Class 6: R functions

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This week we can 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]

```
# 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 snippet of code that solves a simple problem

```
# straightforward mean()
mean(student1)
```

```
[1] 98.75
```

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

```
min(student1)
```

```
[1] 90
```

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

```
[1] 8
```

What I want now is the drop (i.e. exclude) the lowest score from my mean() calculation.

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

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

Now we can use the answer from which.mean() 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 it would not be fair. Not a good approach.

```r
# student2 <- c(100, NA, 90, 90, 90, 90, 97, 80)
mean(student2[-which.min(student2)])
```

```
[1] NA
```

Another approach here 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 find the NA elements?

```r
x <- student2

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

```
[1] 2
```

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

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

Recall we should drop the lowest score now…

```r
mean(x[-which.min(x)])
```

```
[1] 91
```

Now we are essentially there with our working snippet!

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

```
[1] 12.85714
```

Now we make our function

Take this snippet nd 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 snippet of code

Using RStudio I'll select `Code > Extract Function`

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

```r
grade(student1)
```

```
[1] 100
```

```r
grade(student2)
```

```
[1] 91
```

```r
grade(student3)
```

```
[1] 12.85714
```

This looks great! We now need to add comments to explain this to our future selves and others who want to use this function.

```r
#' Calculate average scores 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[which(is.na(x))] <- 0
  # Excludes 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: "https://tinyurl.com/gradeinput"

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

```r
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 run the apply() function and save the results

```
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 
```

Student-18 is the top scoring student overall.

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

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

which.min(ave.scores)
```

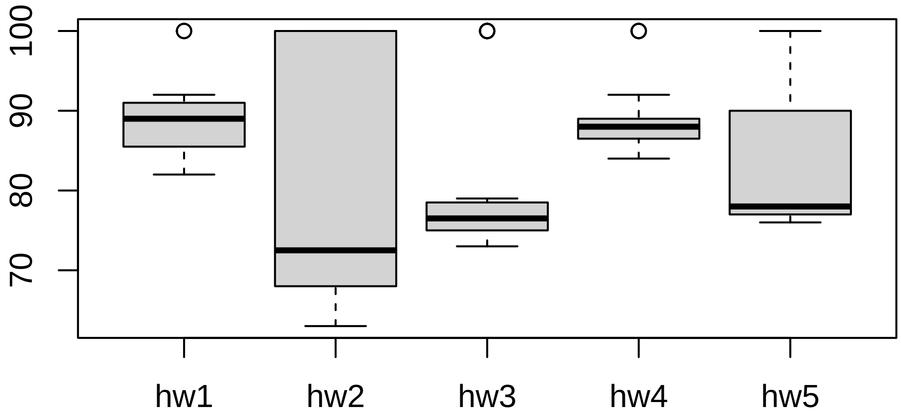
```
hw3 
  3 
```

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

which.min(med.scores)
```

```
hw2 
  2 
```

```
boxplot(gradebook)
```



Hw2 was the toughest on student.

> Q4. Optional Extension: 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. averages core 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
masked.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   0  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   0  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   0
student-16  92 100  74  89  77
student-17  88  63 100  86  78
student-18  91   0 100  87 100
student-19  91  68  75  86  79
student-20  91  68  76  88  76
```

```
cor(results, masked.gradebook$hw5)
```

```
[1] 0.6325982
```

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

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

Hw5 was most predictive of overall score.

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