function as a language: arithmetic, input/output, basic programming support, etc.

# base first

The R Base Package

- ✓ vectors, assignment, lists, and dataframes
- ✓ reading data into R
- ✓ data manipulation use **base** R

Assess whether there is a relationship between the **order** students learn R tools and their ability to complete common **data manipulation** tasks

# Learning objectives

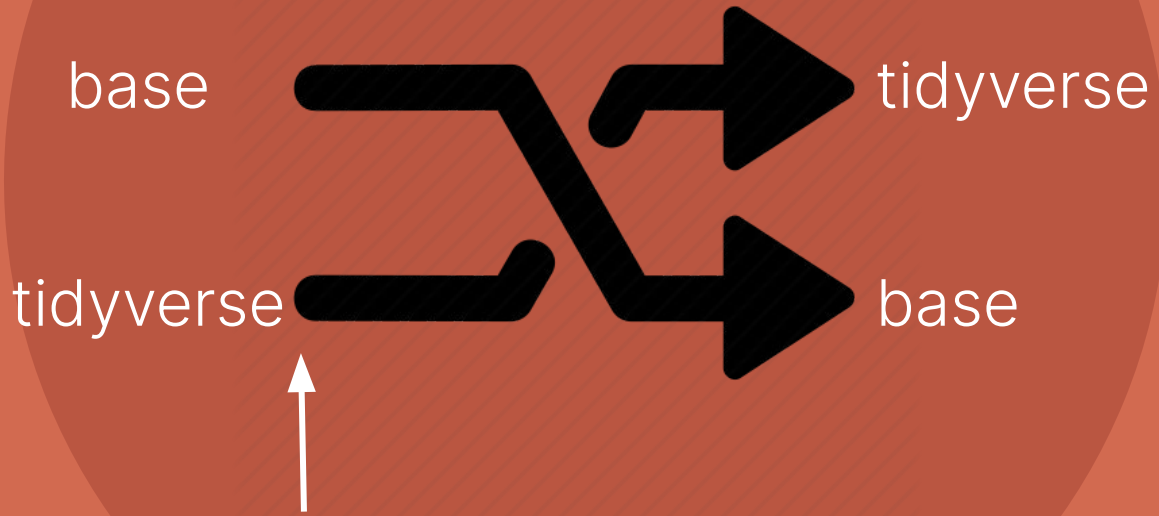
- ✓ Describe a data set
- ✓ Subset a data set by rows or columns
- ✓ Calculate summary statistics within groups

2

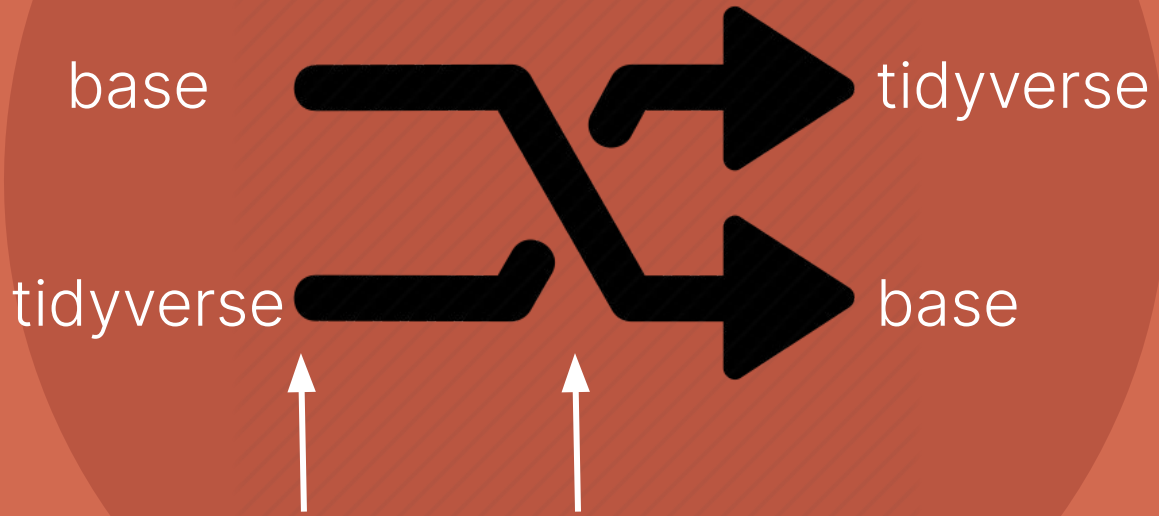
# Design

How did we do it?

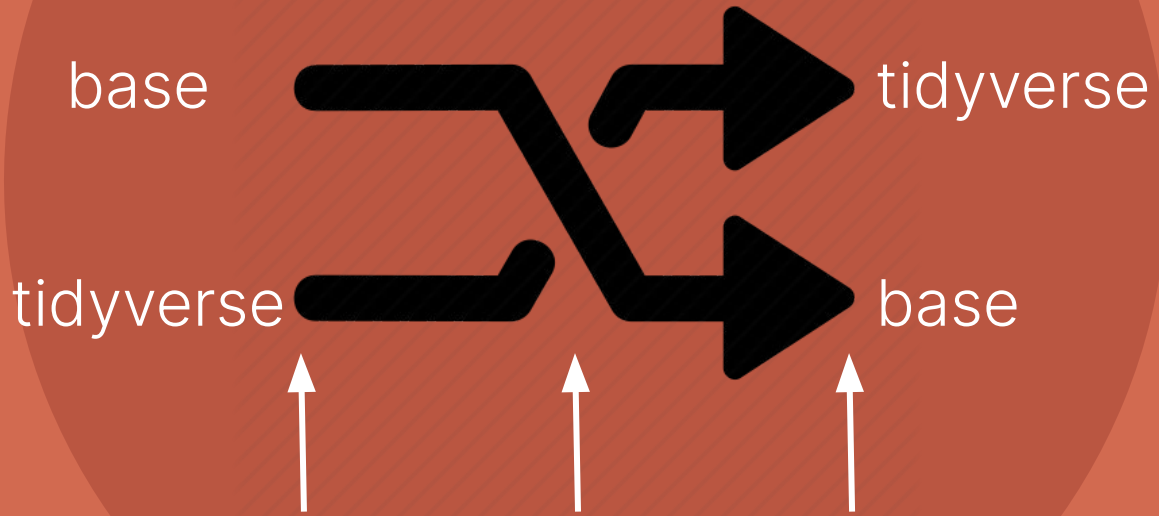

# Crossover randomized trial




# Crossover randomized trial




# Crossover randomized trial




# Crossover randomized trial


♫ SHINY ♫

# shiny

- ✓ Randomization
- ✓ Collecting data
- ✓ learnr modules

# LEARN R FROM THE COMFORT OF YOUR CONSOLE

We have created a six module course that introduces topics commonly used when conducting data analyses using R.

These modules were created as part of a research study examining best practices for learning R - after clicking on the link below, you can optionally opt into participating in this study

The first 150 participants who enroll in the study and complete the course will receive a $5 amazon gift card.

GET STARTED!

# INFORMED CONSENT

You are invited to participate in a research study being conducted at Wake Forest University. The purpose of the research is to examine best practices for teaching R programming. Your participation in the study will take about 1.5 hours.

Participation in this study involves:

- Completing a survey of demographic information
- Completing 6 modules on programming topics in R
- Completing 3 assessments: a pre-assessment to determine prior programming experience, a mid-assessment between the 3rd and 4th module, and a post-assessment at the completion of the 6th module

The order of the 6 modules will be randomized. The risks from participating in this study are not more than would be encountered in everyday life.

From participating in this study, I hope the study will help you learn R and help inform best practices for teaching R in the future.

The study team will take the following precautions to keep your information confidential. We will not collect or save any identifiable information. If you agree to enroll in this study, upon completion you may opt in to provide your email address to receive a gift certificate. Your email address will not be tied to your study responses.

Your participation in this study is voluntary; you can freely decide to participate in the research or not. If you decide to not participate, now or later, nothing bad will happen. You may choose to not answer any question(s) for any reason. To withdraw or drop out from the study at any time please email the primary investigator: Lucy D'Agostino McGowan at mcgowald@wfu.edu.

If you have any questions or concerns about this study, please contact: Lucy D'Agostino McGowan at mcgowald@wfu.edu

If you have questions about your rights as a research participant, contact the Office of Research and Sponsored Programs, (336) 758-5888, irb@wfu.edu. Please reference study "eIRB00023626" when contacting the IRB.

By clicking yes below, you attest that you are 18 or older, reside in the United States, and agree to participate in this research study. By selecting yes below, you will advance to the modules. If you select no, you will return to the homepage.

✔ Yes, I agree to this study | No, I do not agree to this study

Introduction to R | Home | Consent

# INFORMED CONSENT

You are invited to participate in a research study being conducted at Wake Forest University. The purpose of the research is to examine best practices for teaching R programming. Your participation in the study will take about 1.5 hours.

Participation in this study involves:

- Completing a survey of demographic information
- Completing 6 modules on programming topics in R
- Completing 3 assessments: a pre-assessment to determine prior programming experience, a mid-assessment between the 3rd and 4th module, and a post-assessment at the completion of the 6th module

The order of the 6 modules will be randomized. The risks from participating in this study are not more than would be encountered in everyday life.

From participating in this study, I hope the study will help you learn R and help inform best practices for teaching R in the future.

The study team will take the following precautions to keep your information confidential. We will not collect or save any identifiable information. If you agree to enroll in this study, upon completion you may opt in to provide your email address to receive a gift certificate. Your email address will not be tied to your study responses.

Your participation in this study is voluntary; you can freely decide to participate in the research or not. If you decide to not participate, now or later, nothing bad will happen. You may choose to not answer any question(s) for any reason. To withdraw or drop out from the study at any time please email the primary investigator: Lucy D'Agostino McGowan at mcgowald@wfu.edu.

If you have any questions or concerns about this study, please contact: Lucy D'Agostino McGowan at mcgowald@wfu.edu

If you have questions about your rights as a research participant, contact the Office of Research and Sponsored Programs, (336) 758-5888, irb@wfu.edu. Please reference study "eIRB00023626" when contacting the IRB.

randomizes!

By clicking yes below, you attest that you are 18 or older, reside in the United States, and agree to participate in this research study. By selecting yes below, you will advance to the modules. If you select no, you will return to the homepage.

✔ Yes, I agree to this study | No, I do not agree to this study

```
shinyApp(ui = ui, server = server)
```


shiny for randomization

```
shinyApp(ui = ui, server = server)
```


shiny for randomization

```r
server <- function(input, output) {
  output$random <- reactive({
    ifelse(runif(1) > 0.5, "A", "B")
  })
  outputOptions(output, "random", suspendWhenHidden = FALSE)
}
```


shiny for randomization

```
server <- function(input, output) {
  output$random <- reactive({
    ifelse(runif(1) > 0.5, "A", "B")
  })
  outputOptions(output, "random", suspendWhenHidden = FALSE)
}
```


shiny for randomization

```
server <- function(input, output) {
  output$random <- reactive({
    ifelse(runif(1) > 0.5, "A", "B")
  })
  outputOptions(output, "random", suspendWhenHidden = FALSE)
}
```


shiny for randomization

```
ui <- shinyUI(
      ...
       conditionalPanel(
         condition = "output.random == 'A'",
         actionButton(
           inputId = "yes",
           label = "Yes, I agree to this study",
           icon = icon("check"),
           onclick = "window.open('http://link-to-order-A.html')"
         ))
        ...
    )
```


shiny for randomization

```
ui <- shinyUI(
      ...
      conditionalPanel(
        condition = "output.random == 'A'",
        actionButton(
          inputId = "yes",
          label = "Yes, I agree to this study",
          icon = icon("check"),
          onclick = "window.open('http://link-to-order-A.html')"
        ))
        ...
    )
```


shiny for randomization

```
ui <- shinyUI(
      ...
       conditionalPanel(
         condition = "output.random == 'A'",
         actionButton(
           inputId = "yes",
           label = "Yes, I agree to this study",
           icon = icon("check"),
           onclick = "window.open('http://link-to-order-A.html')"
         ))
        ...
    )
```


shiny for randomization

```
ui <- shinyUI(
      ...
       conditionalPanel(
         condition = "output.random == 'A'",
         actionButton(
           inputId = "yes",
           label = "Yes, I agree to this study",
           icon = icon("check"),
           onclick = "window.open('http://link-to-order-A.html')"
         ))
        ...
    )
```


shiny for randomization

```
ui <- shinyUI(
      ...
       conditionalPanel(
         condition = "output.random == 'B'",
         actionButton(
           inputId = "yes",
           label = "Yes, I agree to this study",
           icon = icon("check"),
           onclick = "window.open('http://link-to-order-B.html')"
         ))
        ...
    )
```


shiny for randomization

Introduction to R | Home | Consent

# INFORMED CONSENT

You are invited to participate in a research study being conducted at Wake Forest University. The purpose of the research is to examine best practices for teaching R programming. Your participation in the study will take about 1.5 hours.

Participation in this study involves:

- Completing a survey of demographic information
- Completing 6 modules on programming topics in R
- Completing 3 assessments: a pre-assessment to determine prior programming experience, a mid-assessment between the 3rd and 4th module, and a post-assessment at the completion of the 6th module

The order of the 6 modules will be randomized. The risks from participating in this study are not more than would be encountered in everyday life.

From participating in this study, I hope the study will help you learn R and help inform best practices for teaching R in the future.

The study team will take the following precautions to keep your information confidential. We will not collect or save any identifiable information. If you agree to enroll in this study, upon completion you may opt in to provide your email address to receive a gift certificate. Your email address will not be tied to your study responses.

Your participation in this study is voluntary; you can freely decide to participate in the research or not. If you decide to not participate, now or later, nothing bad will happen. You may choose to not answer any question(s) for any reason. To withdraw or drop out from the study at any time please email the primary investigator: Lucy D'Agostino McGowan at mcgowald@wfu.edu.

If you have any questions or concerns about this study, please contact: Lucy D'Agostino McGowan at mcgowald@wfu.edu

If you have questions about your rights as a research participant, contact the Office of Research and Sponsored Programs, (336) 758-5888, irb@wfu.edu. Please reference study "eIRB00023626" when contacting the IRB.

randomizes!

By clicking yes below, you attest that you are 18 or older, reside in the United States, and agree to participate in this research study. By selecting yes below, you will advance to the modules. If you select no, you will return to the homepage.

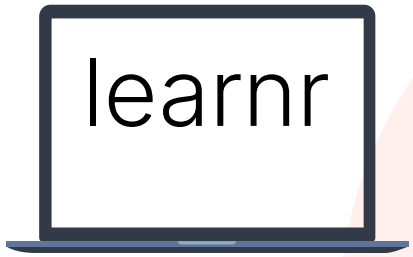
✔ Yes, I agree to this study | No, I do not agree to this study

# shiny

- ✓ Randomization
- ✓ Collecting data
- ✓ learnr modules

# shiny

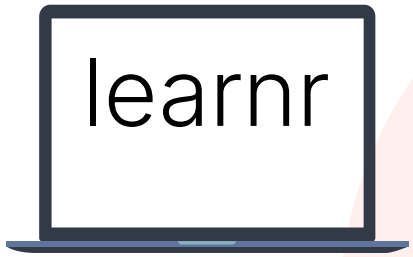
- ✓ Randomization
- ✓ Collecting data
- ✓ learnr modules





# Collecting data

- ✓ Demographic data
- ✓ Assessment data
- ✓ Exercise data
  - What mistakes did they make?
  - What did they skip?





# Collecting data

- ✓ Demographic data
- ✓ Assessment data
- ✓ Exercise data
  - What mistakes did they make?
  - What did they skip?





# Collecting data





**Note:**

Danny Kaplan has been working on a package called {**submitr**} using Google Sheets that I am very excited about: https://github.com/dtkaplan/submitr

outside the shiny app

```
library(rdrop2)

token <- drop_auth()
saveRDS(token, "droptoken.rds")

drop_auth(rdstoken = "droptoken.rds")
```

shiny + learnr + rdrop2 for data collection

inside the shiny app

```
library(rdrop2)

token <- drop_auth()
saveRDS(token, "droptoken.rds")

drop_auth(rdstoken = "droptoken.rds")
```

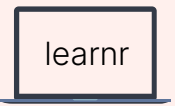
shiny + learnr + rdrop2 for data collection

# Collecting data

- ✓ Demographic data
- ✓ Assessment data
- ✓ Exercise data
  - What mistakes did they make?
  - What did they skip?

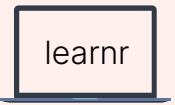


```
event_recorder <- function(tutorial_id,
                           tutorial_version,
                           user_id,
                           event,
                           data) {
  ...
  }
options(tutorial.event_recorder = event_recorder)
```



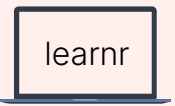

shiny + learnr + rdrop2 for data collection

```
event_recorder <- function(tutorial_id,
                           tutorial_version,
                           user_id,
                           event,
                           data) {
  ...
}
options(tutorial.event_recorder = event_recorder)
```



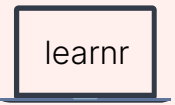

shiny + learnr + rdrop2 for data collection

```
event_recorder <- function(tutorial_id,
                           tutorial_version,
                           user_id,
                           event,
                           data) {
  ...
  }
options(tutorial.event_recorder = event_recorder)
```



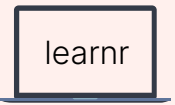

shiny + learnr + rdrop2 for data collection

```r
if (drop_exists(glue("teaching-r-study/data_{user_id}.rds"))) {
    drop_download(path = glue("teaching-r-study/data_{user_id}.rds"),
                  local_path = glue("data_{user_id}.rds"),
                  overwrite = TRUE)
    t <- readRDS(glue("data_{user_id}.rds"))
  } else {...}
     ...
}
```




shiny + learnr + rdrop2 for data collection

```
if (drop_exists(glue("teaching-r-study/data_{user_id}.rds"))) {
    drop_download(path = glue("teaching-r-study/data_{user_id}.rds"),
                  local_path = glue("data_{user_id}.rds"),
                  overwrite = TRUE)
    t <- readRDS(glue("data_{user_id}.rds"))
  } else {...}
     ...
}
```



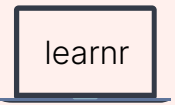

shiny + learnr + rdrop2 for data collection

```r
if (drop_exists(glue("teaching-r-study/data_{user_id}.rds"))) {
    drop_download(path = glue("teaching-r-study/data_{user_id}.rds"),
                  local_path = glue("data_{user_id}.rds"),
                  overwrite = TRUE)
    t <- readRDS(glue("data_{user_id}.rds"))
  } else {...}
    ...
}
```

learnr

shiny + learnr + rdrop2 for data collection

```
if (drop_exists(glue("teaching-r-study/data_{user_id}.rds"))) {
    drop_download(path = glue("teaching-r-study/data_{user_id}.rds"),
                  local_path = glue("data_{user_id}.rds"),
                  overwrite = TRUE)
    t <- readRDS(glue("data_{user_id}.rds"))
  } else {...}
      ...
}
```



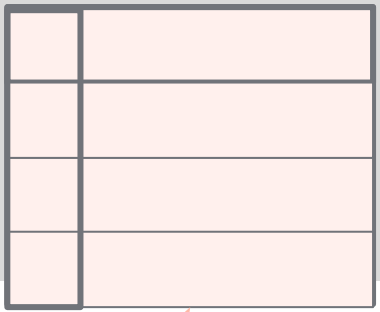

shiny + learnr + rdrop2 for data collection

```
if (drop_exists(glue("teaching-r-study/data_{user_id}.rds"))) {
    drop_download(path = glue("teaching-r-study/data_{user_id}.rds"),
                  local_path = glue("data_{user_id}.rds"),
                  overwrite = TRUE)
    t <- readRDS(glue("data_{user_id}.rds"))
  } else {...}
     ...
}
```

learnr

shiny + learnr + rdrop2 for data collection

```
if (drop_exists(glue("teaching-r-study/data_{user_id}.rds"))) {
    drop_download(path = glue("teaching-r-study/data_{user_id}.rds"),
                  local_path = glue("data_{user_id}.rds"),
                  overwrite = TRUE)
    t <- readRDS(glue("data_{user_id}.rds"))
  } else {...}
     ...
}
```

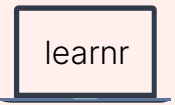


data frame, **t**

learnr

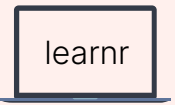
shiny + learnr + rdrop2 for data collection

```
if (drop_exists(glue("teaching-r-study/data_{user_id}.rds"))) {
    drop_download(path = glue("teaching-r-study/data_{user_id}.rds"),
                  local_path = glue("data_{user_id}.rds"),
                  overwrite = TRUE)
    t <- readRDS(glue("data_{user_id}.rds"))
  } else {...}
     ...
}
```



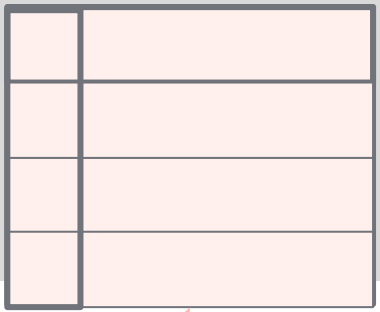

shiny + learnr + rdrop2 for data collection

```
if (drop_exists(glue("teaching-r-study/data_{user_id}.rds"))) {
    drop_download(path = glue("teaching-r-study/data_{user_id}.rds"),
                  local_path = glue("data_{user_id}.rds"),
                  overwrite = TRUE)
    t <- readRDS(glue("data_{user_id}.rds"))
  } else {...}
      ...
}
```




shiny + learnr + rdrop2 for data collection

```
else {
  t <- tibble(
      time = .POSIXct(numeric(0)),
      tutorial_id = character(),
      tutorial_version = character(),
      user_id = character(),
      event = character(),
      data = list())
}
```

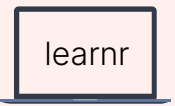


data frame, **t**

learnr

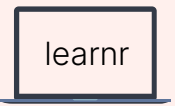
shiny + learnr + rdrop2 for data collection

```
if (drop_exists(glue("teaching-r-study/data_{user_id}.rds"))) {
    ...
 } else {
    ...
 }
    ...
}
```




shiny + learnr + rdrop2 for data collection

```
if (drop_exists(glue("teaching-r-study/data_{user_id}.rds"))) {
    ...
 } else {
    ...
 }
    ...
}
```



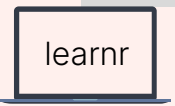

shiny + learnr + rdrop2 for data collection

```
 t <- bind_rows(t,
                tibble(
                  time = Sys.time(),
                  tutorial_id = tutorial_id,
                  tutorial_version = tutorial_version,
                  user_id = user_id,
                  event = event,
                  data = list(data))

)
saveRDS(t, file = glue("data_{user_id}.rds"))
drop_upload(file = glue("data_{user_id}.rds"),
            path = "teaching-r-study")
```

learnr

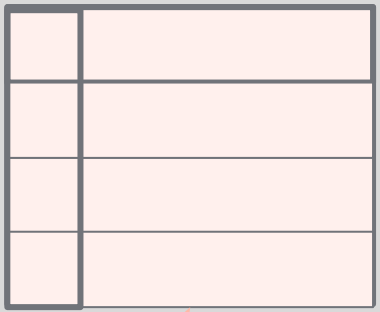
shiny + learnr + rdrop2 for data collection

```
 t <- bind_rows(t,
                tibble(
                  time = Sys.time(),
                  tutorial_id = tutorial_id,
                  tutorial_version = tutorial_version,
                  user_id = user_id,
                  event = event,
                  data = list(data))

)
saveRDS(t, file = glue("data_{user_id}.rds"))
drop_upload(file = glue("data_{user_id}.rds"),
            path = "teaching-r-study")
```




shiny + learnr + rdrop2 for data collection

```
 t <- bind_rows(t,
                tibble(
                  time = Sys.time(),
                  tutorial_id = tutorial_id,
                  tutorial_version = tutorial_version,
                  user_id = user_id,
                  event = event,
                  data = list(data))

)
saveRDS(t, file = glue("data_{user_id}.rds"))
drop_upload(file = glue("data_{user_id}.rds"),
            path = "teaching-r-study")
```

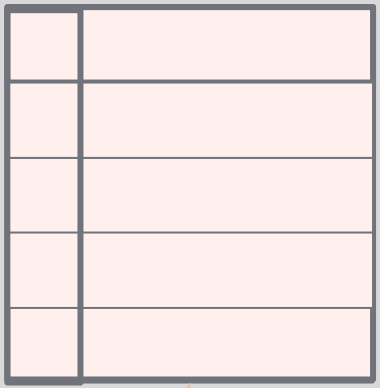


data frame, **t**

learnr

shiny + learnr + rdrop2 for data collection

```
 t <- bind_rows(t,
                tibble(
                  time = Sys.time(),
                  tutorial_id = tutorial_id,
                  tutorial_version = tutorial_version,
                  user_id = user_id,
                  event = event,
                  data = list(data))

)
saveRDS(t, file = glue("data_{user_id}.rds"))
drop_upload(file = glue("data_{user_id}.rds")
            path = "teaching-r-study")
```



learnr

shiny + learnr + rdrop2 for data collection

data frame, **t**

```
 t <- bind_rows(t,
                tibble(
                  time = Sys.time(),
                  tutorial_id = tutorial_id,
                  tutorial_version = tutorial_version,
                  user_id = user_id,
                  event = event,
                  data = list(data))

)
saveRDS(t, file = glue("data_{user_id}.rds"))
drop_upload(file = glue("data_{user_id}.rds"),
            path = "teaching-r-study")
```

learnr

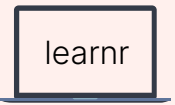
shiny + learnr + rdrop2 for data collection

```
  t <- bind_rows(t,
                 tibble(
                   time = Sys.time(),
                   tutorial_id = tutorial_id,
                   tutorial_version = tutorial_version,
                   user_id = user_id,
                   event = event,
                   data = list(data))

  )
  saveRDS(t, file = glue("data_{user_id}.rds"))
  drop_upload(file = glue("data_{user_id}.rds"),
              path = "teaching-r-study")
```

learnr

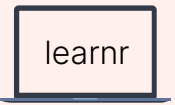
shiny + learnr + rdrop2 for data collection

```r
question_is_correct.always_correct <- function(question, value, ...) {
  return(mark_as(TRUE, message = NULL))
}
```




shiny + learnr + rdrop2 for data collection

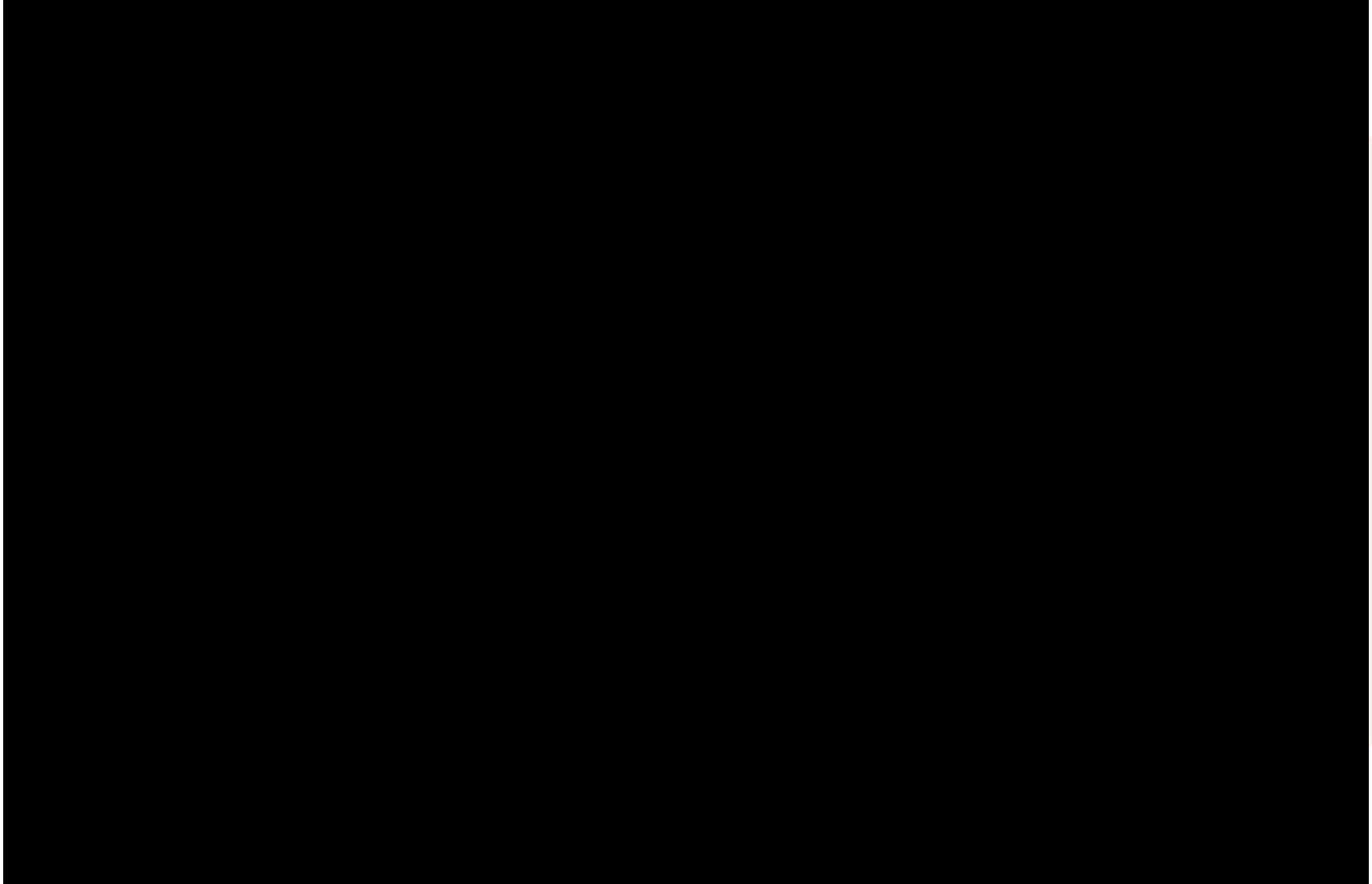
```
question(
  "This is your question?",
  answer("This is an answer..", correct = TRUE),
  type = c("always_correct", "radio_button"),
  correct = "Submitted")
```




shiny + learnr + rdrop2 for data collection

# What we have so far

A sneak peak at what the current pilot looks like



data frame, **t**

```
> head(data_lucymcgowan)
# A tibble: 6 x 6
  time                tutorial_id     tutorial_version user_id  event  data
  <dttm>              <chr>           <chr>            <chr>    <chr>  <lis>
1 2020-05-27 18:12:52 /Users/lucymcg… 1.0              lucymcg… exerc… <nam…
2 2020-05-27 18:12:57 /Users/lucymcg… 1.0              lucymcg… exerc… <nam…
3 2020-05-27 18:13:02 /Users/lucymcg… 1.0              lucymcg… exerc… <nam…
4 2020-05-27 18:13:07 /Users/lucymcg… 1.0              lucymcg… exerc… <nam…
5 2020-05-27 18:13:17 /Users/lucymcg… 1.0              lucymcg… exerc… <nam…
6 2020-05-28 10:39:19 /Users/lucymcg… 1.0              lucymcg… exerc… <nam…
```

data frame, **t**

```
> head(data_lucymcgowan)
# A tibble: 6 x 6
  time                tutorial_id     tutorial_version user_id  event  data
  <dttm>              <chr>           <chr>            <chr>    <chr>  <lis>
1 2020-05-27 18:12:52 /Users/lucymcg… 1.0              lucymcg… exerc… <nam…
2 2020-05-27 18:12:57 /Users/lucymcg… 1.0              lucymcg… exerc… <nam…
3 2020-05-27 18:13:02 /Users/lucymcg… 1.0              lucymcg… exerc… <nam…
4 2020-05-27 18:13:07 /Users/lucymcg… 1.0              lucymcg… exerc… <nam…
5 2020-05-27 18:13:17 /Users/lucymcg… 1.0              lucymcg… exerc… <nam…
6 2020-05-28 10:39:19 /Users/lucymcg… 1.0              lucymcg… exerc… <nam…
```

```
> data_lucymcgowan$data[[1]]
$label
[1] "vector"

$code
[1] "\n\nc(2,4,6,8)\n"

$output
<pre><code>[1] 2 4 6 8</code></pre>
<div class="alert alert-success" role="alert">Superb work!  </div>

$error_message
NULL

$checked
[1] TRUE

$feedback
```

```
> data_lucymcgowan$data[[1]]
$label
[1] "vector"

$code
[1] "\n\nc(2,4,6,8)\n"

$output
<pre><code>[1] 2 4 6 8</code></pre>
<div class="alert alert-success" role="alert">Superb work!  </div>

$error_message
NULL

$checked
[1] TRUE

$feedback
```

+

tidycode matahari

```
> data_lucymcgowan$data[[1]]$feedback

$feedback$message
Superb work!

$feedback$correct
[1] TRUE

$feedback$type
[1] "success"

$feedback$location
[1] "append"
```

# Thank you!

@LucyStats

lucymcgowan.com/#talks