# CIS 8398
# Advanced AI Topics in Business

## #Intro to R

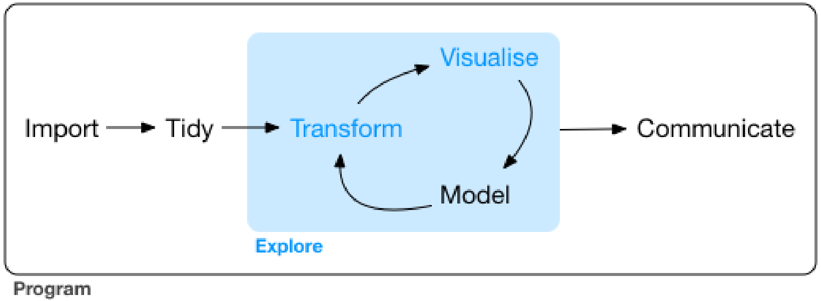
### Yu-Kai Lin

# About me (Yu-Kai Lin)

- Who am I?
- Where did I come from?
- What are my skills and expertise?
- What is my teaching philosophy?

# About this course

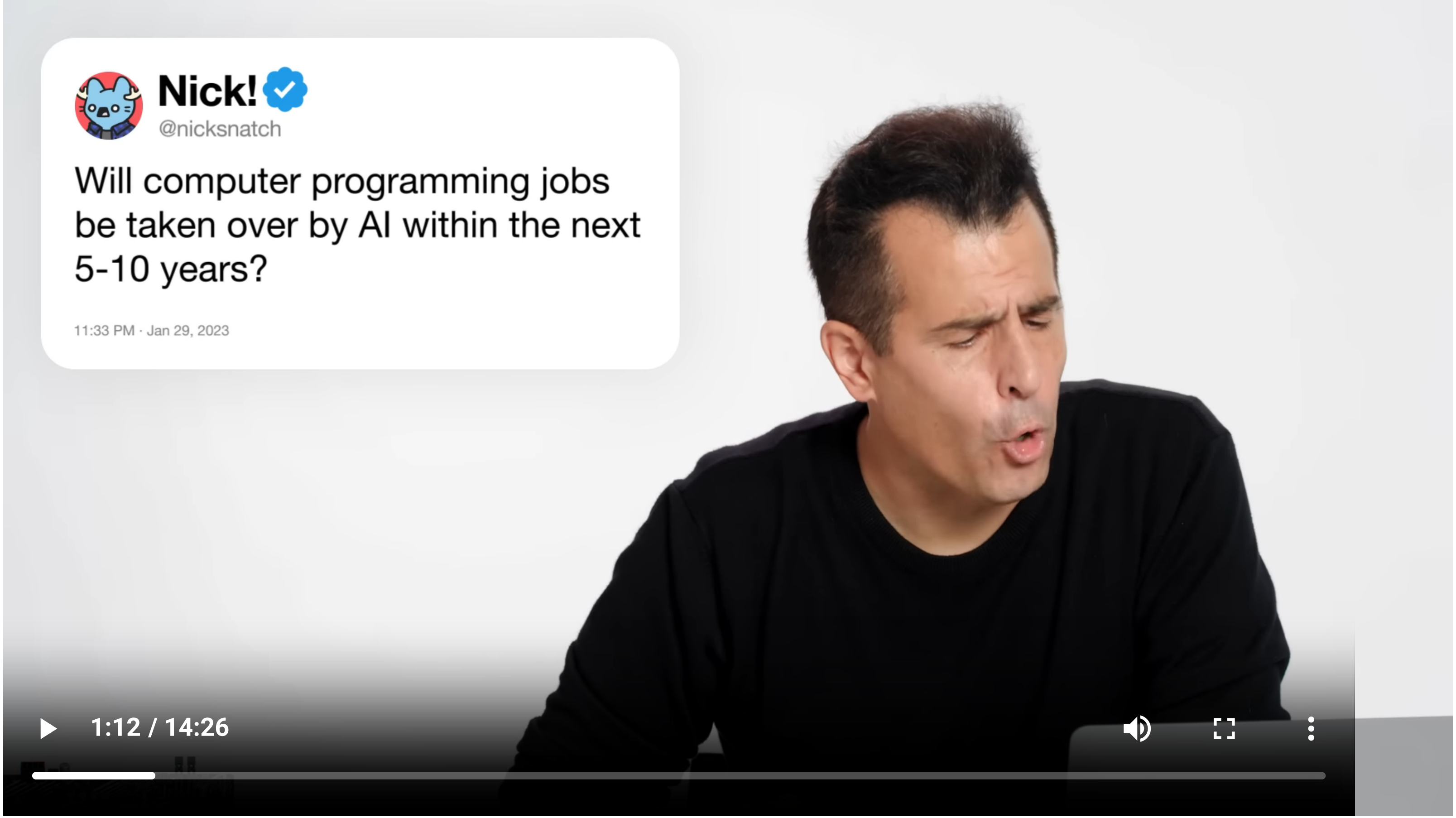
- All about **DOING** data analytics with modern AI tools
    - This Is America’s Hottest Job (Bloomberg, 5/18/18)
    - The Data Analytics Profession And Employment Is Exploding (Forbes, 6/11/21)
    - Data Scientists Are Still the Talk of the Town (Glassdoor, 5/16/23)
    - 30 jobs AI will create (instead of killing) by 2024



- It's **fast-paced** so be prepared to spend time on reading and practicing, even outside the classroom

- We emphasize **learning by doing**: in-class exercises, assignments, and a project

# Do we still need to learn programming?



Nick!

@nicksnatch

Will computer programming jobs be taken over by AI within the next 5-10 years?

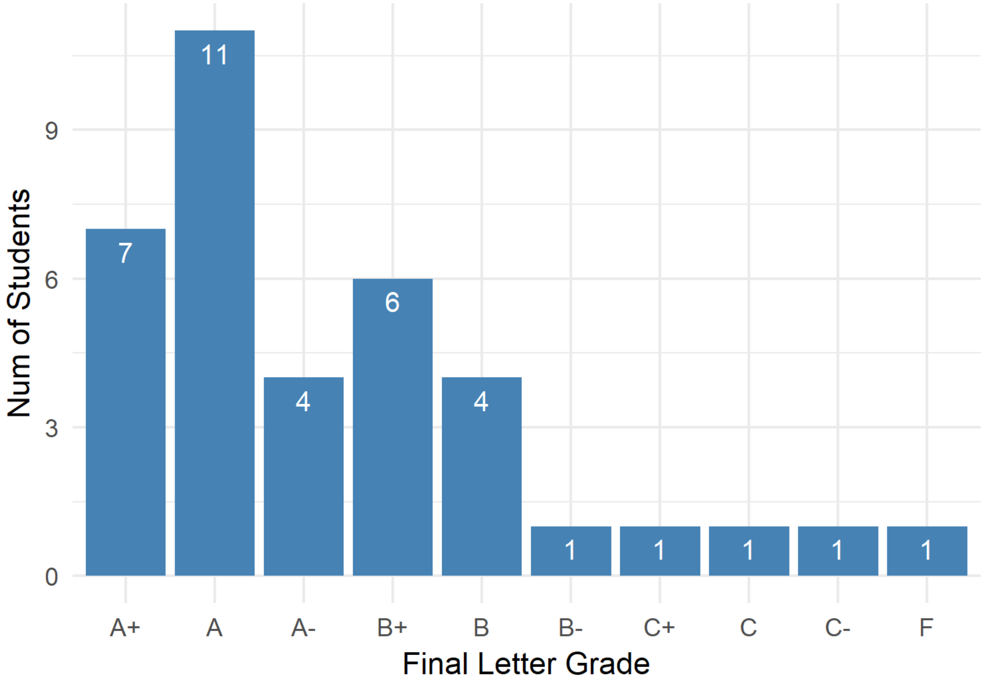
11:33 PM · Jan 29, 2023

Video source: https://www.youtube.com/watch?v=QUNrBEhvXWQ (David Malan, Professor of the Practice of Computer Science at Harvard University)

# Syllabus

- Course Information
- Course Mechanics
  - Typically 3 segments in each session/meeting
- Course Objectives
- Recommended Textbooks
- Technology and Software Requirements (R + RStudio)
- Course Outline
- Student Evaluation (*review the grading expectations carefully*)
  - Assignments: 60%
  - Course Project: 30%
  - Participation: 5%
  - Satisfactory CIS 8880 Co-req: 5%

# Final grade distribution



The B's and C's are due to only one reason: **late submissions**.

# Common Themes in Student Feedback

| Theme | My Response |
|---|---|
| Why R? Why not Python? | Data analysts really need to master both. See Glassdoor's report. Plus, most similar programs for data analytics cover both Python and R (Emory, NYU, UMN, UTD, etc.) |
| Assignments are tough | Assignments are really not more difficult than what we have covered in our lectures. Our lectures may appear to be easier because everything on the slides has been broken down into small pieces and organized in a logical way. Our assignments tend to be problem-driven and require integration and application of skills covered in different slides/lectures. |
| Some topics are difficult | Advanced topics will benefit students' job search. It also goes without saying that you are welcome and strongly encouraged to ask questions and request clarifications--in class, during the break, or after class--whichever way you like. |
| The class has a very fast pace | This is true, but that is just the nature of this course/program. Also, keep in mind that the vast majority of students are doing very well with the current pace. |
| Not enough time for in-class exercise | It is always difficult to budget time for in class exercises. Too long, most students will just sit there doing nothing. Too short, most students cannot finish their work. That said, you can always let me know if you need more time or some help! |
| Many positive comments | Example quotes from students: (1) This course is really helpful for students to learn pioneering topics in big data analytics. (2) Professor plans every class and every assignment. His assignment instructions are very clear. (3) He creates a comfortable environment to interact with him and he is easily accessible. |

# Agenda for this lecture

In this segment, we will quickly go through the following basic topics:

1. Access your virtual machine for this course
2. Set up R and RStudio
3. Understand the layout and functionality of RStudio
4. Experiment with basic R expressions and data types

Most of you are likely to have some experience in these. I will quickly go through them to refresh your memory, and lay the groundwork for more advanced topics.

[**Acknowledgements**] The materials in the following slides are based on the source(s) below:

- R for Data Science, 2nd Edition by Hadley Wickham, Mine Çetinkaya-Rundel, and Garrett Grolemund

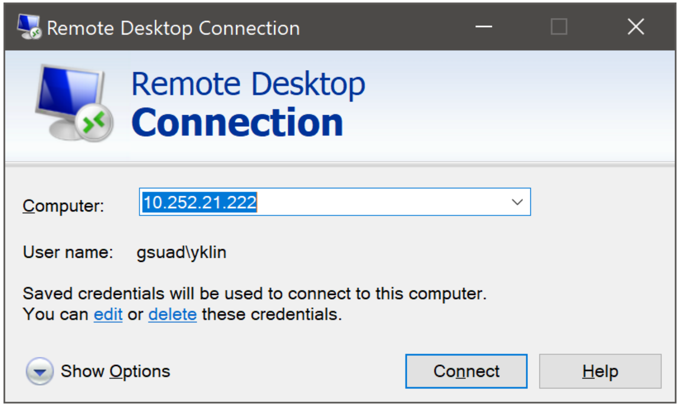
# Virtual machine (VM)

- A VM has been assigned to you. It has all the software, R packages, and large datasets pre-installed.

- The VM will be your primary environment for learning and implementing the topics and techniques taught in this course.

- If you are off campus, you need to connect to the GSU VPN before you can log into your VM.

- Use **Remote Desktop Connection** to log into your VM. Windows has Remote Desktop Connection pre-installed. For Mac users, please download “Microsoft Remote Desktop” from the App Store.



Computer: 10.252.21.222

User name: gsuad\yklin

Saved credentials will be used to connect to this computer.
You can edit or delete these credentials.

# Important notes about the VM

1. You should never shutdown or restart the VM. Just close the Remote Desktop Connection whenever you are done with the VM.

2. There is a limited storage space on the VM. You should not install any software (e.g., Microsoft Office) or add any data that are unrelated to this course to the VM.

3. VMs, just like our own laptops and PCs, can fail or become unresponsive. **ALWAYS** backup your work on the VM and save it to your own laptop or to the cloud.

# Download and install R

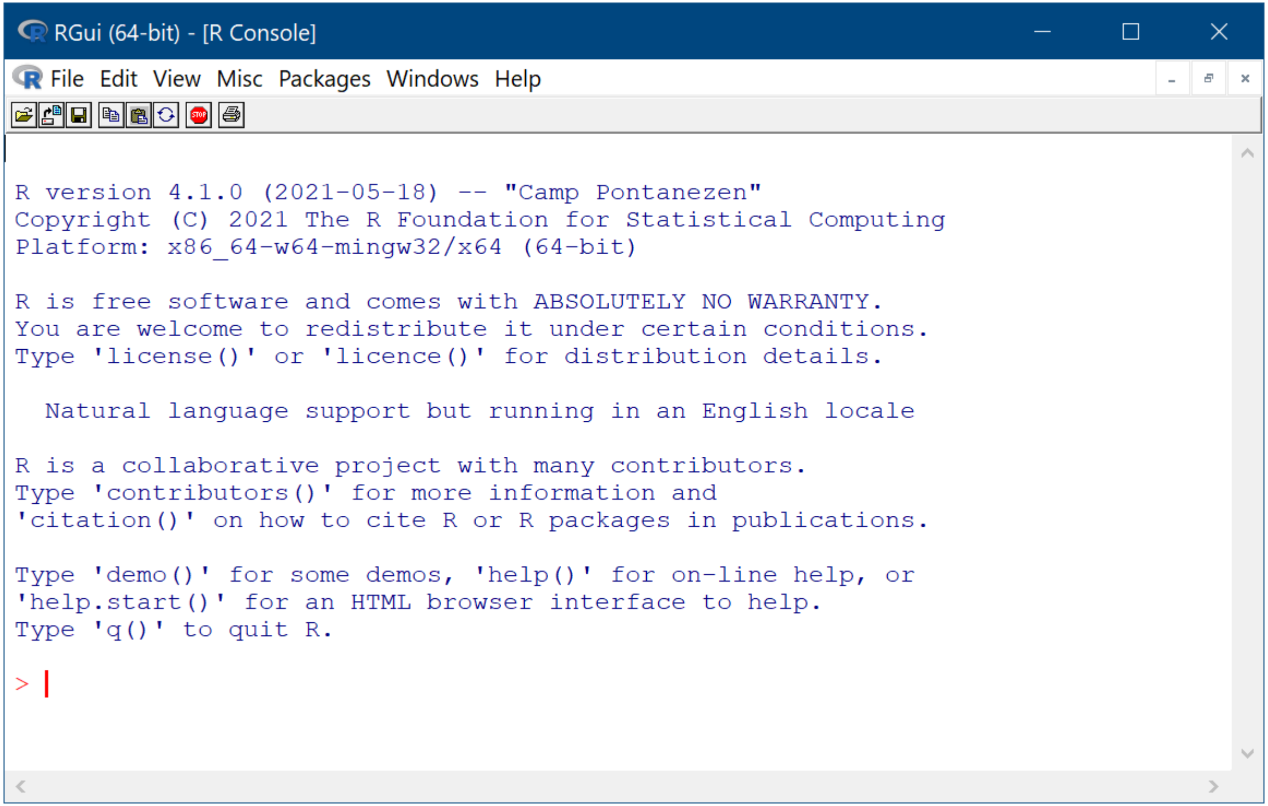
1. Visit CRAN: http://cran.r-project.org
   - CRAN = Comprehensive R Archive Network
2. Click the link on the right to download R for your system (Linux, Mac or Windows)
3. Install R (it is safe to accept the default setting and keep clicking "Next")

Step by step installation guides from YouTube:

- Mac: https://www.youtube.com/watch?v=uxuuWXU-7UQ
- Windows: https://www.youtube.com/watch?v=Ohnk9hcxf9M

# RGui

RGui is an interactive R environment that comes with R installation, but it is very basic and not so user-friendly.



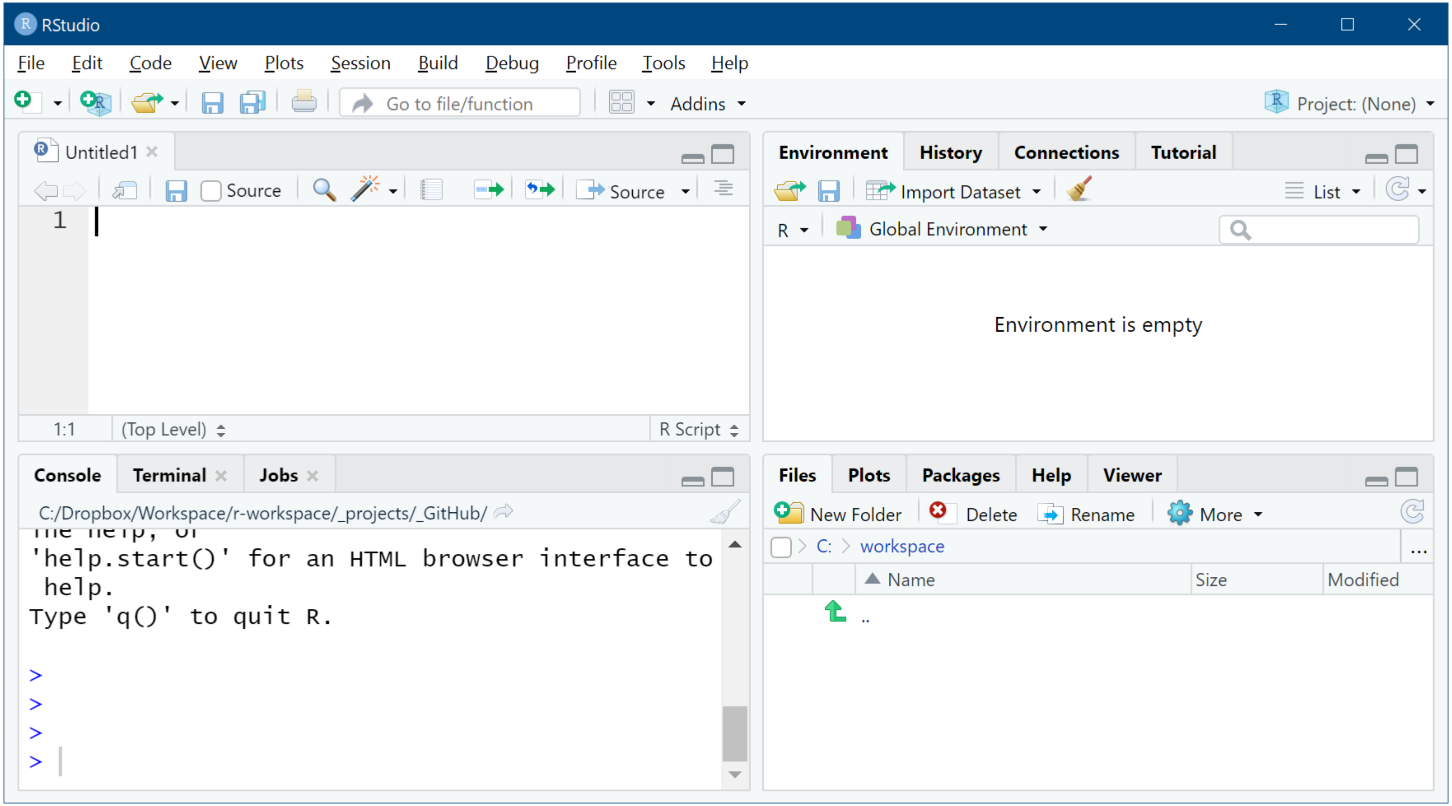
RGui (64-bit) - [R Console]
File Edit View Misc Packages Windows Help

```
R version 4.1.0 (2021-05-18) -- "Camp Pontanezen"
Copyright (C) 2021 The R Foundation for Statistical Computing
Platform: x86_64-w64-mingw32/x64 (64-bit)

R is free software and comes with ABSOLUTELY NO WARRANTY.
You are welcome to redistribute it under certain conditions.
Type 'license()' or 'licence()' for distribution details.

  Natural language support but running in an English locale

R is a collaborative project with many contributors.
Type 'contributors()' for more information and
'citation()' on how to cite R or R packages in publications.

Type 'demo()' for some demos, 'help()' for on-line help, or
'help.start()' for an HTML browser interface to help.
Type 'q()' to quit R.

> 
```

# RStudio

RStudio is a development environment for R, and provides many advanced features to improve efficiency and ease of use for R users.

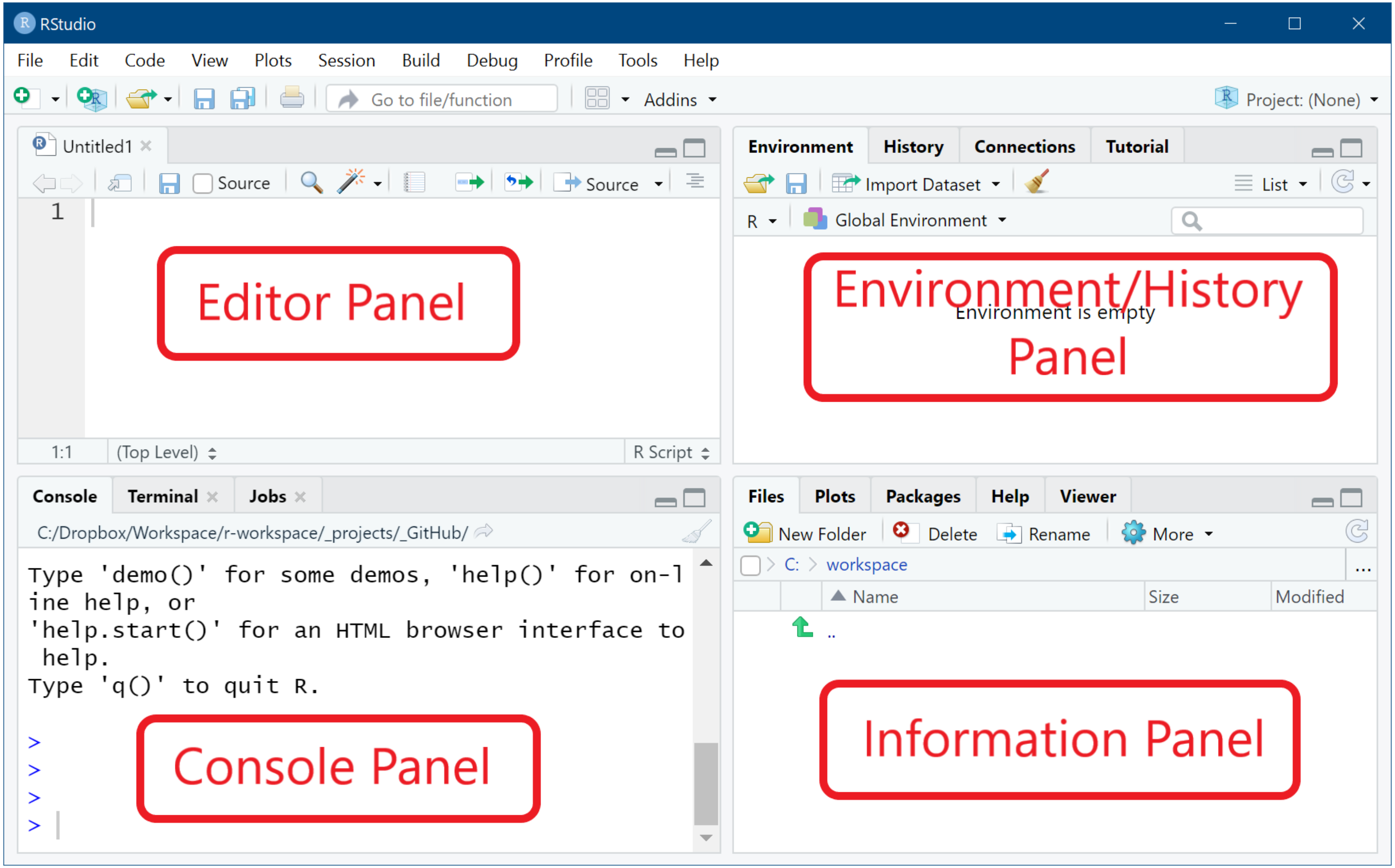
Downloading and installing RStudio: Visit https://posit.co/download/rstudio-desktop/



```
'help.start()' for an HTML browser interface to
 help.
Type 'q()' to quit R.

>
>
>
>
```

RStudio
File Edit Code View Plots Session Build Debug Profile Tools Help
Go to file/function
Addins
Project: (None)
Untitled1
Source
Source
1
1:1
(Top Level)
R Script
Environment History Connections Tutorial
Import Dataset
List
R
Global Environment
Environment is empty
Console Terminal Jobs
C:/Dropbox/Workspace/r-workspace/_projects/_GitHub/
Files Plots Packages Help Viewer
New Folder Delete Rename More
C: workspace
Name Size Modified
..

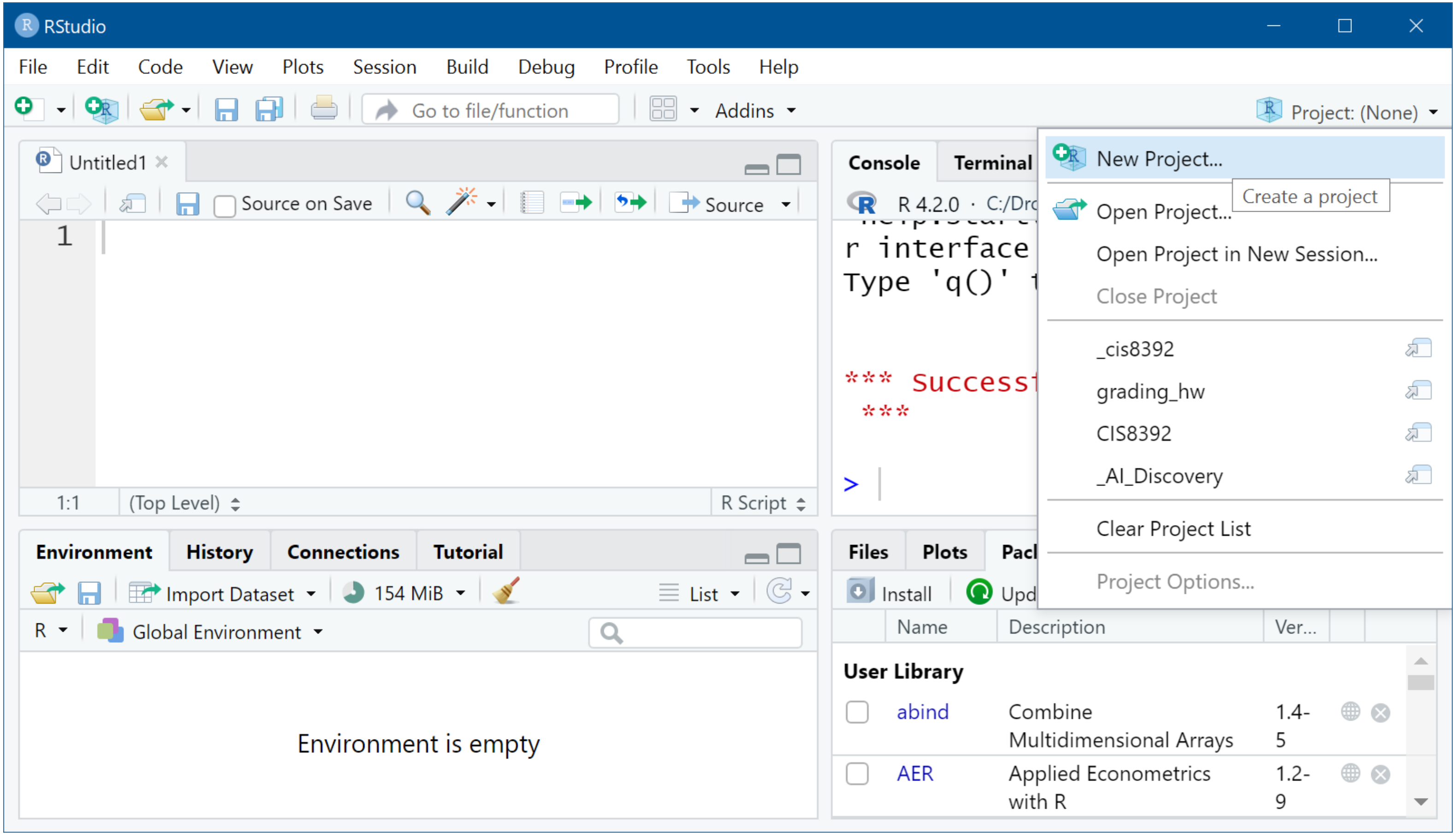
# Getting started with RStudio



```
Type 'demo()' for some demos, 'help()' for on-l
ine help, or
'help.start()' for an HTML browser interface to
 help.
Type 'q()' to quit R.

>
>
>
>
```

- This is the default panel layout. You can easily change the layout, e.g., moving the console panel to the upper right.

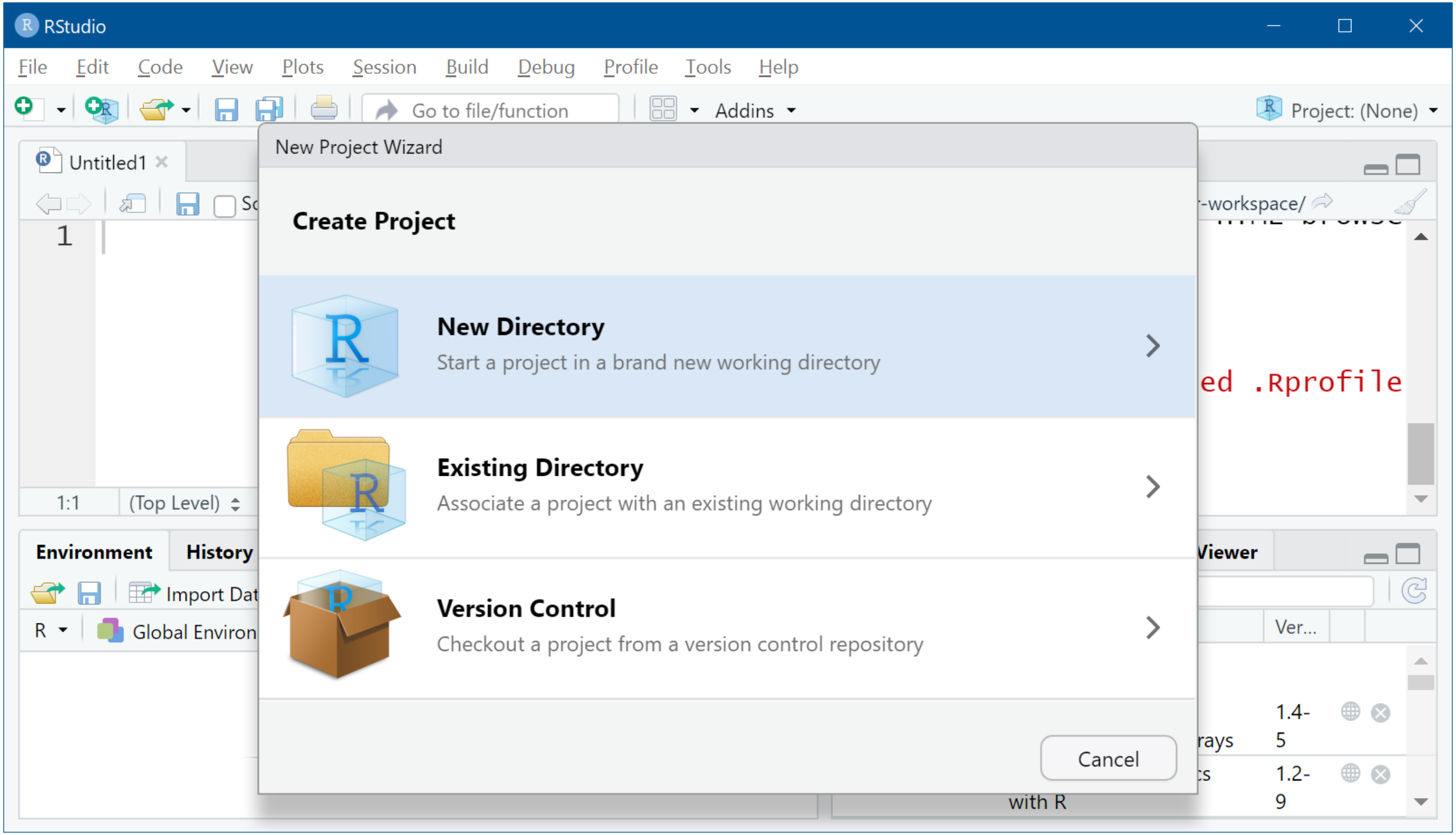
# RStudio: set up a project for this course



```
r interface
Type 'q()' t

*** Success
 ***

>
```

| | Name | Description | Ver... |
|---|---|---|---|
| **User Library** | | | |
| □ | abind | Combine Multidimensional Arrays | 1.4-5 |
| □ | AER | Applied Econometrics with R | 1.2-9 |

# Create project in a new directory:



New Project Wizard

**Create Project**

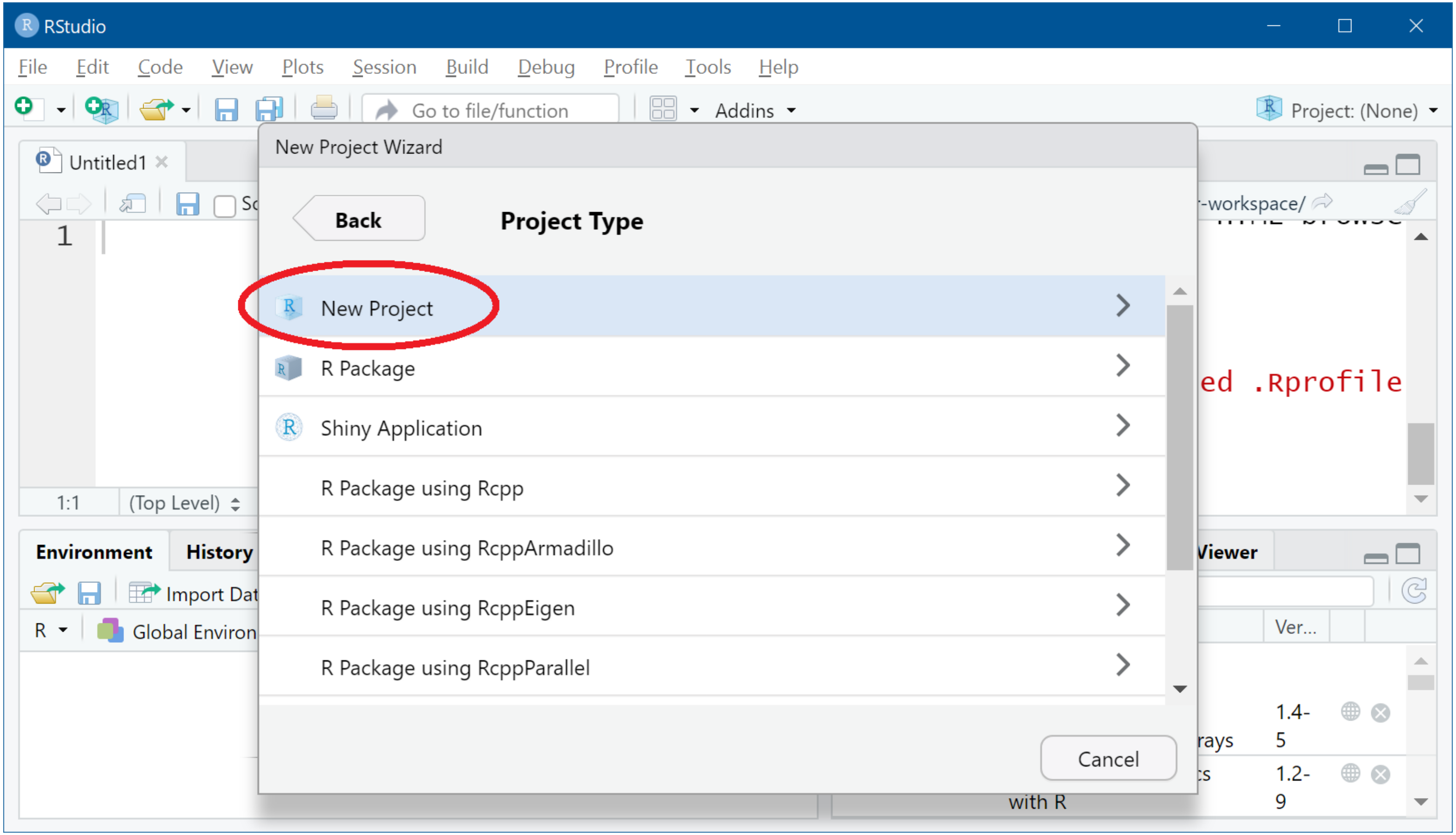
**New Directory**
Start a project in a brand new working directory

**Existing Directory**
Associate a project with an existing working directory

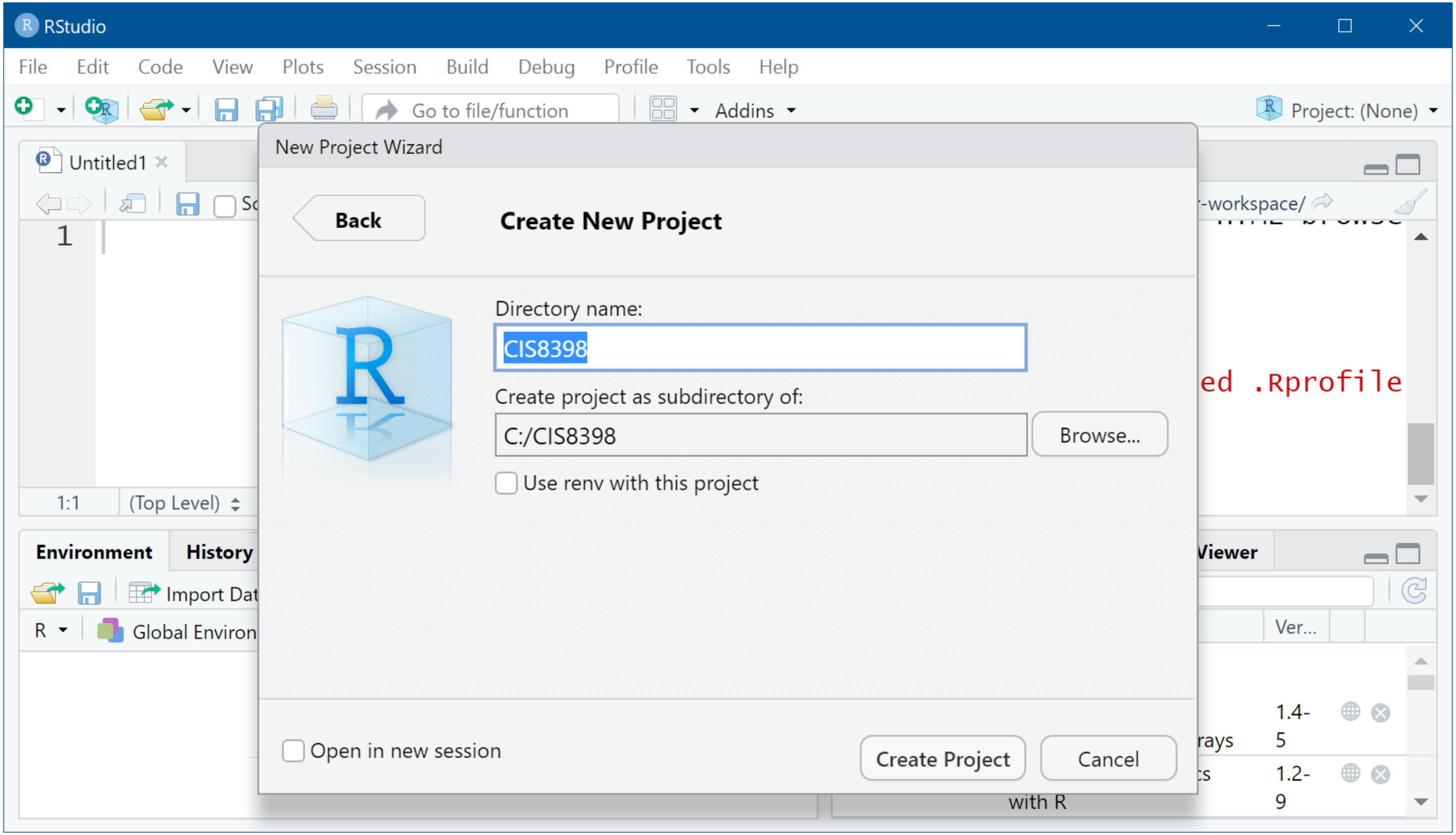
**Version Control**
Checkout a project from a version control repository

Cancel

# Choose "New Project"



1. Directory name: **CIS8398**
2. Create the project as sub-directory of: Anywhere you like



New Project Wizard

Create New Project

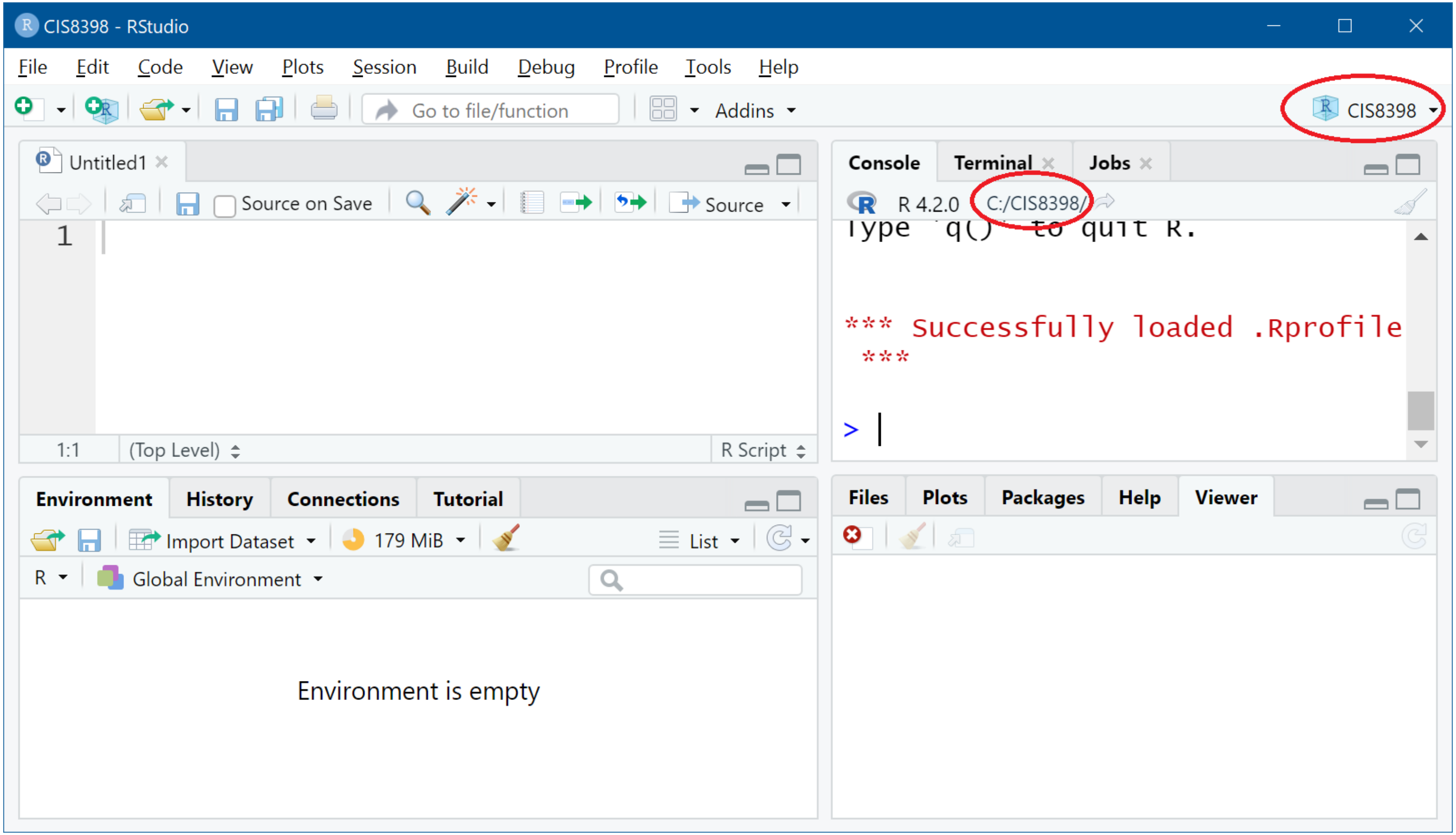
Directory name: CIS8398

Create project as subdirectory of: C:/CIS8398

□ Use renv with this project

□ Open in new session

Once created, you can see from RStudio that you are using the **CIS8398** project and the location of the project directory.

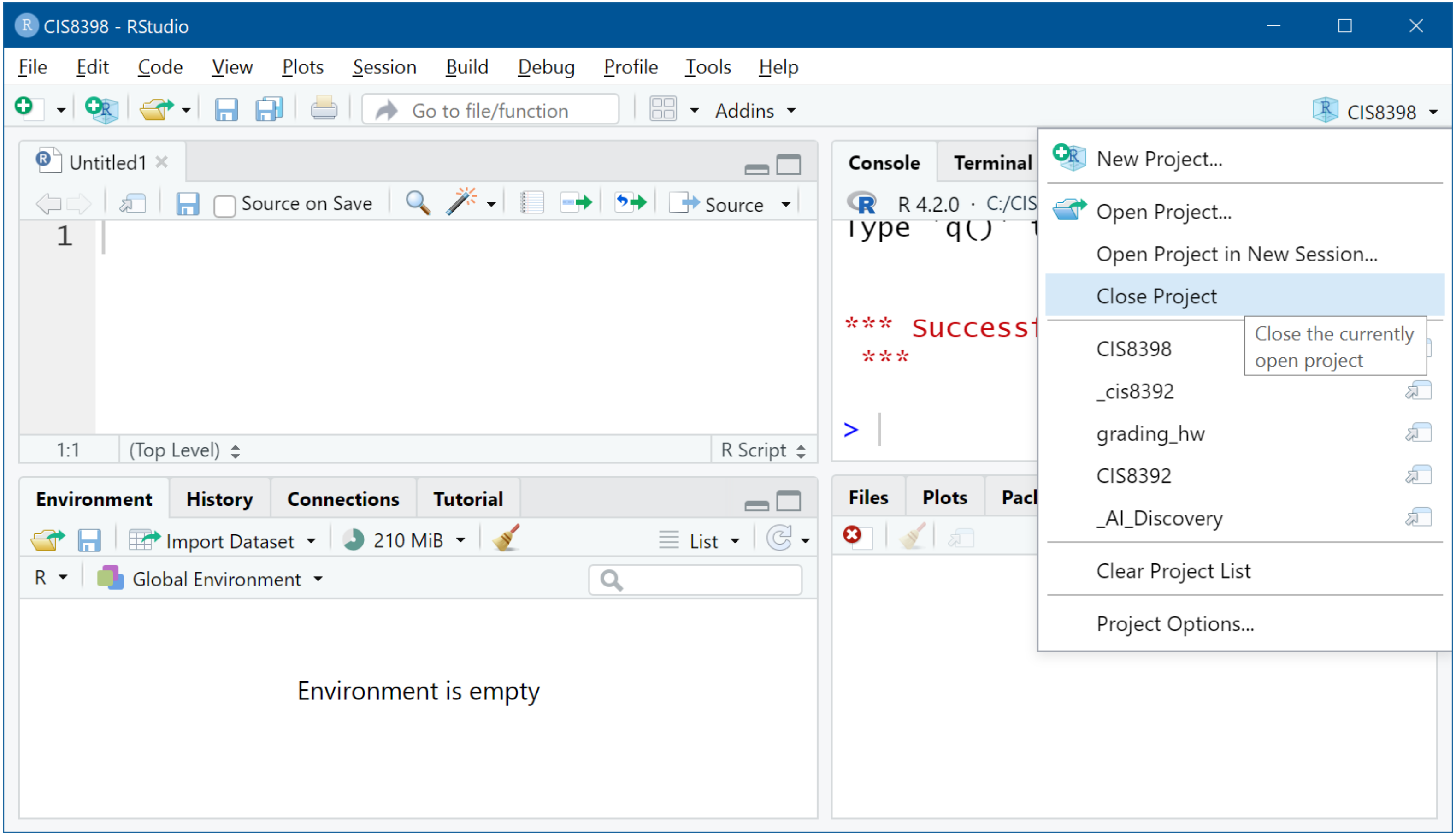


```
Type 'q()' to quit R.

*** Successfully loaded .Rprofile
 ***

> 
```

Environment is empty

You could close the project if you want, **but don't close it now!**

In our lectures, I will always assume that you are using this course-specific project in RStudio.



```
Type 'q()' t

*** Success
 ***

>
```

# Getting Help

There will be many occasions where you want to learn more about a built-in command or function. Type `help(function_name)` or `?function_name` to get more information. For example:

```
help(factorial)
?factorial
```

Use two question marks to search the whole help database, especially when you don't know the exact function name. For example,

```
??read
```

# Basic data types in R

- Numeric
- Character strings (text)
- Logical
- Factor

# Numeric

Any number, no quotes.

Appropriate for math.

```
1 + 1
200000
sqrt(9)
```

```
class(0.3)  # "class" is function that shows the data type of an input
```

```
## [1] "numeric"
```

# Character

Any symbols surrounded by single quotes (') or double quotes (")

```r
class("Artificial Intelligence")
```

```
## [1] "character"
```

```r
nchar('Artificial Intelligence')
```

```
## [1] 23
```

```r
toupper("Artificial Intelligence")
```

```
## [1] "ARTIFICIAL INTELLIGENCE"
```

```r
paste("Artificial", "Intelligence", sep="_")
```

```
## [1] "Artificial_Intelligence"
```

# Logical

Logical values are either TRUE or FALSE (Note: they are uppercase).

```
2 + 3 == 5   # use '==' to check whether two values are equal
```

```
## [1] TRUE
```

```
3 < 2
```

```
## [1] FALSE
```

```
TRUE == T    # use T as a short hand for TRUE; F for FALSE
```

```
## [1] TRUE
```

# Factor

R's form of categorical data. Saved as an integer with a set of labels (e.g. levels)

```
msis_concentrations <- factor(
  c("Big Data", "Digital Innovation", "Cybersecurity")
)
msis_concentrations
```

```
## [1] Big Data           Digital Innovation Cybersecurity
## Levels: Big Data Cybersecurity Digital Innovation
```

```
class(msis_concentrations)
```

```
## [1] "factor"
```

```
levels(msis_concentrations)
```

```
## [1] "Big Data"           "Cybersecurity"      "Digital Innovation"
```

# Detect / convert data types

`is.`*XYZ*`()` functions return Boolean for whether the argument is of type *XYZ*

`as.`*XYZ*`()` functions (try to) "cast" its argument to type *XYZ* --- to translate it sensibly into a *XYZ*-type value

```
is.numeric(7)
```

```
## [1] TRUE
```

```
is.character(7)
```

```
## [1] FALSE
```

```
is.character("7")
```

```
## [1] TRUE
```

```
as.character(5/2)
```

```
## [1] "2.5"
```

```
as.numeric(as.character(5/2))
```

```
## [1] 2.5
```

```
2 * as.numeric(as.character(5/2))
```

```
## [1] 5
```

# Create variables

We can give names to data objects; this gives us **variables**

Variables are created with the **assignment operators**, `<-` or `=`

Be careful because R is a case sensitive language. FOO, Foo, and foo are different!

```r
x = 2      # use the equal sign to assign value
y <- 3     # you can also use an arrow to assign value
x          # print the value of a variable by typing its name
```

```
## [1] 2
```

```r
x * y
```

```
## [1] 6
```

```r
x <- 8
x
```

```
## [1] 8
```

# Improve readability of your code

- A command can be spread across multiple lines. This can often improve readability.

```
x = paste("How", "are", "you?",   # what happens if you only enter this line
          sep=" ")
x
```

```
## [1] "How are you?"
```

- We can put multiple commands in the same line, but they need to be separated by a semicolon (;)

```
a = 1; b = 2
a + b
```

```
## [1] 3
```

# Your turn

1. Create variables `f_name` and `l_name` with values equal to your own first/last names

2. Get the number of characters in `f_name` and `l_name` and save them to `length_f_name` and `length_l_name` respectively

3. Use the `paste()` function to get your whole name

4. `length_f_name` multiplied by `length_l_name`

5. `length_f_name` divided by `length_l_name`

6. Show if `length_f_name` is greater than `length_l_name`

# Composite data types in R

- *Vector*: a set of values, all of the same data type
- *List*: a set of values, potentially with different data types
- *Matrix*: special 2D numerical structure
- *Data frame*: like an Excel sheet or a database table

# Vector

A **vector** is a sequence of values, all of the same type

```
x <- c(1, 3, 7, 15)   # c stands for "combine"
x
```

```
## [1]  1  3  7 15
```

```
is.vector(x)
```

```
## [1] TRUE
```

```
length(x)             # find the number of elements in a vector
```

```
## [1] 4
```

```r
seq(from=1, to=10)         # sequence
```

```
##  [1]  1  2  3  4  5  6  7  8  9 10
```

```r
1:10                       # sequence shorthand
```

```
##  [1]  1  2  3  4  5  6  7  8  9 10
```

```r
seq(from=1, to=10, by=2)   # sequence
```

```
## [1] 1 3 5 7 9
```

```r
rep(7, times=3)            # repeat
```

```
## [1] 7 7 7
```

# Name a vector

```
vec <- c(10, 20, 7, 13) # assigning a vector to a variable
vec
```

```
## [1] 10 20  7 13
```

```
names(vec) <- c("value1", "value2", "value3", "value4")
vec
```

```
## value1 value2 value3 value4
##     10     20      7     13
```

```
vec <- c("value1"=10, "value2"=20, "value3"=7, "value4"=13) #same result
vec <- c(value1=10, value2=20, value3=7, value4=13)         #same result
```

# Combining vectors

```r
vec1 <- c(1, 3, 5)
vec2 <- c(11, 13, 15)
c(vec1, vec2, c(21, 23, 25))
```

```
## [1]  1  3  5 11 13 15 21 23 25
```

# Vector arithmetics

Vector computations are performed **element-wise**

```
earnings <- c(10, 20, 30, 40)
expenses <- c(5, 25, 25, 10)
5 * earnings
```

```
## [1]  50 100 150 200
```

```
earnings - expenses
```

```
## [1]  5 -5  5 30
```

```
earnings * c(1, 2, 3, 4)
```

```
## [1]  10  40  90 160
```

# Recycling

**Recycling** repeat elements in shorter vector when combined with longer

```r
u <- c(10, 20)
v <- c(1, 2, 3, 4, 5)
u + v  # the shorter vector will be recycled to match the longer vector
```

```
## [1] 11 22 13 24 15
```

Under the hood:

u + v

= c(10, 20) + c(1, 2, 3, 4, 5)

= c(10, 20, **10, 20, 10**) + c(1, 2, 3, 4, 5) # *recycling*

= c(10+1, 20+2, 10+3, 20+4, 10+5) # *element-wise operation*

= c(11, 22, 13, 24, 15)

# Test if a vector has a specific value

```r
x <- c(10, 20, 30)
```

Does `x` have 20?

```r
20 %in% x
```

```
## [1] TRUE
```

Does `x` have 40?

```r
40 %in% x
```

```
## [1] FALSE
```

```r
basket <- c("apple", "banana")
```

Does `basket` have apple?

```r
"apple" %in% basket
```

```
## [1] TRUE
```

Does `basket` have cheese?

```r
"cheese" %in% basket
```

```
## [1] FALSE
```

# Missing values: NA

In real world, your data may contain missing values. In R, we use `NA` (upper case) to represent a missing value.

```
vec = c(1, 4, NA, 2)
vec
```

```
## [1]  1  4 NA  2
```

```
sum(vec)
```

```
## [1] NA
```

```
max(vec)
```

```
## [1] NA
```

`NA` creates problems for most numerical functions.

For example, we cannot add `NA` to other numbers.

To apply these numerical functions on data with `NA`s, we just remove the `NA`s from the calculation. That is,

```
sum(vec, na.rm = T)
```

```
## [1] 7
```

```
max(vec, na.rm = T)
```

```
## [1] 4
```

# Vector indexing

You can retrieve elements from a vector by specifying the indexes of the elements. This operation is also known as `subsetting`.

```r
vec <- c("value1"=10, "value2"=20, "value3"=30, "value4"=40)
vec[1] # get the element at index 1
```

```
## value1
##     10
```

```r
vec["value3"] # get the element whose name matches the string
```

```
## value3
##     30
```

You can provide more than just one index.

```
vec[1:3] # specify a vector of indexes
```

```
## value1 value2 value3
##     10     20     30
```

```
vec[c(3, 2, 1, 4)] # return with the specified order
```

```
## value3 value2 value1 value4
##     30     20     10     40
```

```
vec[c("value4", "value4")]
```

```
## value4 value4
##     40     40
```

# List

A list is also a container, but it can accommodate items of different data types.

```
x <- list("Bob", c(100,80,90))
x #whenever you see [[1]], [[2]], ..., the object is a list
```

```
## [[1]]
## [1] "Bob"
## 
## [[2]]
## [1] 100  80  90
```

Just like vectors, you can give each element a name:

```
x <- list(name="Bob", grades=c(100,80,90))
x #whenever you see $xxx, $yyy, ... the object is a list
```

```
## $name
## [1] "Bob"
## 
## $grades
## [1] 100  80  90
```

# List indexing

```
x[2]           # get the second elment as a list
```

```
## $grades
## [1] 100  80  90
```

```
x["grades"]    # get the elment named "grades" as a list
```

```
## $grades
## [1] 100  80  90
```

```
y1 = x[2]
class(y1)
```

```
## [1] "list"
```

```r
x[[2]]         # get the second elment as a vector
```

```
## [1] 100  80  90
```

```r
y2 = x[[2]]
class(y2)
```

```
## [1] "numeric"
```

```r
x[["grades"]]  # get the elment named "grades" as a vector
```

```
## [1] 100  80  90
```

```r
x$grades       # most readable
```

```
## [1] 100  80  90
```

# Your turn

```
## $name
## [1] "Alice"  "Bob"    "Claire" "Daniel"
##
## $female
## [1]  TRUE FALSE  TRUE FALSE
##
## $age
## [1] 20 25 30 35
```

```
## [1] "Bob"
```

1. Create the above **list**
2. Get the name "Bob" *from* the list
   - Hint: Get the name vector from the list and then get the second element in the vector

# Matrix

A matrix is a collection of data elements arranged in a two-dimensional rectangular layout.

```
A <- matrix(
  1:6,                 # the data elements
  nrow=2,              # number of rows
  ncol=3,              # number of columns
  byrow = TRUE)        # fill matrix by rows
A
```

```
##      [,1] [,2] [,3]
## [1,]    1    2    3
## [2,]    4    5    6
```

# Data frame

A data frame is a set of vectors of equal length. Consider a data frame as an Excel sheet or a database table.

```
course <- c("CIS8392", "CIS8010", "CIS8050", "CIS8398")
num_of_students <- c(20, 10, 40, 30)
analytics_course <- c(TRUE, FALSE, TRUE, TRUE)
df <- data.frame(course, n_students=num_of_students, analytics_course)
df # notice the column names and row names
```

```
##    course n_students analytics_course
## 1 CIS8392         20             TRUE
## 2 CIS8010         10            FALSE
## 3 CIS8050         40             TRUE
## 4 CIS8398         30             TRUE
```

# Useful functions for data frames

```
ncol(df) # number of columns
```

```
## [1] 3
```

```
nrow(df) # number of rows
```

```
## [1] 4
```

```
colnames(df) # get column names
```

```
## [1] "course"           "n_students"       "analytics_course"
```

```
rownames(df) # get row names
```

```
## [1] "1" "2" "3" "4"
```

# Change column and row names

```r
df2 <- df # create a copy of df, and name it as "df2"
colnames(df2) <- c("col1", "col2", "col3") # assign column names
colnames(df2)
```

```
## [1] "col1" "col2" "col3"
```

```r
rownames(df2) <- c("row1", "row2", "row3", "row4") # assign row names
rownames(df2)
```

```
## [1] "row1" "row2" "row3" "row4"
```

```r
df
```

```
##    course n_students analytics_course
## 1 CIS8392         20             TRUE
## 2 CIS8010         10            FALSE
## 3 CIS8050         40             TRUE
## 4 CIS8398         30             TRUE
```

```r
df2
```

```
##         col1 col2  col3
## row1 CIS8392   20  TRUE
## row2 CIS8010   10 FALSE
## row3 CIS8050   40  TRUE
## row4 CIS8398   30  TRUE
```

# Get values from a column

There are many ways you can get values out of a column.

- The most readable way: `dataframe_name$column_name`

```
df$course
```

```
## [1] "CIS8392" "CIS8010" "CIS8050" "CIS8398"
```

```
df$n_students
```

```
## [1] 20 10 40 30
```

# Get values from rows

```
df
```

```
##    course n_students analytics_course
## 1 CIS8392         20             TRUE
## 2 CIS8010         10            FALSE
## 3 CIS8050         40             TRUE
## 4 CIS8398         30             TRUE
```

```
df[2,]  # row 2
```

```
##    course n_students analytics_course
## 2 CIS8010         10            FALSE
```

```
df[c(1,3),]  # rows 1 & 3
```

```
##    course n_students analytics_course
## 1 CIS8392         20             TRUE
## 3 CIS8050         40             TRUE
```

# Specify rows and columns

```
df[2,1]              # row 2, column 1
```

```
## [1] "CIS8010"
```

```
df[c(3,4),c(1,2)]    # rows 3 & 4, columns 1 & 2
```

```
##    course n_students
## 3 CIS8050         40
## 4 CIS8398         30
```

```
df["2","n_students"] # "2": row name, "n_students": column name
```

```
## [1] 10
```

# Your turn

```
##          name female age
## row_1   Alice   TRUE  20
## row_2     Bob  FALSE  25
## row_3  Claire   TRUE  30
## row_4  Daniel  FALSE  35
```

1. Create the above **data frame** (don't forget the column/row names!)

2. Obtain the mean of the age column from the data frame