Class 06: R Functions Lab

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

Step 1: Write a working snippet of code that solves a simple problem.

```
# Straight forward mean()
mean(student1)
```

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

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

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

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

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

```
# 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.min() to return all other elements of the vector.

```
# This is our 1st working snippet
mean(student1[-which.min(student1)])
```

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

What about the other example students? Will this work for them? We could try using na.rm=TRUE argument for mean but this is not a good approach (i.e. unfair).

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

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

```
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 find the NA elements?

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

is.na(x)
```

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

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

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

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

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

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

Instead, we will make the NA elements zero.

```
# 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 should 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
```

Step 2: Now, we make our function.

Take the snippet and turn 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 will select '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 others who want to use this function.

Answer:

```
#' Calculate the average score for a vector of student scores, dropping the lowest score. Missing value
#'
#' @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 lowest score from mean
  mean(x[-which.min(x)])
}
```

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

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

```
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
```

Answer: The top scoring student overall in the gradebook is:

```
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
```

Answer: The toughest homework (i.e. obtained the lowest scores overall) on students is:

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

```
##      hw1      hw2      hw3      hw4      hw5
## 89.00000 80.88889 80.80000 89.63158 83.42105
```

```
which.min(ave.scores)
```

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

Additional practice: The homework with the lowest median scores overall.

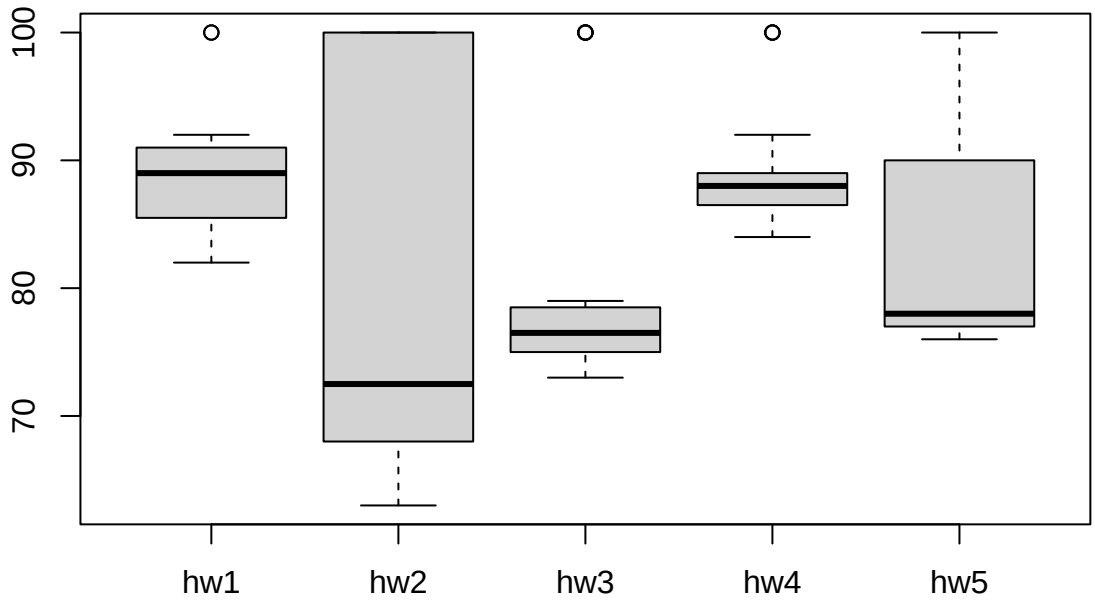
```
med.scores <- apply(gradebook, 2, median, na.rm=TRUE)
med.scores
```

```
##  hw1  hw2  hw3  hw4  hw5
## 89.0 72.5 76.5 88.0 78.0
```

```
which.min(med.scores)
```

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

```
boxplot(gradebook)
```



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. average score for each student) correlated with the results (i.e. scores) for individual homeworks (i.e. gradebook's 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$hw1)
```

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

Look at correlation of each homework.

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

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

Answer: The homework that is most predictive of overall score (i.e. highest correlation with average grade score) is:

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

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

```
which.max(cor.scores)
```

```
## hw5
##   5
```

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

Knit the document to make a PDF.