# Week 3: R Functions

Sarah Tareen

2023-04-21

This week we are introducing **R functions** and how to write our own functions.

Questions to answer:

> Q1. Write a function grade() to determine an overall grade from a vector of student homework assignment scores dropping the lowest single score. If a student misses a homework (i.e. has an NA value) this can be used as a score to be potentially dropped. Your final function should be adquately explained with code comments and be able to work on an example class gradebook such as this one in CSV format: "https://tinyurl.com/gradeinput" [3pts]

```r
# Example input vectors to start with
student1 <- c(100, 100, 100, 100, 100, 100, 100, 90)

student2 <- c(100, NA, 90, 90, 90, 90, 97, 80)

student3 <- c(90, NA, NA, NA, NA, NA, NA, NA)
```

Follow the guidelines from class

- Write a working snipper of code that solves a simple problem

```r
# Straightforward mean()
student1 <- c(100, 100, 100, 100, 100, 100, 100, 90)

mean(student1)
```

```
## [1] 98.75
```

But... We need to drop the lowest score. First we need to identify the lowest score.

```r
# Which element of the vector is the lowest?
which.min(student1)
```

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

What I want is to now drop (ie. exclude) this lowest score from my mean() calculation.

```r
# This will return everything but the eighth element of the vector.
student1[-8]
```

```
## [1] 100 100 100 100 100 100 100
```

Now we can use the answer from which.min() to return all other elements of the vector.

```r
#This is our first working snippet!
mean( student1[-which.min(student1)] )
```

```
## [1] 100
```

What about the other example students? Will this work for them?

We could try using the na.rm = TRUE argument for mean but this is pants! not a good approach i.e. unfair.

```r
student2 <- c(100, NA, 90, 90, 90, 90, 97, 80)
mean(student2, na.rm=TRUE)
```

```
## [1] 91
```

```r
student3 <- c(90, NA, NA, NA, NA, NA, NA, NA)
mean(student3, na.rm=TRUE)
```

```
## [1] 90
```

Another approach is to mask (i.e. replace) all NA values with zero

First we need to find the NA elements of the vector. How do we do this?

```r
student2 <- c(100, NA, 90, 90, 90, 90, 97, 80)
x <- student2

is.na(x)
```

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

```r
which( is.na(x) )
```

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

Now we have identified the NA elements, we want to "mask" them. Replace them with zero?

```r
# This does not quite get us there
mean(x[-which(is.na(x))])
```

```
## [1] 91
```

Instead we will make the NA elements zero

```r
#Cool, this is useful
x[is.na(x)] <- 0
x
```

```
## [1] 100   0  90  90  90  90  97  80
```

```
mean(x)
```

```
## [1] 79.625
```

Recall we shoudl drop the lowest score now..

```
x[is.na(x)] <- 0
mean( x[-which.min(x)] )
```

```
## [1] 91
```

Now we are essentially there with our working snippet!

```
student3 <- c(90, NA, NA, NA, NA, NA, NA, NA)
x <- student3
x[is.na(x)] <- 0
mean( x[-which.min(x)] )
```

```
## [1] 12.85714
```

## Now we can make our function

Take the snipper and turn it into a function. Every function has 3 parts:

- A name, in our case 'grade()'
- Input arguments, a vector of student scores
- The body i.e. our working snipper of code

Using RStudio I will select code then do `Code > Extract Function`

```
grade <- function(x) {
  x[is.na(x)] <- 0
  mean( x[-which.min(x)] )
}
```

```
grade(student1)
```

```
## [1] 100
```

```
grade(student2)
```

```
## [1] 91
```

```
grade(student3)
```

```
## [1] 12.85714
```

This looks great! We now need to add comments to explain this to our future selves and other who want to use this function. You can select code from bottom up and select `Code > Roxygen skeleton`.

```r
#' Calculate the average score for a   vector of student scores dropping the  lowest score.
#' Missing values will be treated as zero.
#'
#' @param x  A numeric vector of homework scores
#'
#' @return Average score
#' @export
#'
#' @examples
#' student <- c(100, NA, 90, 97)
#' grade(student)
#'
grade <- function(x) {
  # mask NA with zero
  # Treat missing values as zero
  x[is.na(x)] <- 0
  # Exclude the lowest score from mean
  mean( x[-which.min(x)] )
}
```

Now finally we can use our function on our "real" whole class data from this CSV format file: "https://tinyurl.com/gradeinput"

```r
url <- "https://tinyurl.com/gradeinput"
gradebook <- read.csv(url, row.names = 1)
```

```r
# Use this to apply the function to the rows of the data table
apply(gradebook, 1, grade)
```

```
##  student-1  student-2  student-3  student-4  student-5  student-6  student-7
##      91.75      82.50      84.25      84.25      88.25      89.00      94.00
##  student-8  student-9 student-10 student-11 student-12 student-13 student-14
##      93.75      87.75      79.00      86.00      91.75      92.25      87.75
## student-15 student-16 student-17 student-18 student-19 student-20
##      78.75      89.50      88.00      94.50      82.75      82.75
```

> Q2. Using your grade() function and the supplied gradebook, Who is the top scoring student overall in the gradebook? [3pts]

To answer this we can run the apply() function and save the results.

```r
results <- apply(gradebook, 1, grade)

sort(results, decreasing = TRUE)
```

```
## student-18  student-7  student-8 student-13  student-1 student-12 student-16
##      94.50      94.00      93.75      92.25      91.75      91.75      89.50
##  student-6  student-5 student-17  student-9 student-14 student-11  student-3
##      89.00      88.25      88.00      87.75      87.75      86.00      84.25
##  student-4 student-19 student-20  student-2 student-10 student-15
##      84.25      82.75      82.75      82.50      79.00      78.75
```

```
which.max(results)
```

```
## student-18
##         18
```

Q3. From your analysis of the gradebook, which homework was toughest on students (i.e. obtained the lowest scores overall? [2pts]

```
gradebook
```

```
##            hw1 hw2 hw3 hw4 hw5
## student-1  100  73 100  88  79
## student-2   85  64  78  89  78
## student-3   83  69  77 100  77
## student-4   88  NA  73 100  76
## student-5   88 100  75  86  79
## student-6   89  78 100  89  77
## student-7   89 100  74  87 100
## student-8   89 100  76  86 100
## student-9   86 100  77  88  77
## student-10  89  72  79  NA  76
## student-11  82  66  78  84 100
## student-12 100  70  75  92 100
## student-13  89 100  76 100  80
## student-14  85 100  77  89  76
## student-15  85  65  76  89  NA
## student-16  92 100  74  89  77
## student-17  88  63 100  86  78
## student-18  91  NA 100  87 100
## student-19  91  68  75  86  79
## student-20  91  68  76  88  76
```

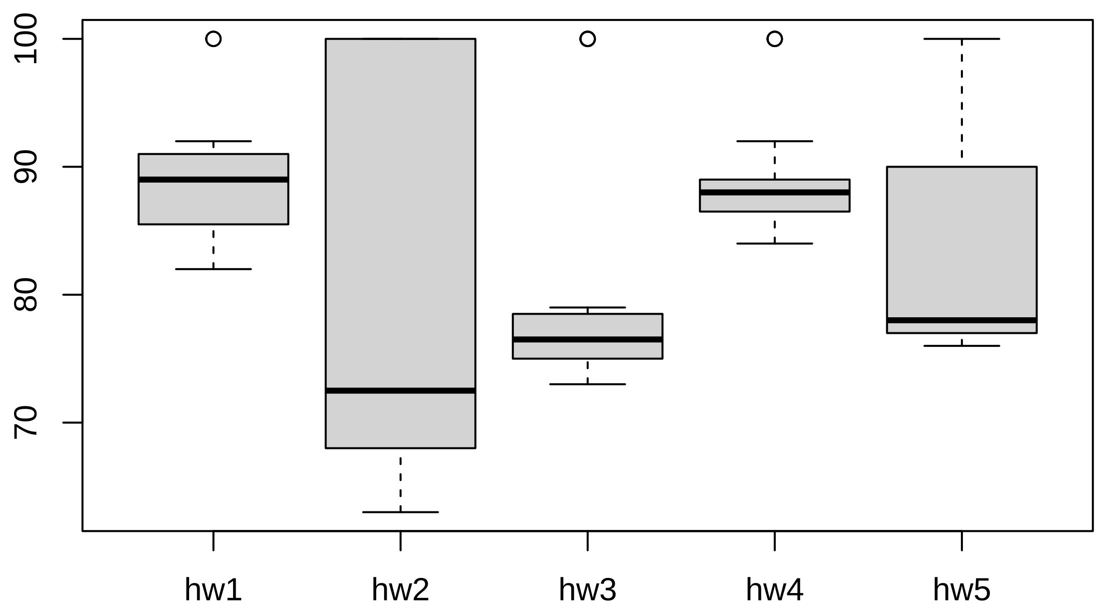
```
ave.scores <- apply(gradebook, 2, mean, na.rm=TRUE)
which.min(ave.scores)
```

```
## hw3
##   3
```

```
med.scores <- apply(gradebook, 2, median, na.rm=TRUE)
which.min(med.scores)
```

```
## hw2
##   2
```

```
#line shows median
boxplot(gradebook)
```



Since the median is less sensitive to outliers we should use it as an average. Therefore, HW 2 got the most lowest scores overall.

> Q4 From your analysis of the gradebook, which homework was most predictive of overall score (i.e. highest correlation with average grade score)? [1pt]

Are the final results (i.e. average score for each student) correlated with the results (i.e. scores) for individual homeworks - the gradebook columns.

```
masked.gradebook <- gradebook
masked.gradebook[is.na(masked.gradebook)] <- 0

# And look at correlation
cor(results, masked.gradebook$hw1)
```

```
## [1] 0.4250204
```

```
apply(masked.gradebook, 2, cor, x=results)
```

```
##       hw1       hw2       hw3       hw4       hw5
## 0.4250204 0.1767780 0.3042561 0.3810884 0.6325982
```

HW 5 has the highest correlation value with the average scores and is most predictive of overall score.

Q5 Make sure you save your Quarto document and can click the "Render" (or Rmarkdown" Knit") button to generate a PDF format report without errors. Finally, submit your PDF to gradescope. [1pt]

Knit the document to make the PDF