

First assignment: The Class

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Introduction

The first exploratory project in the Exploratory Data Analysis and Visualization focuses on the survey response dataset, acquired through the online questionnaire about statistical and technical literacy distributed among the students of EDAV class.

We want to analyze the characteristics of EDAV students in terms of 3 overall dimensions:

- Knowledge of tools
- Confidence in skills
- Preference of text editor

The data we will be working with for this assignment consists of survey responses from **114** graduate students, which are enrolled in one of the following programs:

- IDSE
- Data Science Certificate
- Statistics
- Others (includes QMSS, Applied Math, Biomedical Informatics etc.)

Cleaning the data

In order to work with clean and consistent data, we created a function called ‘tinydata’ that takes the *xlsx* file containing the raw responses and returns a consistent data frame used across all the analyses performed.

Tidy data transformations are stored as a script file named `tidydata.R` in our working directory that is sourced and run before we start the analysis.

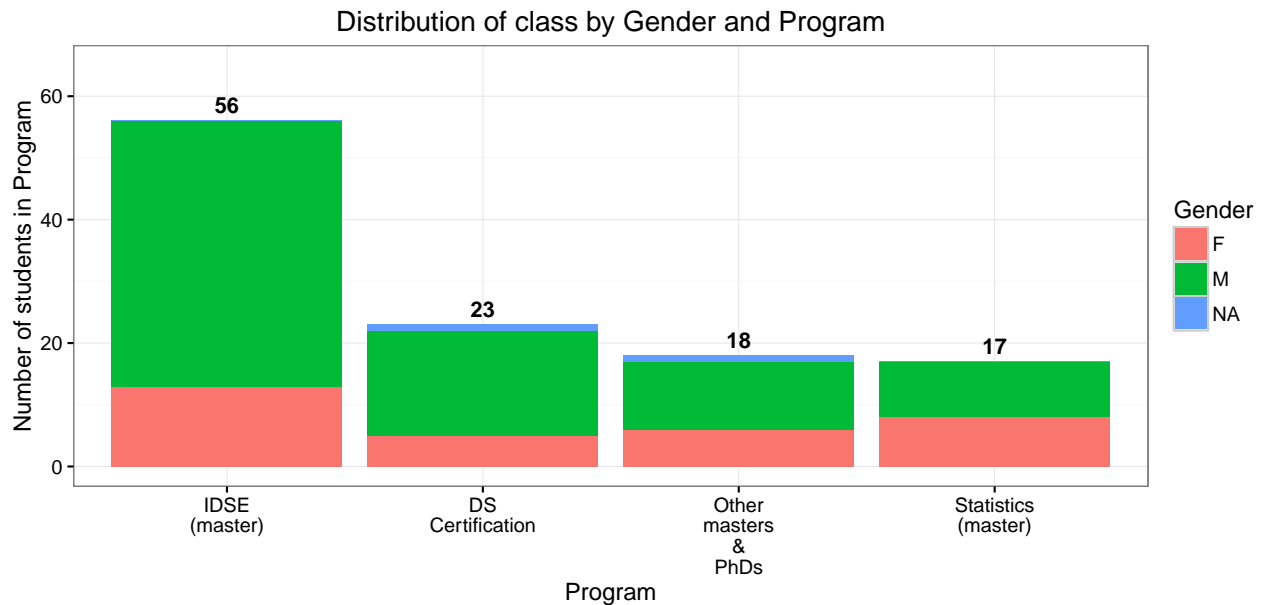
In a nutshell, tidydata does the following:

1. Removes the columns that have no observations in them.
2. Regroups the columns in a logical manner.
3. Organizes the factor levels in the following columns
 - a. Waiting List Info
 - b. Gender
 - c. Program
 - d. Text Editors
4. Splits the “Experience with Tools” column to multiple columns with a 1/0 value depending on if the skill was reported or not. Splitting the variable makes it tidy.

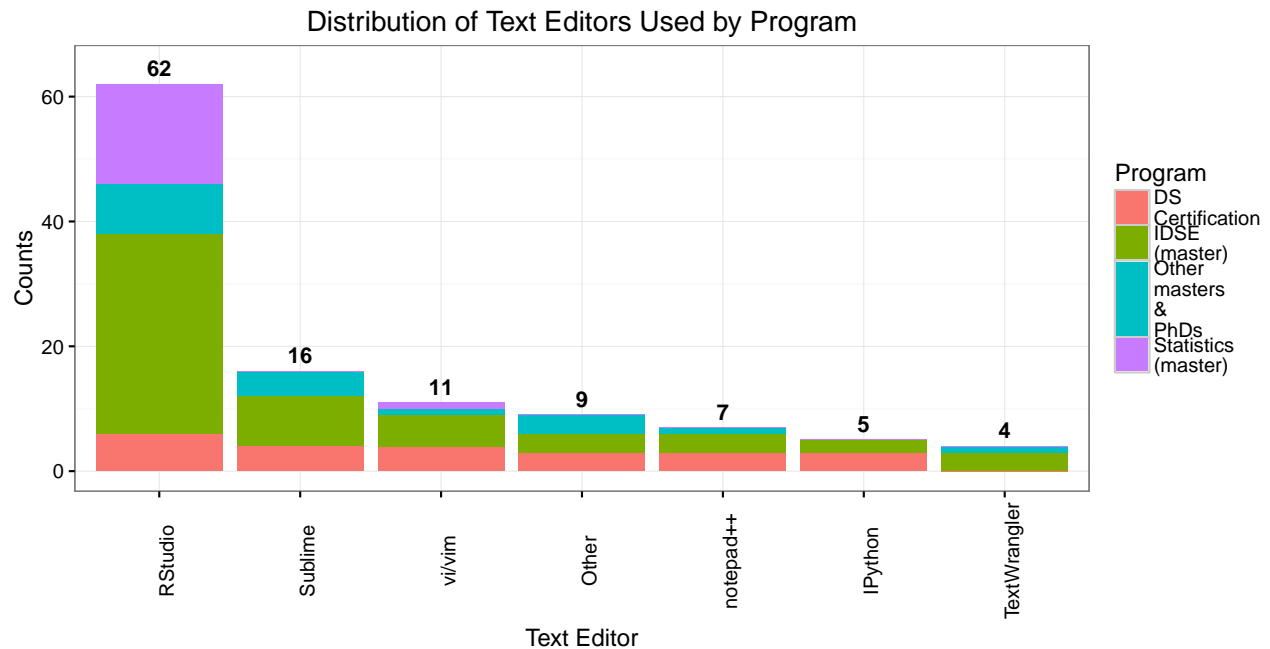
The codebook for tidy dataset is provided in the project main directory (`codebook.txt`), one can refer to it regarding the information each variable, its possible values, levels etc.

The distribution of respondents by program and gender is as follows:

```
#the source code for each plot can be found in /src/ folder in main project directory
source("src/tidydata.R")
source("src/GenderProgramPlot.R")
filename <- "raw/Survey+Response.xlsx"
df <- tidydata(filename)
GenderProgramPlot(df)
```



As it can be concluded from the chart, the men's population is considerably larger than women's in each of the programs presented on the course with relatively the same ratio across the programs. What is more, the chart allows us to judge to what extent each of the programs is presented on this course. The largest portion of students predictably comes from DSI master program since this is the core curriculum course within this master program. This block of students is followed by DSI certificate students, and the third large identified group is Master in Statistics program. However, there is 18 students more in the course whose institute affiliation is different from the programs mentioned above, varying from QMSS programs and Applied Mathematics PhD.



Another set of interesting facts can be revealed from the distribution of preferred text and code editors across the programs presented on the course. As the majority of students come from data science and statistics programs, it is quite expected that the leading code editor named in the survey is RStudio, which is the leading IDE for R development. RStudio is followed Sublime, which is one of the most widespread and very universal code editors in the market right now, and surprisingly the third place is taken by vi/vim, which is a quite sophisticated command line text editing tool, which indicates that the course accommodates significant portion of students with vast programming background, besides the overall programming literacy on the course is sustainably high. Surprisingly few people selected IPython as their preferred text editor, though it is considered as a really convenient interactive tool for Python development, which is also extremely widespread for statistical calculations.

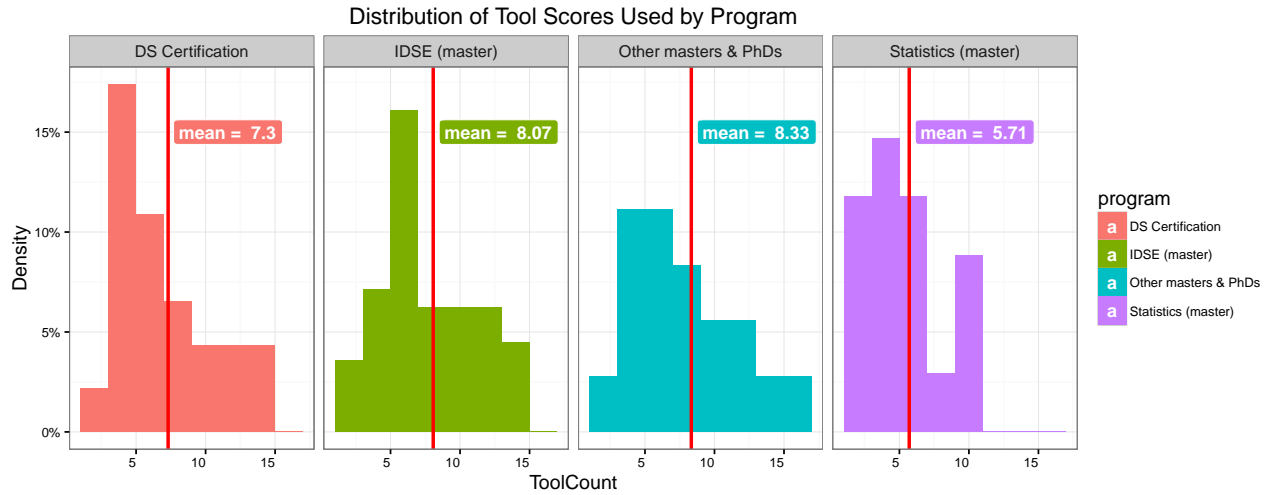
Speaking further, we would like to point out to another curious fact that can be spotted on this bar chart. Proportion of Data Science certificate students who have chosen RStudio as their preferred text editor is extremely low in both absolute and relative terms compared to the other programs and the other tools. This might suggest us the following conclusion: most certificate students come from the technical or semi-technical occupations and are exposed to writing code and developing products on the regular basis. However, this activity most probably is not limited to data analysis and statistical calculations, thus RStudio does not seem to be a natural choice for them and they stick to more universal and generally accepted tools like Sublime, vi, notepad++ etc.

We continue our analysis by exploring different toolkits that students from different programs pick to be using.

Knowledge of Tools

As we mentioned in the previous chapter, the respondents come from very diverse backgrounds and, as such, have learned and been exposed to very different sets of tools.

The questionnaire provided a list of **20 possible choices** to select from, corresponding to different tools, programming languages and frameworks, and each student was asked which of these he or she was comfortable working with. Multiple selections were available. As we can see in the following plot, “IDSE” and “Others” tend to know over 8 tools on average, compared to 5.7 by masters in statistics.

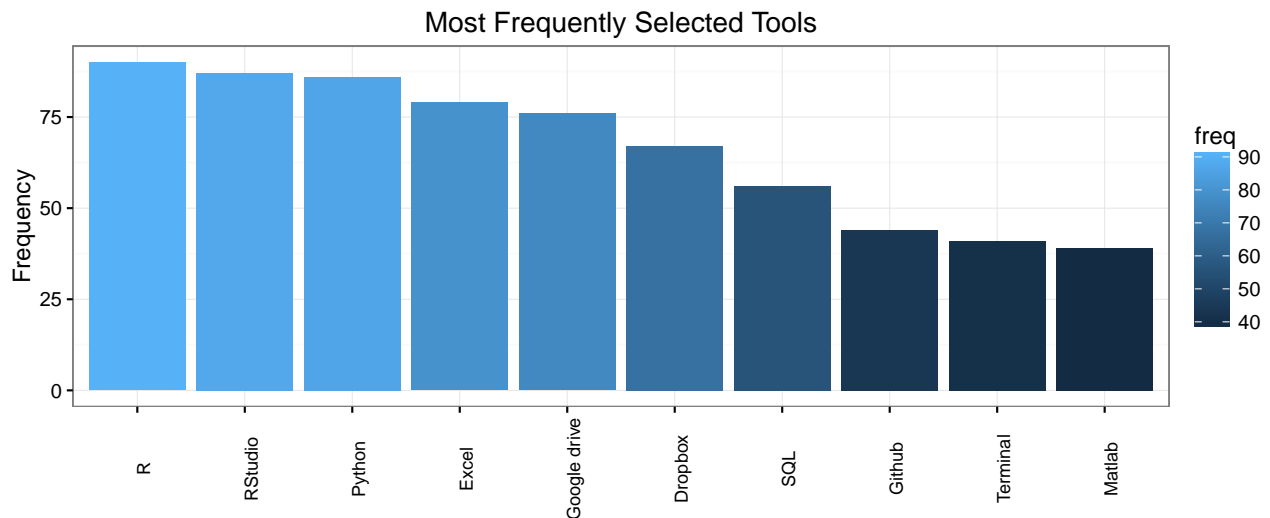


Taking into account the number of people in each group we can say that with certain level of confidence we can treat each of these four distributions as normal. And taking a look at the means of each distribution plotted above the bars, we can extract some potentially valuable knowledge:

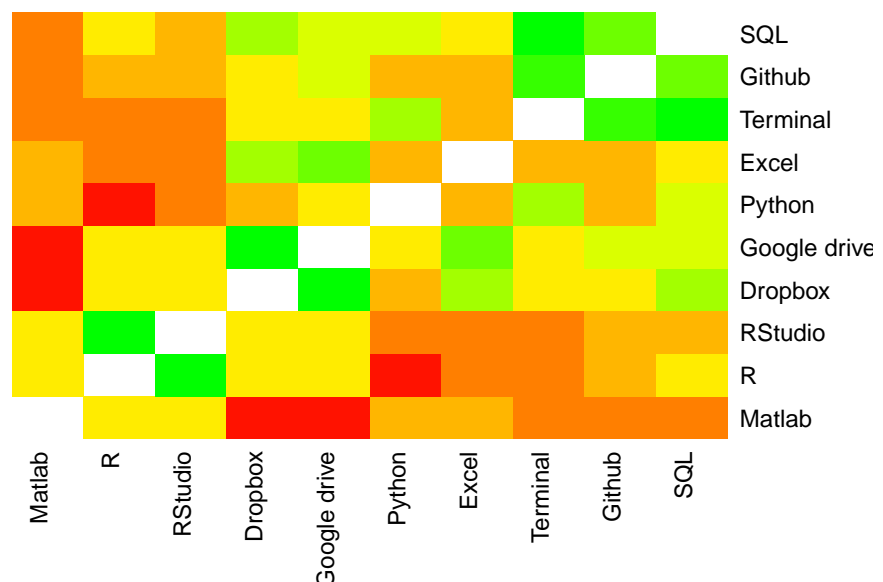
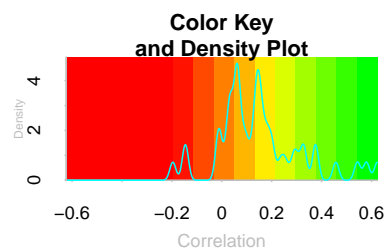
- Master students on Data Science program on average **8.1** have knowledge of bigger amount of skills considered data-related compared to certificate students. And as we remember from the text editor preference exploration, it corresponds perfectly with the fact that certificate students have a solid level of programming literacy, though they most probably come from different fields of IT industry and their work stack includes different programming languages and frameworks.
- Group of students from all other programs tend to have the highest average score **8.3**, which is really interesting, though might be an indicator of bigger academic experience among these students, hence broader range of used tools in data analysis. As we stated previously, PhD students were aggregated to this category and they can be those outliers, who drive the sample average to bigger values.
- Students from masters program in Statistics demonstrate the lowest score. This reveal can potentially correspond to the fact that Statistics programs focus on theoretical (*say, "paper-based"*) studies and exercises and do not have substantial experience with full stack of data science programming tools.

The next question we sought to answer was whether there are correlations between different sets of tools. In order to visualize this, we created a heatmap showing the correlation matrix for the top 10 tools.

At first we filtered out top 10 frequently mentioned tools, as demonstrated on the chart below. Then this set of tools was used to build a pair-wise correlation heatmap, which is also provided below. The point was to identify the tools that compliment each other and typically are mentioned together.



The very first glance at this color map reveals that the toolset picked for further exploration is actually very versatile in terms of correlation with each other. The color scale legend in the top-left corner demonstrates that the correlation values go from -0.6 to 0.6, which says about spurious nature of this toolset and students' experience with it.



As we can see, SQL, Github and Terminal have the strongest correlations, meaning that people that tend to know any these tools, on average will know how to use the other two with a higher probability than the average student.

- This result was somewhat expected. In general people with a stronger CS background will tend to know these three programs.

Interesting insights can also be observed by looking at the negative correlations seen between Python-R and between Matlab-Dropbox and Matlab-Google Drive.

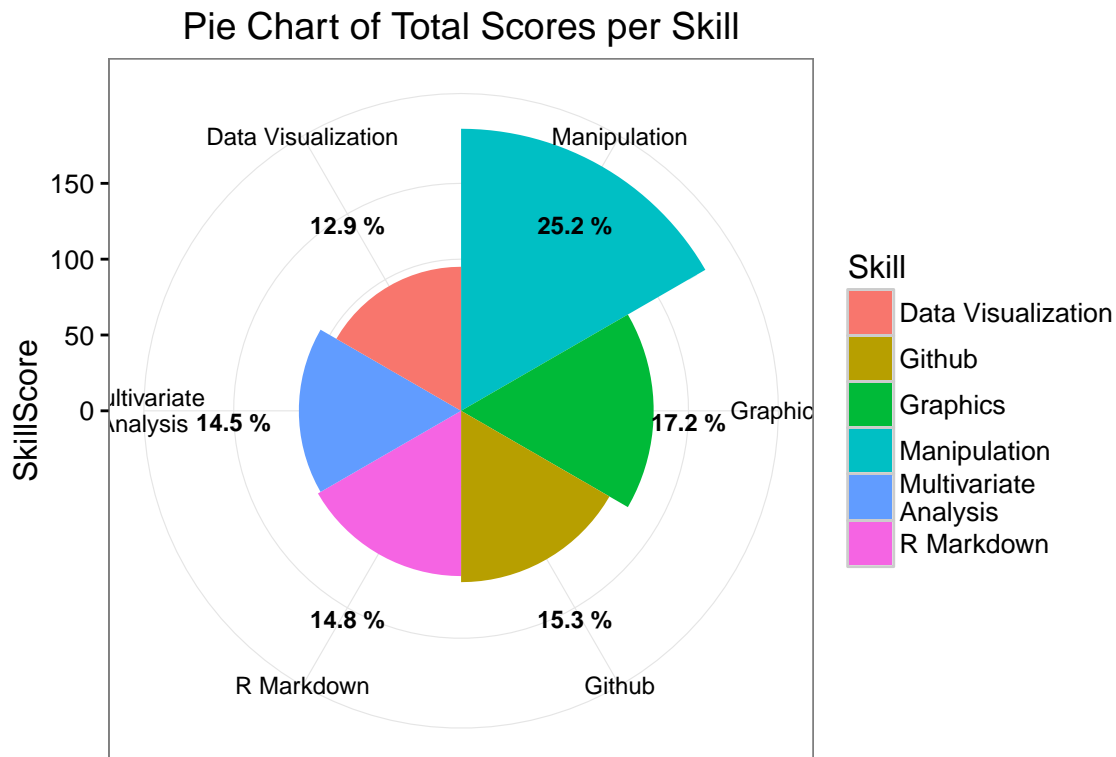
- We are not surprised to see a negative correlation between R and Python. In general, they can be regarded as “substitute” tools, so people can work with one without ever having to learn the other.
- The negative correlations between Matlab and Dropbox/Google drive are harder to explain. One potential explanation is that people that didn’t know Matlab felt the need to fill in more tools, and so inputted dropbox or google drive. It is important to remember that this information is self reported, which may lead to inaccuracies and inconsistencies.

Skillsets

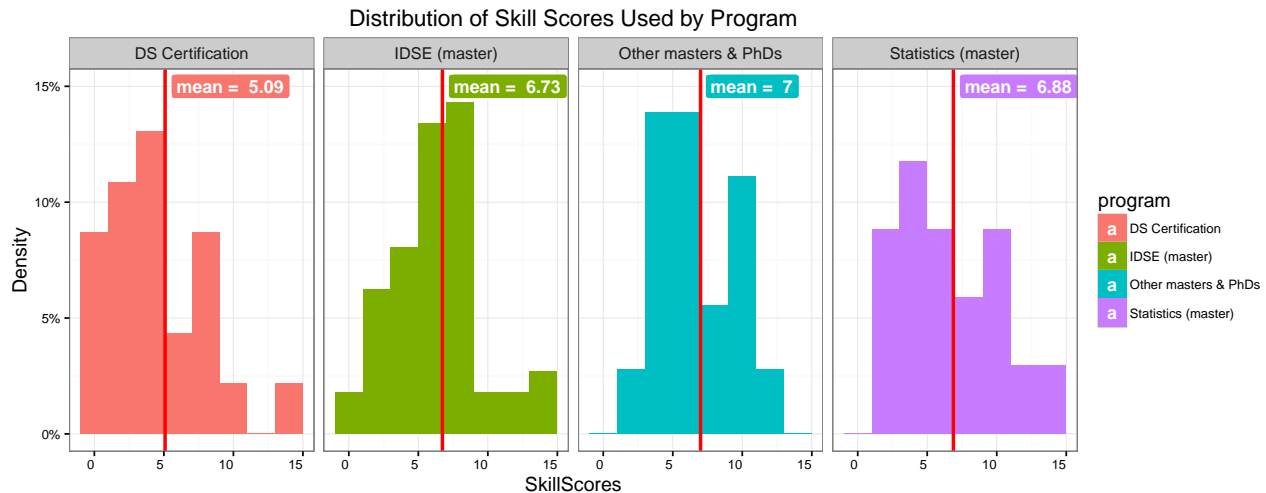
The next section of our work is dedicated to understand the skillsets that were reported by respondents.

The survey asked respondents to grade their level of confidence in 6 different dimensions which we call “Skills”. The possible responses were “None”, “A little”, “Confident”, and “Expert”. As mentioned before, we assigned values from 0 to 3 to these levels to be able to aggregate data and compute averages. It is important to mention that this score is not perfect for several reasons, starting with the fact that these are self reported levels of confidence, and equal weight is being assigned to each skill.

The first exploratory attempt we did was to compute aggregated levels of confidence (called scores from here onward). The distribution of scores by skill is described with the following pie chart:



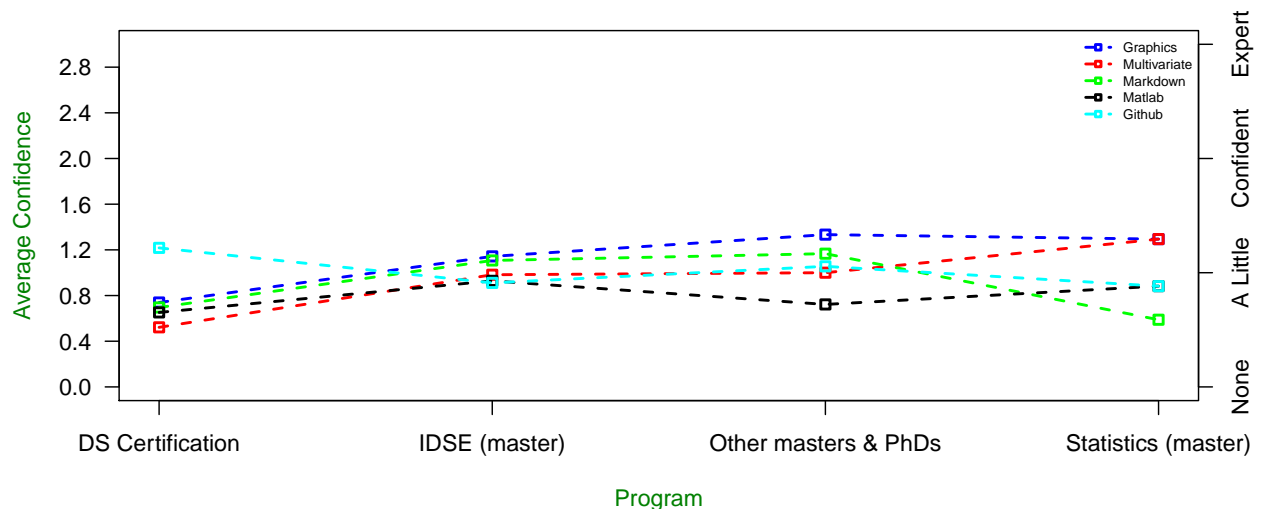
Not surprisingly, we see that multivariate analysis has the highest overall confidence level. Now, we wish to have a bit more insight about how these confidence levels look when grouping by masters.



Another follow-up to this study direction comes from the histogram analysis of skill levels of confidence grouped by programs represented in the dataset. The logic behind this chart is almost analogous to the one behind the tool count histograms provided in the previous chapter.

Interestingly, Data Science Certificates and Statistics masters students seem to have the lowest level of confidence in their skills. The category of others demonstrates the highest mean in this cross-section as well, which serves as yet another proof that PhD-level students demonstrated better academic and educational background towards this course, and those observations could leverage the mean of the respective sample up being outliers in that sample of students.

In order to understand which masters are confident with which skills, we took the analysis one step further to show with a plot this level of detail:



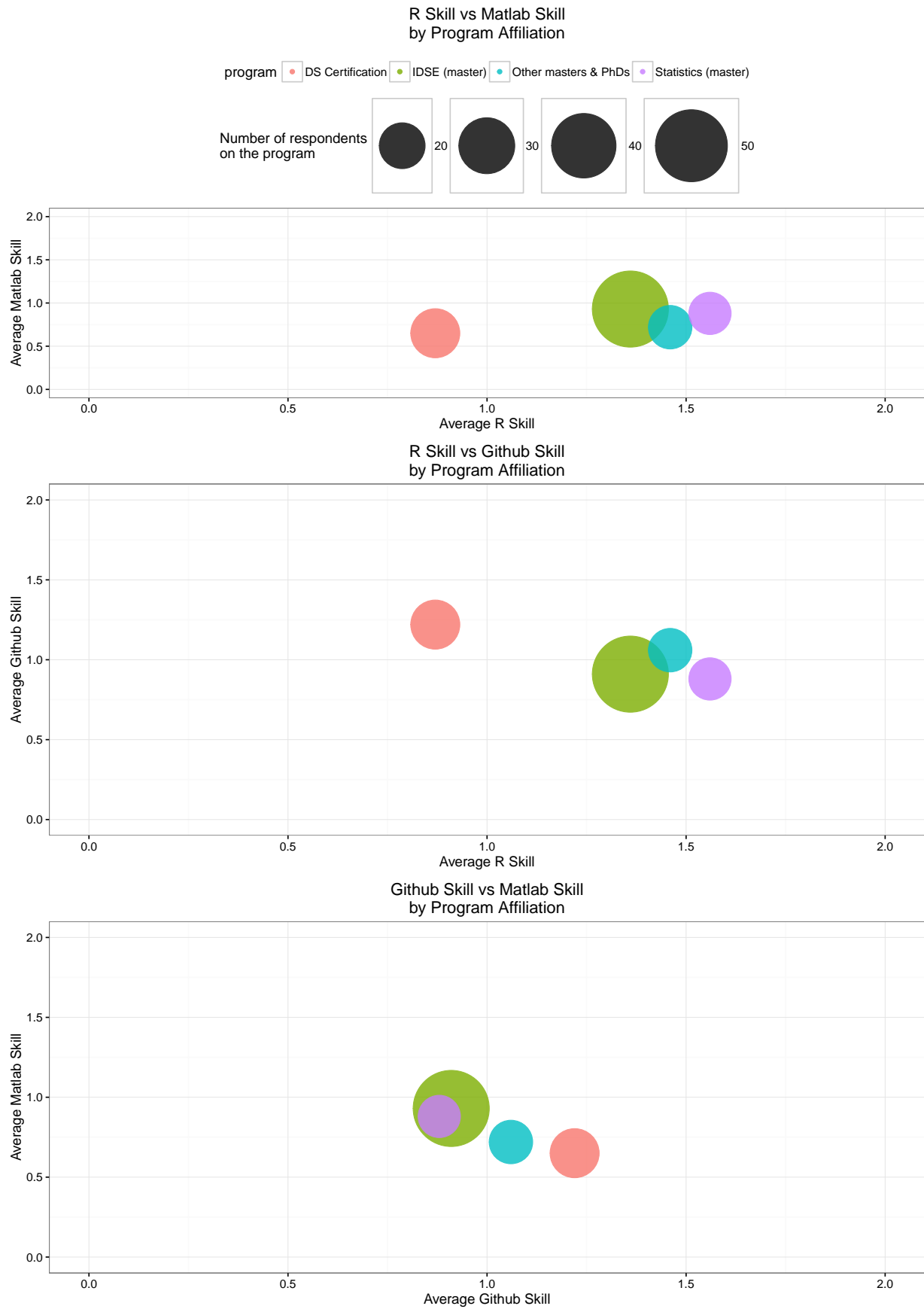
It is worth noting that most of the programs have on average somewhere close to “a little” level of confidence in the dimensions explored. However, we see some important differences across programs.

-Averages seem to be consistently close to a score of 1 (a little confident). -IDSE students seem to be the most balanced program, ranking relatively similar to other masters’ average. -DS certificate students scored remarkably high on Github, relative to their other skills. Relative to other programs, they scored quite low in every skill with the exception of Github. -Statistics students were relatively high in Graphics and multivariate analysis, but surprisingly low on Markdown, Matlab and Github (relative to what we would have expected)

Finally, to understand whether these skills tend to be correlated among each other, we decided to plot bubble diagrams to add new insights. For this purpose, we grouped these skills in 3 sets: Github, Matlab, and R (R set includes Multivariate analysis, graphics, and Markdown). It is important to note that the grouping is not

perfect, because not all multivariate analysis, or graphics are done in R, however, we believe that it is an acceptable way to group these skills given that R is the predominant tool that we observed (see previous analyses).

The line chart connecting levels of confidence in 5 data analysis and collaboration skills allows us to compare these levels program-wise, and indeed it brings a couple of interesting points to highlight. First of all, the results are generally coherent with what was demonstrated previously, master students are more familiar with data analysis core skills compared to certificate students. However, certificate students demonstrate the highest level of expertise with git and Github, which serves as a demonstration of their industry background – collaboration tools are the ones they feel themselves most confident with. They are making the shift towards data science in their careers, but we can clearly see the evidences of their previous experience in other field of IT industry. And finally, masters in Statistics predictably the most confident group of students in multivariate data analysis, as it is their domain of knowledge speaking in general.



These three bubble charts help us understand the correlation between the most predominant skills in the survey. The interpretation of the bubble charts are similar to those of the heat map. The top chart reflects little correlation between R and Matlab. However, the middle chart reflects that those who have dedicated themselves in statistical fields have garnered significant strength in R, but have not been practicing Github as prevalently. Likewise in the bottom chart, those in statistical fields are stronger in Matlab than Github which further affirms our conclusion.

Conclusion

The analysis conducted throughout this paper was targeted to reveal potentially interesting directions for further research of the topic if needed. Among these we would like to mention the following:

- Students in Statistics masters program show high level of confidence in multivariate data analysis which concur accurately with their field of study.
- Students in Data Science masters and certification program demonstrated much sophistication in technological tools which can be because of their extensive experience in technology industry.
- Other Masters and PhD students demonstrate highest combined mean score across various skills and that can be because the skills could be more academically oriented.

However, it should be noted that, all the conclusions drawn above might be purely speculative, and these suggestions might fuel further hypotheses and experiments designed to prove or disprove these hypotheses.