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MASTER THESIS

TITLE: Project for the development of a Higher Education Management Dashboard in R

MASTER DEGREE: Master's degree in Applied Telecommunications and Engineering Management (MASTEAM)

AUTHOR: Dimitrios Chatzos

ADVISOR: Prof. Vicenç Fernández

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Abstract

Dashboards are information management tools, for monitoring and analysing of different organization's behaviour. The purpose of management Dashboards is to observe, identify and solve problems and to justify patterns with monitoring the key performance indicators.

The Dashboards are not just reporting tools, they are interactive communication tools with meaning and purpose. They can analyse big amount of data and return as a result complete storyline of information letting the audience to understand how an organization works.

Thus, this Master Thesis aims to identify and analytically examine the key features, purposes, uses, and benefits of performance dashboards and to develop a Higher Education Management Dashboard in R for the needs of MASTEAM Master of the Polytechnic University of Catalonia (UPC).

The Thesis is highlighting the methodology and the designing rules for creating dashboards and taking the full potential and benefits of them. Based on them, in the Thesis is implemented a real education management Dashboard in R programing language.

The fundamental rules are used for the implementation of the MASTEAM Master Dashboard. The Dashboard will include the most important features and information about the MASTEAM, which are pointed from the coordinator of the MASTEAM through an interview.

The main goal is to give the coordinator the ability to observe and analyse the behaviour of significant areas in the Master. For instance, some of the areas are the enrolment status, student's information, grades, courses, graduated rates, etc.

Finally, the results of the programing part will demonstrate the last version of the MASTEAM Dashboard web page that can be used from the coordinator. He can monitor the behaviour of the Master and take necessary decisions. According to the visualised data, the maintenance of the good condition of the existing Master is also possible.

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As the Greek poet, Constantine P. Cavafy says *"Importance is not the destination but the journey"*, this achievement would not have been possible without any of my family, friends, advisors, professors and colleges until now.

Thank you.

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INTRODUCTION

The big increase of digital data due to Information and Communication Technologies is a universal phenomenon. Daily every company or organization is struggling to analyse all those big amount of data and to discover patterns that can help them to improve the productivity and the performance [1] .

Thus, analytics and management Dashboards were created in order to enhance decision making from humans, combining the management and the software programing languages. Hence, the development of Dashboards is increasing rapidly almost in every organization to provide a quick overview of their performance [2] .

Dashboards are defined as tools for analysing and providing detailed information about the status of an association and to mark the key performance indicators (KPI). Those KPI's can give the ability to the person who runs an organization to handle huge amount of data that is easier to manipulate them through Dashboards.

The organizations, which can take advantage from the creation of Dashboards, are not only the companies, but also universities that are handling in daily base with big amount of data. Universities have different departments and people who are working there such as professors, managers, students, until economists. All those areas need somehow to be monitored and controlled from the university.

Thus, the purpose of this Master thesis is to create a higher educational management Dashboard for the needs of the Polytechnic University of Catalonia (UPC) and more specific for the Master's degree in Applied Telecommunications and Engineering Management (MASTEAM) department [3] [4] .

The Polytechnic University of Catalonia (UPC) is among the greatest universities in the world and one of the best in Spain. UPC is fifty-one (51-100) in the world in Computer Science and Information Systems [5] . Moreover, is 47th globally and 1st in Spain in Telecommunications, according to the *"National Taiwan University Ranking by subject"* [6] .

UPC has several schools in Barcelona and in towns in the near like Castelldefels, Manresa, Sant Cugat de valles, Terrasa and Vilaniva i la Geltrú. All these schools have high education system and high reputation and history in the world.

The MASTEAM Master department belong to Castelldefels School of Telecommunications and Aerospace Engineering (EETAC) [7] . The EETAC is technical school of higher education system of UPC and Barcelona TECH.

The EETAC has a various fields of education programs in the fields of Telecommunications and Aerospace Engineering. The school is famous for his strong commitment with educational innovation and quality for activities that are related with the industrial environment and with main goal to contribute in the Society making it better in several technological fields.

The high education management Dashboard for the MASTEAM case will be implemented in R programming language and in the end, it will provide a functional Dashboard to the coordinator of the Master to monitor and analyse the behaviour of the Master.

To create a successful Dashboard for examining the performance of the MASTEAM many parameters need to be examined. Every Dashboard that is implemented need to have a reason and purpose, to be useful and to have the correct interactivity with the end user. Thus, this Thesis is trying to combine the programing part with the management philosophy and to give a different approach to any digital application, because the ideology of the programmer and the ideology of the end user most of the times is different.

The work present all the fundamentals and designing rules to create useful Dashboards and the benefits of them. The main four pylons that need to be carefully considered when creating a successful Dashboard are the Content, Layout, Colours and Fonts. Furthermore, the following step is to build the Dashboard's Wireframes. These are preprogramed Dashboard versions created on a paper and according to them will be programed the digital view of the Dashboard's web page.

The MASTEAM case contains an analysis of the Master that is done through an interview with the coordinator Dr. David Rincon Rivera. The interview will explain into details what are the important areas of the Master and what kind of data are needed for the Dashboard. Moreover, those data need to take the correct format and to be adapted inside the R program.

The preprogramed Wireframe versions of the MASTEAM need to be created also with the important datasets inside. According to those Wireframes the programing part will start. A detailed explanation of every part of the MASTEAM Dashboard will be provided by figures. The clarification of what is the reason and why everything was programed in the way that they are is included.

As final step, in this thesis the most important parts and parameters from the R code will be explained to provide a general idea how the program is working. The explanation of the R code is also important for the maintenance of the Dashboard, for future needs and can provide to the coordinator the ability to include new data inside for the new academicals years or to change the existed ones.

The remainder of the document is organized as follows. The first chapter presents all the information about the Dashboard's definition and all the fundamentals and steps that are needed to create a correct and useful Dashboard. The next chapter is analysing the MASTEAM case and is providing the results of the interview with the coordinator of the Master. The third chapter includes the creation of the MASTEAM CSV datasets and the creation of the Wireframes. The fourth chapter is implementing the MASTEAM Dashboard and is providing the results with figures and explanations. In the Chapter 5 is the explanation of the R code and the ways to maintain the Dashboard for future needs. Finally, the main conclusions and future work of the thesis are presented.

CHAPTER 1. DASHBOARD DEFINITION

The majority of the people had already use a reporting software and the question is why and for what is the need of Dashboards at all. Many user can say that dashboards are just another way of representing the information that already is in reports. The truth is that the Dashboards **are not reports** they contain abilities that never can be detected in a normal reporting software [8] .

The majority of reports until now are static without any interaction with the end user. Reports may provide useful information, but they are showing only one piece of the puzzle. What is more, many users (especially managers) lack the time to understand what a report or Dashboard means. Reports do not allow the users to add more pieces of information, dig in to real-time data, or change how information displayed are. Furthermore, reports only include pre-determined datasets [9] .

Dashboards are analytics tools that give to the users a consolidated view of the most important data. They fuse together real-time information in a simple, easy-to-understand, and dynamic format. Dashboards are especially useful to observe, analyse or compare multiple datasets at the same time [10] .

Dashboards can be detached according to role that they have and are either **strategic**, **analytical**, **operational**, or **informational** [11] .

Strategic dashboards support managers at any level in an organization, and provide the quick overview that decision makers need to monitor the health and opportunities of the business. Dashboards of this type focus on high-level measures of performance, and prediction. Strategic dashboards benefit from static analysis of data (daily, weekly, monthly, and yearly) that are not constantly changing from one moment to the next [11] [12] .

Dashboards for analytical purposes often include more context, comparisons, and history, along with KPI performance evaluators. Analytical dashboards typically support interactions with the data, such as drilling down or drill though into the underlying details [11] [12] .

Dashboards for monitoring operations are often been designed differently from those that support strategic decision-making or data analysis. This Dashboards are monitoring activities and events that are constantly changing and might require attention and response at a moment's notice [11] [12] .

However, a dashboard is only as effective as its design and that design should be dictated by the needs of the users. That is why defining the audience is an essential first step in Dashboard design [9] .

Analysing the different use cases in each areas as well as with the distinct needs of different users across the different organization can provide three categories or personas that are mentioned below [9] :

- **Information consumers:** The majority of analytics users fall in this category. These users prefer to work with a predefined dashboard experience where they can regularly view, interact with, and personalize a preconfigured asset.

- **Content creators:** A creator's self-service experience is more managed than predefined. These users want the ability to choose the data they need and supplement those existing dashboards and reports with their own metrics.

- **Data analysts:** An analyst's experience is entirely self-directed. These power users prefer to bring their own data, build their own dashboards and reports, and mine insights they can share with others.

Once is decided what kind of Dashboard it will be created according to his role (**strategic**, **analytical**, **operational**, or **informational**) and the users are placed into the three buckets above, the next step is to arrange interviews with each group of users about their requirements.

1.1 The guidelines of the dashboard design

After analysing the meaning of the Dashboards, defined the audience and the purpose of the Dashboard is the time to create an attractive Dashboard for the user needs [13] .

To create a successful Dashboard, need to be implemented some general rules and ideas for the designing part like a guidelines. These general ideas are the following:

- **Design for a target:** The designer need to follow the goal of the Dashboard, and who is the target user otherwise will fill the dashboard with too much useless information.

- **Keep everything at a glance:** The main page of the Dashboard need to give the information directly with no any additional clicks or scroll downs to the user.

- **Keep it simple:** Keep the Dashboard design simple and understandable to the end users.

- **Highlight the most relevant information:** The dashboard is like a page of a magazine, each location has its meaning and a different level of importance. Information and charts in random places are simple wrong.

- **Be clear:** The use of acronyms are bad. The use of legends is better.

- **Start from zero:** Chart axes must be used consciously. Every chart need numbers and limits.

- **Shorten the numbers:** Dashboards users want to see the overall picture.

- **Show the context:** Numbers carry their meaning only within their context.
- **Choose the right colours:** Many people suffers from colour blindness. Correct use of colours is important.
- **Design dashboards not reports:** Not all the details from the datasets are suitable for a dashboard.
- **Show variations:** Make the Dashboard able to make the math do not let users do the math.
- **Pick the right chart:** Each piece of information must be displayed using the correct chart in the dashboard. The correct visualization technic need to be chosen wisely.

Each piece of the information and data for the Dashboard need to apply these general ideas to be useful and understandable from the end user.

1.2 The fundamentals of dashboard design

After defining the general rules and guidelines that need to follow, they are four important fundamentals of Dashboard design **Content**, **Layout**, **Colour**, and **Fonts** that the designer need to know how to correct implement them. By manipulating each of these fundamentals, the Dashboard can be successful and useful to the user [9] [13] [14] .

1.2.1 Content

The content is the general view of the Dashboard how it looks and is giving emphasis to the important information. The correct content need to follow some general rules like to keep the content relevant, to keep it simple and to use iconography [9] [15] .

1.2.1.1 Keep it relevant

Already mentioned before that the content should be relevant to the defined audience. Part of accomplishing that is removing everything else. Simplify content and reduce visual elements to only the most critical pieces.

For example in a car the Speed meter that is the most important thing inside the car is huger and focused than all the other instruments. Finally, every Dashboard needs to focus in the important things and to give priority to the audience needs without any useless details than can confuse the audience.

1.2.1.2 Keep it simple

Data visualisation is one of the most important designing part on the Dashboards. The use of visualisation techniques is important but do not overload the Dashboard. Visualization techniques can be charts, plots and graphs.

Visualization is at the same time good and bad for the reason that if the Dashboard is overloaded as was mentioned before can confuse the audience. The designing part must focus only to the main data that need to be visualized.

Visual effects like background gradients, shadows, and 3D elements are not good to be part of the Dashboard. The correct colours and elements need to be created to be able to give emphasis to the parts that the user need to focus.

1.2.1.3 Iconography

The use of iconography is an important design part for the reason that the Dashboard content is limited to text and charts, so need to contain the correct icons that will help the audience to navigate their selves.

Iconography is important for both stylish and development reasons and icons like close, delete, eject, search and hide will make the Dashboard more useful and efficient for user experience.

For the iconography part, are two options, the first option to use an already existed icon font pack or the second option is to create custom images. The first option is more easy and fast for the Dashboard design the second option is time consuming and need drawing techniques.

The below figure ***Fig. 1.1*** is giving an example of some iconography icons.

Fig. 1.1 Iconography -icons- [12]

1.2.2 Layout

The layout of the Dashboard is sawing how the data are placed together. Moreover, if they are in the correct order and size and if they fill correct the entire Dashboard page without useless empty spaces. The layout need to follow some general rules that will be explained in details below [9] [16] .

1.2.2.1 Group related data together

Once all the data that are needed to be used for the Dashboard are gathered, need to be grouped together and to be related to each other. The data need to be visualized with the right size and in the right position to be able to highlight the most important parts of the Dashboard.

1.2.2.2 Keep uniform size

The size of the icons or the graphs is important to be the same and similar. This need to be done to reduce the distractions and let the user to be able to identify all the features in the screen. This method helps to make the design easier and geometrically correct. Different visualizations techniques can be created and placed together on the same screen. This can give different points of view to the dataset that need to be visualised.

Furthermore, the figure ***Fig. 1.2*** below is giving an example of a Dashboard page with the incorrect and correct layout.

Fig. 1.2 Layout -Wrong & Correct- [9]

1.2.2.3 Put limits to your data

One other parameter that need to be considered is to put reasonable limits to the data that will include on the Dashboard. This because the big amount of data may affect opposite and to distract the user.

The data need to be visualised correct and to be understandable from the users as the below figure ***Fig. 1.3*** is showing.

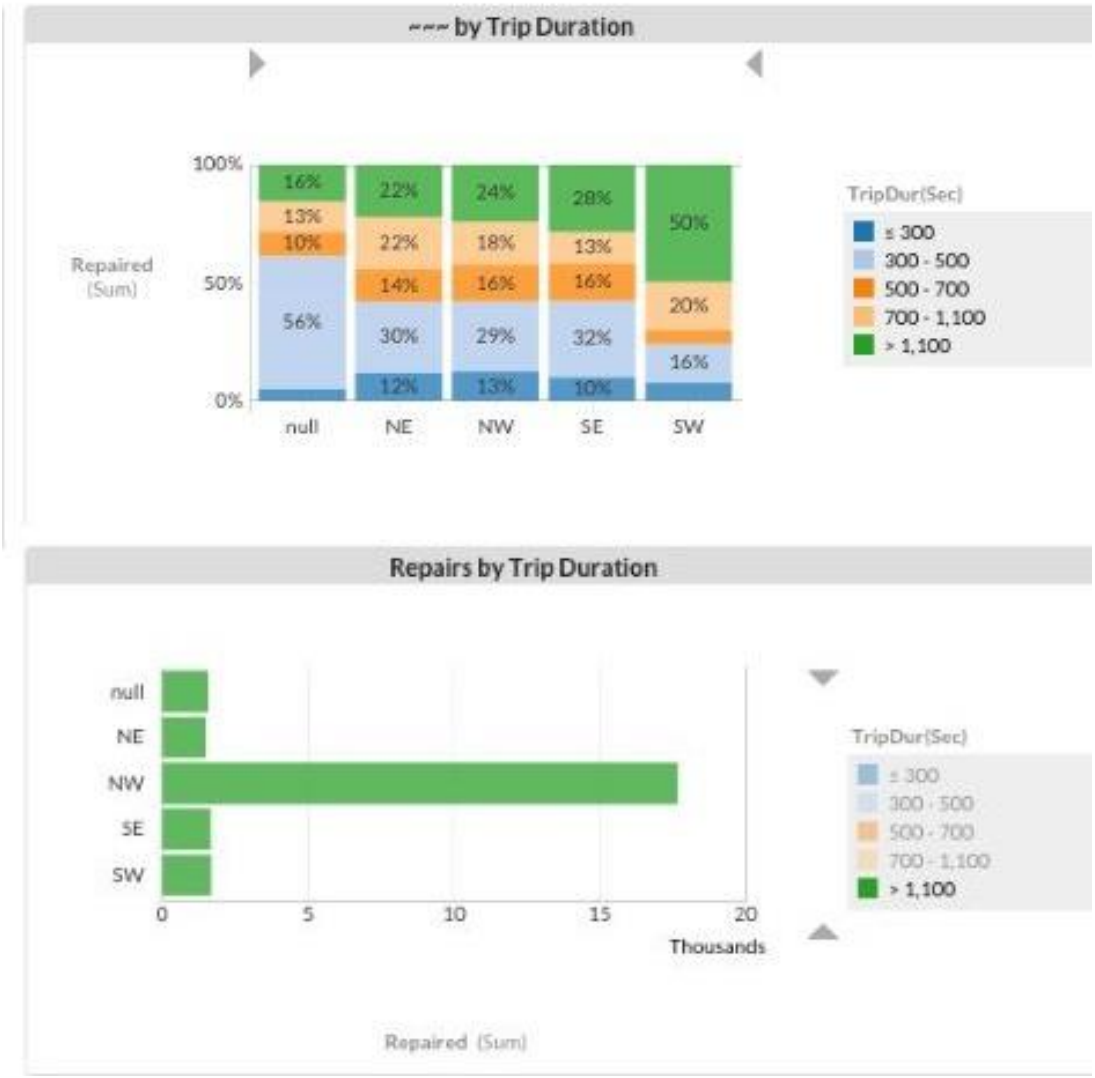


Fig. 1.3 Data limits [9]

1.2.3 Colours

One of the most important things to create a good Dashboard is the colours. Many users cannot understand the importance, of choosing the correct colours and is the first mistake that are doing when they are designing a Dashboard. Below are some colour parameters that the user need to take into account [9] [17] .

1.2.3.1 Leverage contrast

The correct and good choice of colours can be a good start for the Dashboard to make the data that need to visualize clear to the audience.

Different colour combinations need to be visualised to make the data easier for the user to distinguish the difference. The combination of the colours is important and need to be chosen carefully.

1.2.3.2 Use colours only for specific reasons

The colours in the Dashboard need to be used only for serving a specific reason. For example, when is needed to highlight something or to put the attention of the audience to that specific panel of information.

In the other hand, colours can be used also when a group of data need to visualised together on the same chart and need be to separate from each other. The different colour combinations are making easier for the user to understand and separate the data that are placed together.

The figure ***Fig. 1.4*** below is showing a chart example with different information in the same table with different colours.

Fig. 1.4 Colour combination [9]

A good method to choose colours is to have in mind not to use more than six different colours in the same visualization part. This is because the use of many different colours can make difficult for the users to understand the difference between the meanings of the datasets.

The use of natural colours is good to distinguish the information and the use of bright or dark colours for highlighting the important things.

When the colours are used, the programmer need to be aware that the background colour is the correct also. This is needed to make the other colours visible for the user to understand them.

Important is to keep in mind always that as long as the question ***"What aim does this colour deliver, and will it deliver it efficiently?"*** can be answered then the use of colours is been chosen correctly.

1.2.3.3 Pay attention to the meaning of colours

Important information about the colours is that they are not only colours. Every colour have also a background meaning.

For instance, when the colours red and green will be used most of the people will understand that red is colour to highlight something bad or to put a warning and the green colour to highlight something good. Another example is with red and blue colours that anyone can associate them with hot (red) and cold (blue).

The use of the colours needs to be with the correct purpose. For example the use of two different colours means that are two different information or to highlight something. Never use more than one colour to represent the same information.

Simple colours like black and white are good to be used to the Dashboard. This is because sometimes the simplest is also and the best way to represent something.

The Figure ***Fig. 1.5*** below is representing some colour combinations with white and black letters.

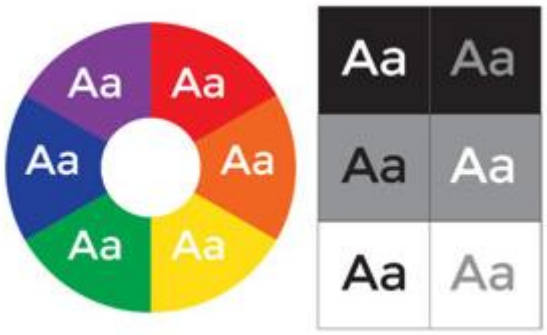


Fig. 1.5 Colour Font combination [9]

1.2.3.4 Test for colour blindness

Another important parameter for the Dashboard page that need to be taken into account is to choose the correct colours for colour blindness users [55] . Colour-blind users cannot recognise well the different colours, like red and green that are almost the same for them.

Statistics shows that globally 8 percent of men and 0.5 percent of women have a colour vision defect [55] . The colour blindness problem can be solved thanks to some simulator programs like Colour Brewer [18] . This program can help to make the Dashboard visible to all the users and all of them to understand the differences between the colours.

Furthermore, the below Figure ***Fig. 1.6*** is an example of a Dashboard for colour-blind users.

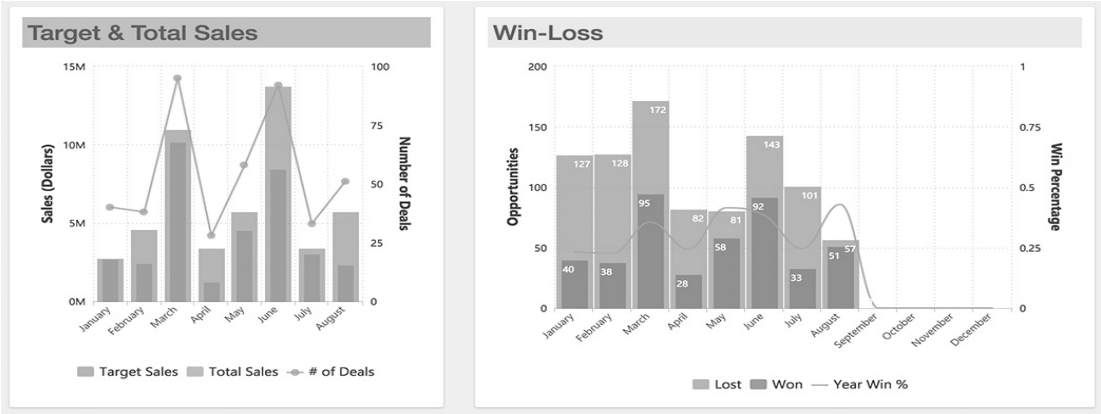


Fig. 1.6 Colour-blind Dashboard [9]

1.2.4 Fonts

After the colour part, another important parameter for the design is the fonts and the letters that will be used. Most of the times the general rule for the Font size is 12 for Times New Roman and 10 for Arial. Keep in mind that, all the fonts must be maximum three times the size of the original Font, when is needed to write something with bigger font [9] [19] .

1.2.4.1 Keep standard your font sizes

The goal is to design a Dashboard with homogenous environment that will be easy to give emphasis to the words and let the users to understand them.

An example of the correct use of the fonts is given in the below figure ***Fig. 1.7*** with the blue colour is the wrong font and with black the correct one.

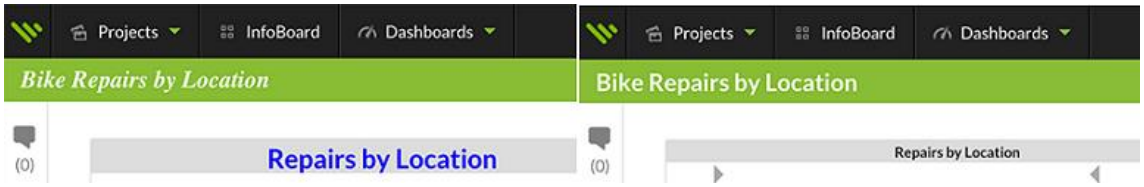


Fig. 1.7 Font size [9]

There are two main categories of fonts the Serif and the Sans-Serif families. Both of them have a different purpose in the designing part.

Moreover, Serif font is suitable for the main text that need to be included because is easier for reading it. On the other hand, Sans-serif fonts are more suitable for short texts, like headlines or words that need to have emphasis. This is because the Sans-serif font attract the attention of the user easier than the Serif Font.

The designer need also to decide how it will be the space between the lines and the space between the words or the individual letters. These simple details can make the text more readable to the end user.

Valuable information is that most of times the users tend to see first what is bigger in the screen without paying attention what is the font. That is also the reason that the headlines must be always bigger that the other text.

1.2.4.2 Combining fonts and colours together

The final part for the colour design is to combine the fonts and the colours together. Both of them need to be combined correct and visualized well together. The colours can give different approaches on the text, sometimes good and sometimes bad [20] .

For instance, is forbidden to design dark text together with dark background or white text with bright background. Another tip is not to use bright colours for the font with bright background, such as yellow font and green background. This will confuse and make difficult for the users to read something on the Dashboard.

The figure ***Fig. 1.8*** below is showing some colour combinations between fonts and background.

Fig. 1.8 Combination of fonts and backgrounds colours [9]

1.3 Visualization of the Dashboard

The part of visualization is the part that it will be decided how to visualize the datasets, for instance with toolbars charts, pies, etc. This part, it will provide the visualization techniques that will be used to visualise the important information that had been noticed on the interview part with [21] .

The way that the designer it will represent the data is the key to visualize big amount of datasets together. This can let the users to analyse the different datasets easy and without any problems [22] .

Furthermore, some main visualization types and charts can be used for the designing part. These visualization types are analysed into details in the below categories:

- **Tabular format:** This format is one of the best to visualize exact amount of data. This is because can be represented in rows and columns to analyse any kind of data providing the summary of them. Unfortunately, this format is not so good for analysing and comparing different data together. This is because the Tabular format it will be very complicated and difficult for the user to analyse it.

- **Line charts:** This format is good to visualize continuous data over time and to observe the evolution of them. Line charts are very useful for analysing data with different parameters and to notice if the goal is achieved or not.

- **Area Charts**: They are like the line charts with further information available inside about the datasets.

- **Bar charts:** This format is the best to analyse different data categories together in the same chart. Bar charts can be visualized horizontally or vertically. Bar charts can combine many datasets together in the same chart. The X-axis contain the different data categories that exit and the Y-axis is the numerical data of them that need to be compared.

- **Pie charts:** This format is the best to represent the percentage of different data together. The data are divided inside the pie chart according to the percentage that they have in the total 100% percent. Important is to use until five different categories inside the chart, because after five categories the Pie will be complicated and difficult from the user to understand it.

- **Heat Maps:** This format is suitable to provide and analyse geographical areas. Heat maps can be used also for weather data analyses and prediction. An example of Heat Maps can be observed in the figure ***Fig. 1.9*** below.

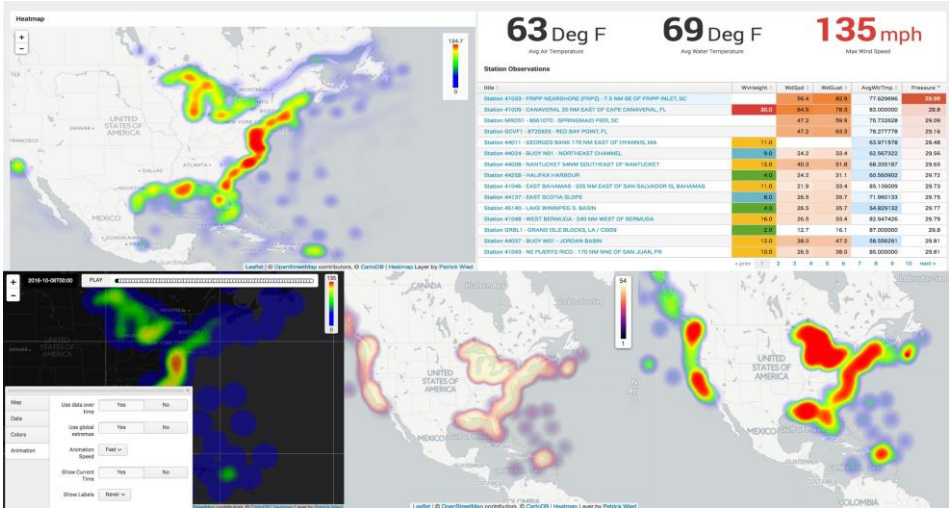


Fig. 1.9 Heat maps [21]

- **Bubble Charts:** This format is proper to visualize datasets in the three dimensions.

- **Funnel charts**: This charts, are used to represent the different stages in a sales process and to provide the loos or profit in every step. This type of chart is suitable to identify potential problematic areas in the organization's sales processes. A funnel chart is similar to a stacked percent bar chart.

- **Sparkline Charts:** The Sparkline is a very thin line chart without axes or coordinates. It represent the general observation of the data (typically over time) in different calculations, such as temperature or stock market price, in an easy way to understand them.

- **Pyramid Charts:** Are ideal to provide comparisons between datasets. They are using the thickness of layers to designate the relative values.

- **Radar chart:** This chart is a method of displaying multivariate data in the form of a two-dimensional chart of three or more quantitative variables represented on axes starting from the same point. The relative position and angle of the axes is typically uninformative. Alternative names include polar chart, web chart, spider chart, and star chart.

- **Scatter Charts:** This format can be a chart or a mathematical diagram that is using the Cartesian coordinates to display the values from two different datasets. The data are displayed as collection of points and each of the points have the value of one variable in a determined position on the horizontal axis and the same for the other variable on the vertical axis.

- **Whisker Charts (Box Plots)**: This chart is a method to provide analytically groups of numerical data through their quartiles. Box plots may also have lines outside of the boxes that are indicating the variability outside the upper and lower quartiles, hence the terms box - whisker plot and box - whisker diagram.

1.4 Visualisation Techniques

The next step for the visualization part is to decide how the Dashboard need to be visualised. There are three visualisation categories the Static, the Animated and the combination of the two of them together [21] .

1.4.1 Static visualization

The Static visualization highlight only the important information and keep the Dashboard static. This means that the user is not able to do any additional actions, because everything is represented in the main page. Static visualization can be a text or an image. This visualization technique does not need any live browser or any add-ons because the data are designed not to change [21] .

1.4.2 Interactive visualization

Interactive visualization give the option to the users to interact with the data inside the Dashboard. The Dashboard now looks animated with extra options such as drill down and drill-through and let the user to explore all the information that are available.

For this visualization technique, the data can be also live-stream and to change through time. The live-stream technique need some advance options like Flash player or HTML5 [21] .

1.4.3 Drilldowns vs. Drill-Through

The interactive Dashboard include also some other options, like drill down, drill-through and zoom out/zoom in that are analysed below [21] .

1.4.3.1 Drilldowns

Drilldown technique have the ability to move from general data to more detail data, focusing on the things that the user want. The user is able to search through deeper layers and to click to the information in order to reveal more details.

1.4.3.2 Drill-through

Drill-thought allow the user to jump from one report to another with the specific ability to focus on specific data. The users can right-click in the data that they want and to Drill Through inside the pages to get more details that are available.

1.4.3.3 Zooming

Zooming is the ability to dig deeper in the visualization part letting the user to click and see more details. For example, a map that the user can zoom into geographical places for more details, or a timeline chart with the ability to zoom and focus in a specific year and time for more details.

1.5 Validation of the Dashboard

The last and the most important step to finish the Dashboard is the validation part. The purpose of this step is to discover what the user’s opinion about the Dashboard is. This is because the user may have different opinion than the designer for the general view of the Dashboard [23] .

In this part the designer need to implement some beta versions of the Dashboard with the main datasets inside. This part is showing in action how the combination between the main ideas and the datasets are visualised together.

The final information about the Dashboard that the designer need to know is how the Dashboard interacts with the end user, if is correct or not. That information can be provided through the beta versions of the Dashboard that the designer will create and give to random users for evaluation.

The validation part is especially important but need to be with the correct use. Changing the Dashboard many times through the beta versions, may affect the main idea of the Dashboard and destroy all the work that is done until now.

Through the evaluation of the beta versions, the users can give feedbacks for the design. The user experience is the most important parameter to understand how useful or not the Dashboard is. Letting the users to interact with the Dashboard betas in daily base can make the designing part easier. Through that, the designer can ask the user's opinion for how to make the Dashboard better and more useful.

The users can answer to some basic questions such as "How they prefer the data to be visualized", "what kind of data and information are better for them", or "what is useful for them to understand the data results".

The designer can also ask the users to draw some basic ideas about how they think the Dashboard, or to provide some small examples about how they think that the Dashboard can be better.

During this process, the design of the Dashboard can be improved. The designer can solve in advance problems that has not thought before for the Dashboard design.

1.5.1 Build a Wireframe

Important step for the validation of the Dashboard is to create these beta versions of the Dashboard. The beta versions for the Dashboard is called wireframe. Wireframe is nothing more than a basic draw of the dashboard with all the datasets together to show how they look when will be visualised [24] .

The wireframe is the draft version of the Dashboard and looks more like a painting than an application. Is common the main ideas to be designed first on a paper and then to proceed with the programing of them, as can be observed in the example of the figure ***Fig. 1.10*** below.

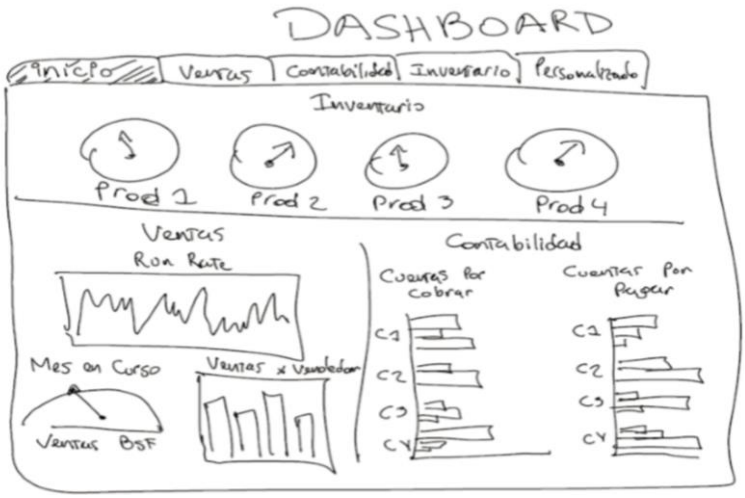


Fig. 1.10 Example of Dashboard Wireframe [23]

The wireframe is providing to the designer how it will distribute the space that has and how will put the charts, buttons, images and the data all together. Knowing from the beginning where to put all these charts, buttons or images etc. can save precious time from the programming part.

1.5.2 Build prototypes

After the wireframe creation, is the time to build the first prototype of the first Dashboard version. Remember that this is not the final version of it. Below is an example of a prototype that can be analysed on the below figure ***Fig. 1.11*** [25] .

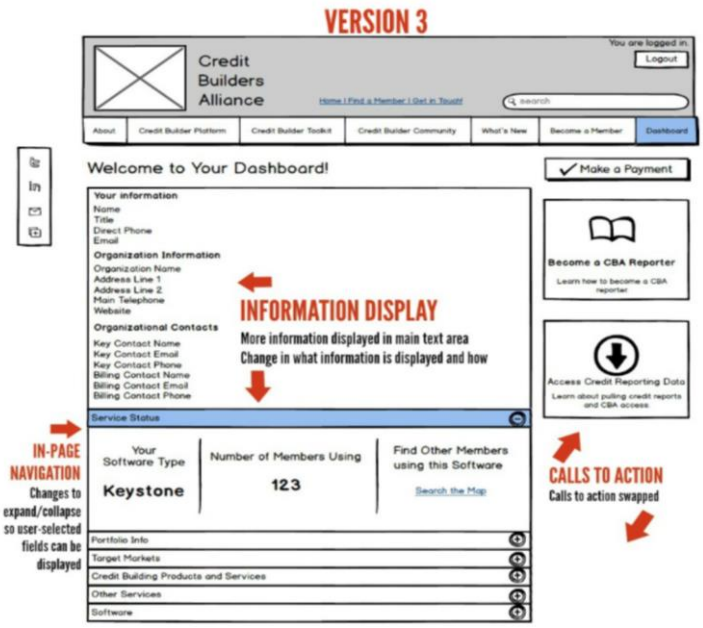


Fig. 1.11 Dashboard prototype [23]

As the figure ***Fig. 1.11*** is showing, this will not going to be the final version of the Dashboard. More than one versions of the Dashboard can exist. The design can be developed further over time and over the prototypes, with improvements until to obtain the desirable design.

The feedbacks from the users is the important parameter here to know until when the Dashboard need to be improved. When the users star to give more positive feedbacks than negative ones then the improvement part is almost done. Is almost impossible the Dashboard to be for all the users perfect so is normal to have and some negative feedbacks all the time.

1.5.3 Regularly tests and upgrades

Finally, important is when the design is finished and the final version of the Dashboard is done to not stop searching how to improve it in the future. Keep testing the Dashboard and taking into account all the feedbacks from the users is a solution. Remember that everything needs to be evolved over time and to provide new updated versions of the Dashboard in the future.

1.6 Future work of Dashboard Design

Everything that is evolved with the informatics and technology need to keep evolving through time, the same is with the Dashboards. Is important for every Dashboard to be the same useful like the first day until the end [26] [27] .

Below are some important parameters for the future evolution of Dashboards that the designers need to implement in the designing part:

- **Simpler Interfaces:** Simpler interfaces means that the designer need to create a successful interface with a good user experience easy to understand and easy to navigate. No more big letters without a purpose, no more many colours, no more three-dimension treatments that can distract the user. Remember that simpler does not mean that just put text and that is all, simpler mean to provide an easy and useful user experience.

- **Needs of the On-the-Go User (Mobility):** As technological evolution keep growing so much the users are more and more attached to their phones and tables so that means that the Dashboard need to provide them good mobility experience.

- **Colour Balance:** As was mentioned before no more many colours without meaning. There is often problem in some Dashboards to be either too much colourful or to less. The design needs to be “Colour Balanced” with the meaning of monochromatic background colours in contrast with bright colours when something need to be highlighted on the datasets.

- **Iconography**: Less is more, is the main rule of the future Dashboards and Iconography is a part of that. Designers need to create more often Dashboards with small icons or photos with short descriptions to let the user to understand directly what they want to see without reading the content. Some “smart” photos can give an efficient and quicker navigation interface.

- **Dynamic Dashboards:** Dynamic Dashboards is the future of Dashboards for the reason that any dataset need to be able to be upgraded and interact with the Dashboard at any time. The designer need to be able to customize the Dashboard at any time and to provide new things to the users as the technology and the Internet evolves. Without a Dynamic Dashboard, it will impossible for the designer to upgrade the Dashboard for future needs.

- **Interactive and live data:** Interactive Dashboards are needed in our days for the reason that the users are more technological efficient than in the past and it will be more interesting for them to interact with the data and to have more options to analyse them. All the techniques that was analysed before like zooming, drilldowns and drill through plus elements like videos need to be includes in the design.

The most important thing now is the Data to be live, users are more interested to see what is happening at the moment that they are searching for something than to have only past datasets.

- **Dashboards with High Location Technology:** In the past, the traditional computer Dashboards were using static maps for analysing different areas when the user wanted. Now with the mobility evolution the Dashboards need to be more efficient and with the use of mobile Gps to be able to analyse datasets that they are in the same geographical area automatically.

- **Future prediction on Dashboards:** Until now, the user is used to see on internet weather forecasts, election forecasts or in mobile phones possible text prediction according to the text history. The next big thing on the Dashboards is the data analytic predictions. Analysing information from different datasets can be useful to predict patterns and facts that are inside the data and to help the users or the companies to organise their plans better.

CHAPTER 2. ANALYSIS OF THE MASTEAM CASE

One of the most important things for the creation of a successful Dashboard is to know in advance for what reason and why is going to be designed. This will give an advantage when creating a Dashboard with the most relevant information that the user want to observe and analyse.

To know in advance that important information is needed to learn how the user is thinking and what kind of information want to see on the Dashboard. To achieve that and to gather that information some interviews between the user and the programmer need to be arranged as it was explained already in ***CHAPTER 1***.

For the purpose of the MASTEAM Dashboard, an interview with the coordinator of the MASTEAM Master Dr. Rincon Rivera David was arranged. This interview provide in advance the information that is important for him and that will be used to create a successful Dashboard.

2.1 Creation of the Interview questions

Important for the interview part is to prepare a list with possible interview questions. Those questions will refer to the MASTEAM topics and will have an explanation why they are important for the designing part.

Choosing the questions is valuable, because from that will be more understandable what is important for the Dashboard through the correct questions and what is not through the wrong questions.

The main idea for how the Dashboard need to be is most of the times different for the prospect of the designer and from the prospect of the user. Most of the times the designer probably does not know how important or not is what is designing or what is the purpose of putting a specific information on the Dashboard.

For the purpose of the MASTEAM interview, was created a list with possible questions with an explanation to each of them why they are important to be included on the Dashboard. Following are the interview questions for the MASTEAM case.

- **How much are the Tuition Fees? -** Is important to know how much the Master cost, or what are the other economical information that the Master include.

- **Enrolment status -** Maybe the most important thing that the user want to see any time on an Educational Dashboard is the current status of all the Master students and enrolment applications.

- **How many are the courses on the MASTEAM and which are they? -** Like in any education institute, one of the most important thing that the user want to know are the offered courses.

- **The total grades of the courses -** It is important for the evaluation of any subject to know what the grades of each student are.

- **The percentage of the graduated students -** Important parameter for the evaluation of the master in total every year and how successful the Master is.

- **Information about the students like age, gender, nationality -** Any information about the students is important before the enrolment and during the Master for the evaluation system.

- **How many are the new students in each semester? -** Important information because the master is divided in 2 periods and there new students every autumn and spring semester.

- **How many internships the University is providing and what kind -** Useful information to know any time what are the internships that the MASTEA provide and to inform anyone that is interested.

- **How many students are going after the MASTEAM for a PHD? -** Maybe important information to know what is the percentage of the students that are going for PHD.

- **How many are the professors that the master have and how many of them with a PHD degree? -** Possible information for someone that is interested for the status of the professors of the master.

- **Who are the professors that are involved in the research projects and the students that are participating? -** Possible useful information about the professors and the students that are involved on university projects to help for evaluation purposes.

- **What are the external activities that the MASTEAM offer? -** Useful information to inform the students about any activities that the master offers like seminars, workshops, etc.?

- **Nobilities about the students -** Like in any Master degree there students coming from other Universities for a double degree or for Erasmus or the opposite students of the MASTEAM are going to other Universities for the same purposes.

- **What is the Evaluation system of the MASTEAM? -** Any information that can be included in the Dashboard about evaluation purposes is important.

The creation of the interview questions is a part that most of the times is individual and different for every designer that want to design a Dashboard. A successful formula for specific questions or instructions that the designer can follow does not exit.

Every Dashboard is different and could be with various purposes. Every possible question that can be created for the interview part is very individual and based on what the designer is thinking as important for the Dashboard. All the real important parts of the Dashboard will come through and after the interview part.

Furthermore, it is important to notice that every possible question that the designer consider for important or not, maybe will not going to be from the same importance for the user that is involved in the interview. It is possible to have similar thoughts or very diverse ones.

As mentioned before, it does not matter if the questions are correct or not, the purpose of the interview is to learn what the most relevant information for the Dashboard are and through them to evolve what is already planned.

During the interview part, not only the designer can be effected positive but also the user. The designer knows better what can be visualised or not, and can explain to the user through the interview, that every possible dataset can be visualised in ways that the user might not thought before.

2.2 Interview part

During the interview with the coordinator, Dr. David Rivera Rincon, many useful things about the Master were mentioned. The important information that need to be included on the Dashboard was specified and the unnecessary information was excluded.

The interview was very useful for understanding how an educational Dashboard needs to be. In addition, it was detailed the purpose of every information and how it will be visualised.

The main mistake in the prepared questions for the MASTEAM was acquired from the fact that not all the questions were made from the perception of the coordinator, but instead of what a student want to see on the Dashboard.

According to the interview, only the bellow information is useful and important to be included in the Dashboard:

- **Enrolment:** The most important data that has to be on the Dashboard include all the information about the students, the old ones and the new enrolled ones for studying the MASTEAM. In addition, it should include the percentage off the accepted applications and the rejected one.

- **The Courses:** The number of the courses, their explanation and the edition of the course according to the year and the semester.

- **Number of students:** The number of students that the MASTEAM has in total and in each course individual. Furthermore, what is important here is the number of new students that are enrolled in each semester.

- **Grades:** The grades of the students in average and in each course individual. Also the total average of the grade on each course.

- **Percentage of Graduated students:** Here, it is meaningful to know the percentage of the graduated students, adding the initial and end year of Master. It need to be included also the percentage of the students that failed to graduate or they quitted for some reason.

- **Information about the students:** Important information about the students such as age, gender and the geographical region European citizens or not. Necessary for this part is also the universities that the students studied before, for instance if they had studied in UPC, in different Spanish university or universities abroad.

- **Information about Internships:** The students who were evolved in internships and the evaluation that they received Also a list of the top companies where students can do an internship.

- **Information about Motilities:** The students that are coming to study MASTEAM, which are from ERASMUS or from double degree programs. The opposite should be pointed as well who are the students from MASTEAM who are going abroad. Important to know here are the number of the students, the grades on each lesson and the average grade in total.

- **The evaluation System:** Last but not least, the Dashboard need to provide the evaluation system that every university has and need for each Master individual. This can evaluate all the activities that the MASTEAM provide and give a total score that is important for the Government.

After the end of the interview part, it is clearer what kind of data need to be included in the MASTEAM Dashboard. The way to visualise the data is also clearer now.

One important issue that may exist about the MASTEAM data is, if is allowed everyone to have access to them due to the data privacy regulation. Moreover, the reason to include these data inside the Dashboard and the purpose that the user is going to use them might be an issue, this because need not to violate the human rights.

Furthermore, another issue that may exist is that only authorized users from the UPC directory have access to the datasets that contain information about the University. This might be a problem for the programmer, but not for the coordinator of the Master because he is an authorized user and he has the rights to access this kind of information.

Finally, after all those useful information obtained during the interview part and taking into account all the issues about the data privacy, the next step is to decide what datasets will be used for the MASTEAM Dashboard.

CHAPTER 3. MASTEAM DASHBOARD DESIGN

The most important parameter to create a Dashboard is to know in advance, which kind of data will be used for the designing part and what is the purpose of them.

Due to the data privacy issue is preferred the creation and the use of non-real datasets, that they will contain fake but relevant information about the MASTEAM case. The creation of those possible non-real datasets examples thy will be explained below.

The datasets they will be in CSV format and they will include information about the enrolment, information about the students including their grades and all the information about the courses. Moreover, the datasets will contain the information about the academicals years 2015, 2016 and 2017.

Additionally, it need to be mentioned that the Dashboard can manipulate any kind of information and datasets, not only the datasets that they will be created for the MASTEAM case. The fake datasets are only an example, which through that real data can be implemented.

All the important data will be included in the Dashboard as individual categories and as combination of all the datasets together. The goal is to provide the general view of the MASTEAM only in one screen and latter to analyse the data into details in different pages.

The main idea is to create a Dashboard page that will contain the important data about the enrolment and the students together. This approach can show to the coordinator the general view of the MASTEAM Master directly from the first page.

After the creation of the first Dashboard page, the next step is to create the other pages, separating the Dashboard into different categories and examine them with further details. For instance one page with the data about the students, one page with the grades or one page about the MASTEAM courses.

3.1 Creation of the MASTEAM datasets in CSV format

To create the MASTEAM Dashboard is needed to import the data inside the programing platform. The datasets they will be in Excel CSV format and they will include the non-real data that was mentioned before.

The datasets that were created for the MASTEAM case are the following ones, 1) **Enrolment CSV dataset**, 2) **Students Information CSV dataset**, 3) **Students Grades CSV dataset**, 4) **Courses and Grades CSV datasets** and 5**) Number of students per course CSV dataset**.

All the above datasets they will be explained with further details in the below subchapters. Figures of every CSV dataset is also included.

3.1.1 Enrolment CSV dataset

The first created dataset was the Enrolment CSV file that contain information about the students who enrolled the MASTEAM in years 2015, 2016 and 2017.

The Enrolment CSV file contain the total number of applications that the interested students applied for the MASTEAM, the number of the applications that had been accepted, the number of the rejected one and from the accepted applications the number of the student that finally enrolled to the Master.

Furthermore, the below figure ***Fig. 3.1*** is an example of a possible CSV file with the enrolment information.

A1 | Enrollment

	A	B	C	D	E	F	G
1	Enrollment	Applications	Accepted	Rejected	Students Enrolled		
2	Year2017	30	25	5	20		
3	Year2016	24	21	4	17		
4	Year2015	22	20	2	18		

Fig. 3.1 Enrolment dataset

3.1.2 Students information CSV datasets

The second created CSV datasets were about the personal information of each student in the MASTEAM for the years 2015, 2016 and 2017. These CSV datasets contain the information about, the students id number for the University, the names of the students, the age, the gender, their countries with the geographical coordinates, the semester with the date that were enrolled and their nationalities (European or Non-European).

Furthermore, the below figure ***Fig. 3.2*** is showing an example of a possible CSV file that contain the students information for the academically year 2015.

B1 | Students 2015

	A	B	C	D	E	F	G	H	I	J
1	ID Number	Students 2015	Age	Gender	Country	Nationality	Semester	Date	long	lat
2	5698	Student121	22	Male	Spain	EU	September	20/09/2015	-3.74922	40.46367
3	5698	Student222	25	Male	Algeria	NONEU	September	20/09/2015	1.659626	28.03389
4	5512	Student223	21	Male	Portugal	EU	September	20/09/2015	-8.22445	39.39987
5	3657	Student224	26	Female	Germany	EU	September	20/09/2015	10.45153	51.16569
6	3615	Student225	30	Male	Spain	EU	September	20/09/2015	-3.74922	40.46367
7	3203	Student226	28	Male	Bolivia	NONEU	February	20/02/2016	-63.5887	-16.2902
8	3697	Student277	29	Female	Ecuador	NONEU	February	20/02/2016	-78.1834	-1.83124
9	3056	Student228	24	Female	Cameroon	NONEU	February	20/02/2016	12.35472	7.369722

Fig. 3.2 Students personal info year 2015

3.1.3 Students grades CSV datasets

The third created CSV datasets were about the individual grades of each student in the courses that enrolled for the years 2015, 2016 and 2017. These CSV files contain the names of the students and the grades that obtained in all the courses that had enrolled.

Furthermore, the below figure ***Fig. 3.3*** is an example of a possible CSV file that contain the student grades from the year 2017.

A1 | Students

	A	B	C	D	E	F	G	H	I	J
1	Students	Optim	Neteg	Wicom	Sensors	Entrep	Iot-IP	5gplan	Image	Optical
2	Student1	6	8	7	5.5	8.6	6.5	9	0	9
3	Student2	7	7	7	6.5	8.5	8.6	6.5	6.5	6
4	Student3	5	6	8	7.4	8.7	6.9	8	8	8
5	Student4	9	9	9	7.3	9	5	7	9	5.6
6	Student5	8	7	6	9	10	8	6.5	7	7.3
7	Student6	6	5	5	5	6.3	7		6.5	
8	Student7	7	5	6	6	9.2	6	5	9	5.8
9	Student8	6	6	7	8	8	9	6	5.3	9
10	Student9	9	8	8	5.2	7	5			7.3
11	Student10	8	9	6	6.2	6	6.5	8	6	7
12	Student11	6	7	9	7.5	9.2	9.7			
13	Student12	9	5	7	6.3	9.8	7.3	7.3		5

Fig. 3.3 Students Grades

From the figure ***Fig. 3.3***, can be observed that some squares are empty without any grades, this is because the students were not enrolled on these courses.

3.1.4 Courses and Grades CSV datasets

The fourth created CSV datasets were about the courses, the enrolled students per course and the grades that obtained for the years 2015, 2016 and 2017.

These datasets are similar to the ***3.1.3 Students grades CSV datasets***, but with the difference that are showing information from course to course and not from student to student.

Important to mention here is that, the datasets with the MASTEAM information for the three years 2015, 2016 and 2017 they have exactly the same CSV format. The only difference are the data inside, which are different from year to year.

Furthermore, the figure ***Fig. 3.4*** below is an example of a possible CSV file that contain the courses with the enrolled students per course and the grades that obtained.

G	H	I	J	K	L	M	N	O	P
Sensors	SensorsGrades	Entrep	EntrepGra	Iot-IP	IOTGrades	5Gplan	5GplanGrades	Image	ImageGrades
Student1	9	Student1	9	Student2	6.5	Student1	9	Student5	5
Student2	10	Student2	8	Student3	7.5	Student5	8.5	Student6	6
Student3	5.3	Student3	9.5	Student4	8	Student6	7.5	Student10	7
Student4	6.5	Student4	8.6	Student6	9	Studnet7	9.5	Student11	6.5
Student5	7.3	Student5	7.8	Student10	10	Student8	10	Student12	8
Student6	6.4	Student6	9	Sudent12	5.5	Student10	5.6	Student13	9
Student7	5.5	Student7	10	Student14	6	Student11	6.6	Student15	10
Student8	8.3	Student8	10	Student15	6.3	Student15	7.5	Student17	7.6
Student9	7	Student9	9.5	Student17	7.5	Student16	6.5	Student18	8.5
Student10	6.8	Student10	8.5	Student19	8	Student17	8.5	Student19	8
Student11	6.7	Student11	6.5	Student20	6	Student18	6.5	Student20	6
Student12	5.6	Student12	7			Student19	9.3		
Student13	5	Student13	7.9			Student20	7.3		
Student14	5	Student14	8.5						
Student15	8.3	Student15	9						
Student16	9	Student16	9						
Student17	10	Student17	10						
Student18	5.3	Student18	10						
Student19	6.3	Student19	10						
Student20	6	Student20	9						

Fig. 3.4 Courses Grades and enrolled students

3.1.5 Number of students per course CSV dataset

The fifth created dataset was about the number of enrolled students that each course had for the years 2015, 2016 and 2017.

Furthermore, the below figure ***Fig. 3.5*** is giving a possible CSV file that contain the number of students per course for the three years.

A1 Cources

	A	B	C	D	E
1	Cources	Year2017	Year2016	Year2015	
2	Optim	20	20	19	
3	Neteg	14	18	16	
4	Wicom	16	17	15	
5	Sensors	16	15	11	
6	Entrep	18	18	16	
7	Iot-IP	10	11	7	
8	Arasm	9	15	4	
9	5Gplan	8	11	8	
10	Image	12	10	9	
11	Optical	13	6	6	
12	Bodysens	5	19	4	
13	Netauth	16	7	14	
14	Big Data	14	14	16	
15	SDR	7	13	8	
16	LowPow	4	6	9	
17	Business	20	15	14	
18	Service	15	19	12	
19	Creativity	14	11	18	

Fig. 3.5 Number of student per course

3.2 Build the dataset Wireframe

The non-real CSV datasets with the MASTEAM data are ready for use. The next step is to proceed with the Wireframes. The Wireframe is the procedure before the programming part, which the main ideas about the visualization of the datasets in the Dashboard, are going to be created on a paper.

The paper or papers with the draws of the Dashboard together with the draws of the visualized datasets, is what Wireframe means. According to the instructions and the draws that are in the Wireframes, it will be implemented the digital view of the MASTEAM Dashboard.

The important areas of the Master according to the interview was the enrolment status, all the data about the students including the grades of them and every data about the MASTEAM courses.

Taking into account the important areas of the Master, the Wireframes for the MASTEAM are the **Main page Wireframe**, the **Students page Wireframe** and the **Courses page wireframe**. Moreover, the three different Wireframes they will be explained in details below.

3.2.1 Main page Wireframe

The creation of the main page of the Dashboard is maybe the most important one. Through the main page, the Dashboard need to provide to the coordinator the general view of the MASTEAM only from one page.

The coordinator need to understand from the beginning what is the status of the MASTEAM, without spending additional time to search for important information about the Master. The main page will contain information about the enrolment, information about the students and information about the graduation rate.

The enrolment part will provide information about the total number of the admission applications for the three academicals years 2015, 2016 and 2017. From the admission applications, it will provide the total number of the accepted one, the number of the enrolled one and the percentage of graduated students for the three years.

The Main page Wireframe it will contain also information about the students such as, the number of male/female and European/Non-European students. Moreover, an addition information about the percentage of the male/female and European/Non-European it will be also included.

The last part of the Main page it will contain all the above information in details.
It will provide for each year individual the enrolment status, the number of male/female and European/ Non-European.

3.2.2 Students page Wireframe

The Students page Wireframe it will contain the CSV files with all the personal information about the students and all the grades that they achieved in each course.

The first part of the Students page it will contain information about the obtained grades that the students had per course. Moreover, the average grade for each student it will be also included. The page it will have the grades from the years 2015, 2016 and 2017.

The second part of the Students page it will have a geographical map, which is showing from each courtiers the students are. Like before and here the map is providing the students countries for each year separately.

Moreover, the third part of the Students page it will contain the data tables with the students personal information such as name, id number, age, gender, nationality, enrolment date and the semester that they will start.

Finally, the last part of the Students page it will provide in details the grades of each student on each course that enrolled. Three different data tables will have these data one for each year 2015, 2016 and 2017.

3.3.3 Courses page Wireframe

The last and final Wireframe is about the courses and is the Course page. The Wireframe it will be consisted of all the information about the courses, which the coordinator need to know. This information are, the enrolled student per course, the obtained grades and the average grade for each course for the years 2015, 2016 and 2017.

This part is similar to the Students wireframe because contain also the students grades. Although this Wireframe it will be with different visualization technique as was mentioned on the subchapter ***3.1.4 Courses and Grades CSV dataset***.

Furthermore, the Courses page Wireframe it will have the number of enrolled student per course for each of the three academicals years. Moreover, for the enrolled students it will be an additional information about the number of students that pass or fail the courses. The average grade per course it will be also included according to the obtained student's grade in each course separately.

The Courses page Wireframe it will also provide a comparison between the same courses for the three different years. For example, it will show the course "Sensors" for the years 2015, 2016 and 2017 together in a box, letting the coordinator to observe and evaluate every course individual for the three years together.

Conclusively, like every page's Wireframe at the end it will be included in details three different data tables with all the information about the courses of the three academicals years.

CHAPTER 4. IMPLEMENTATION OF MASTEAM CASE

All the steps that are needed to begin with the implementation of the Dashboard are accomplished. After the interview questions, the interview part, the CSV dataset creation and Dashboard's Wireframes is the time for the programing part.

The procedure will began with the implementation of the wireframes that were explained in the subchapter ***3.2 Build the dataset Wireframe*****,** to real Dashboard pages through the programing part with R programing language and the R-Shiny Dashboard [28] [29] .

The R language is a powerful programing platform for big data analyses and for complex mathematical equations. R-Shiny is an extension of R-studio that helps to make interactive web applications to visualize datasets. R-Shiny can analyse the datasets that were been created and at the same time to visualise them with different visualization techniques online on the Dashboard web page [30] .

The MASTEAM Dashboard contain three main pages that are following the same methodology according to the Wireframes. The first page that is the MASTEAM View page, the second page is the Students View page and the third page that is the Courses View page. Additionally, the below figure ***Fig. 4.1*** is showing the three different main MASTEAM Dashboard pages.

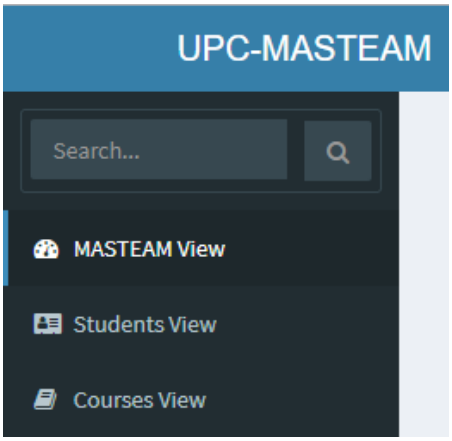


Fig. 4.1 Main MASTEAM pages

4.1 Implementation of the main Dashboard page

The implementation of the MASTEAM View page is accomplished. The programming is following the instructions that were explained in the subchapter ***3.2.1 Main page Wireframe***.

Moreover, the visualization of the MASTEAM View page can be observed in the below figures ***Fig. 4.2*** and ***Fig. 4.3***. Furthermore, every part of the page it will be explained part by part on details

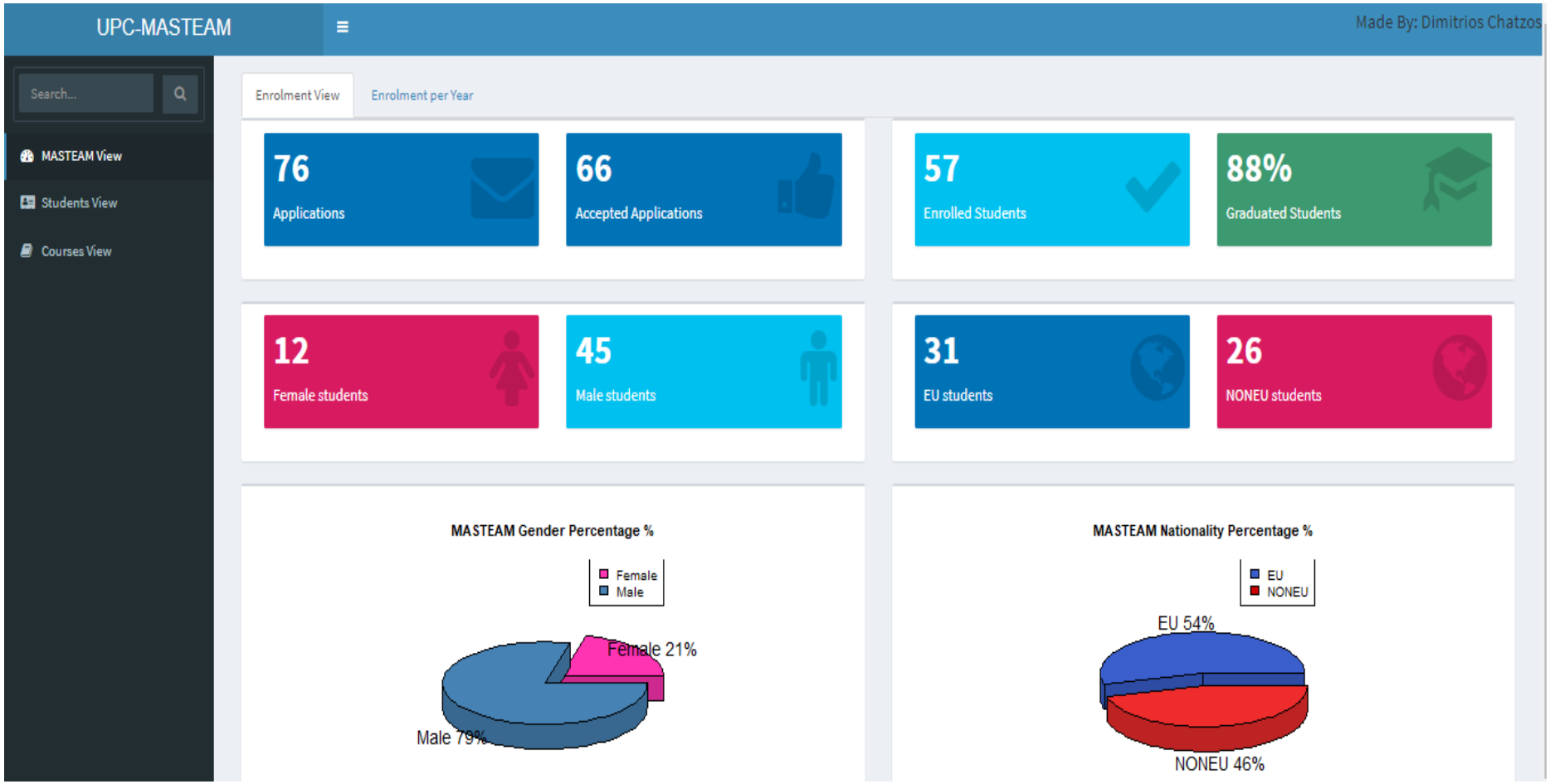


Fig. 4.2 MASTEAM View Enrolment View

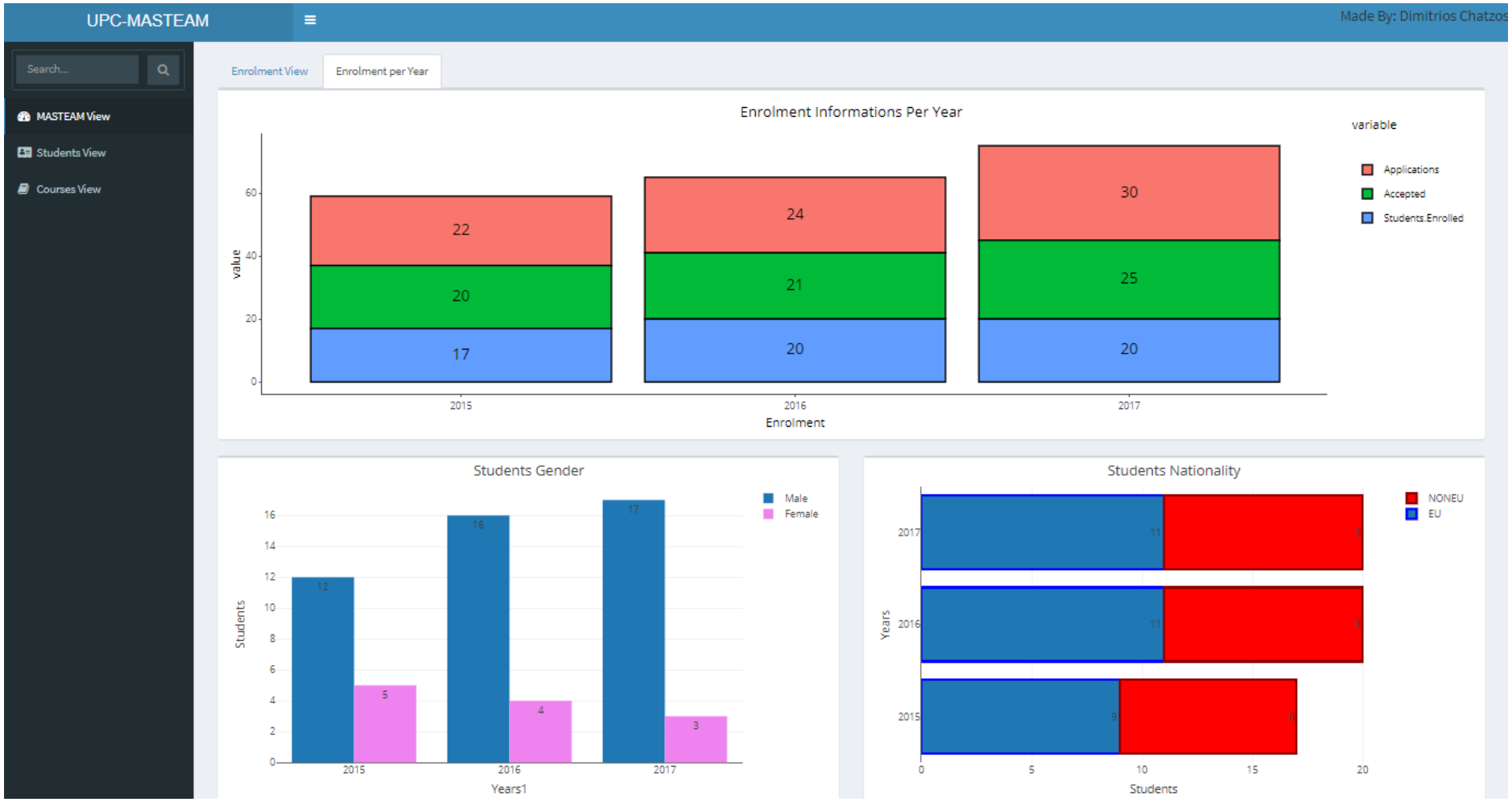


Fig. 4.3 MASTEAM View Enrolment per Year

4.1.1 Enrolment View

The Enrolment view page that the figure ***Fig. 4.2*** is showing contains the total number of submission letter applications for the MASTEAM, the total number of the accepted ones, the total number of the enrolled ones and the graduation rate.

Moreover, from the enrolled students the number of male, female and European, Non-European students are presented also in the boxes. The percentage of the gender and the nationality is also visualised through two pie charts.

To achieve these results the three different datasets from the years 2015, 2016 and 2017 were merged together like one dataset. This technique is giving the ability to R program to search through only one dataset the information that were needed to be an output for the boxes.

The R program is programmed to count from the merged new dataset the total number of the female and male students and the total number of the European and Non-European students. The green box with the ratio of graduated students is programed to count all the students that had passed the Master Thesis. This can be done through the students Master Thesis grades, checking which of them had grade grater or equal to five.

This page can demonstrate to the coordinator the information about the students of the MASTEAM and the enrolment status through time. According to the numbers, the coordinator can understand if any problem exist for the students of the MASTEAM. For example, the number of the male students in the MASTEAM is triple of the number of the female students. This information shows to the coordinator that is a problem with the few female students and additional decisions need to be taken for this to change.

4.1.2 Enrolment per Year

The second page of the MASTEAM View as the figure ***Fig. 4.3*** is showing contain with more details what the first page is visualizing, but not for the three years together but for each year separately.

The upper part of the Enrolment per Year page contain a stacked bar plot with the number of applications, the accepted ones and the enrolled ones for every year. The down part of the page have two different bar plots, one horizontal with the number of male and female students for each year, and one vertical bar plot with the number of the European and Non-European students for each year again.

For further details the Enrolment stack bar plot, the gender bar plot and the nationality bar plot can be observed in the below figures ***Fig. 4.4***, ***Fig. 4.5*** and ***Fig. 4.6***.

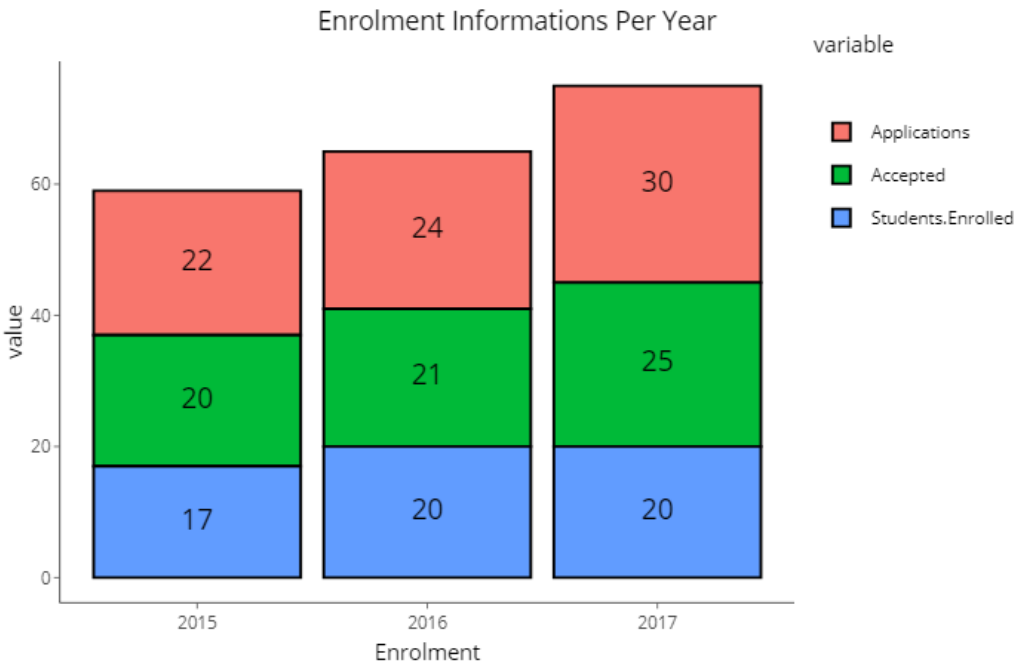


Fig. 4.4 Enrolment Stack bar plot

From the stacked bar plot in the figure ***Fig. 4.4*** can be noticed on top the total number of Enrolment applications, below the number of the application that had been accepted from the Enrolment applications and in the bottom is the number of the final enrolled one from the accepted application.

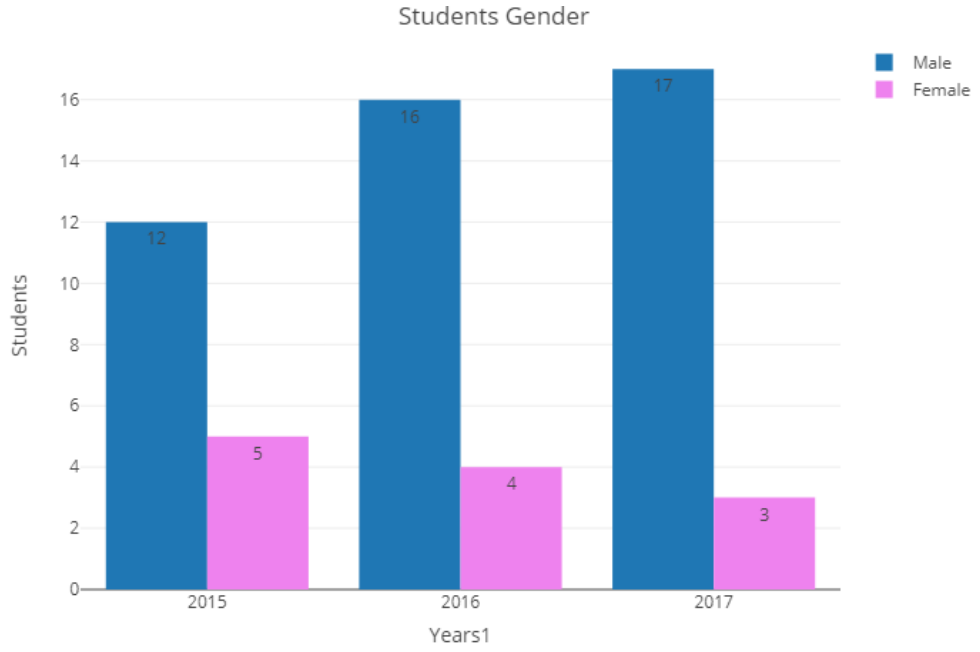


Fig. 4.5 Gender bar plot

From the bar plots in the figure ***Fig. 4.5***, can be observed with blue the number of male student and with pink the number of female. The figure ***Fig. 4.6*** below is displaying with blue the number of European student and with red the Non-European ones.

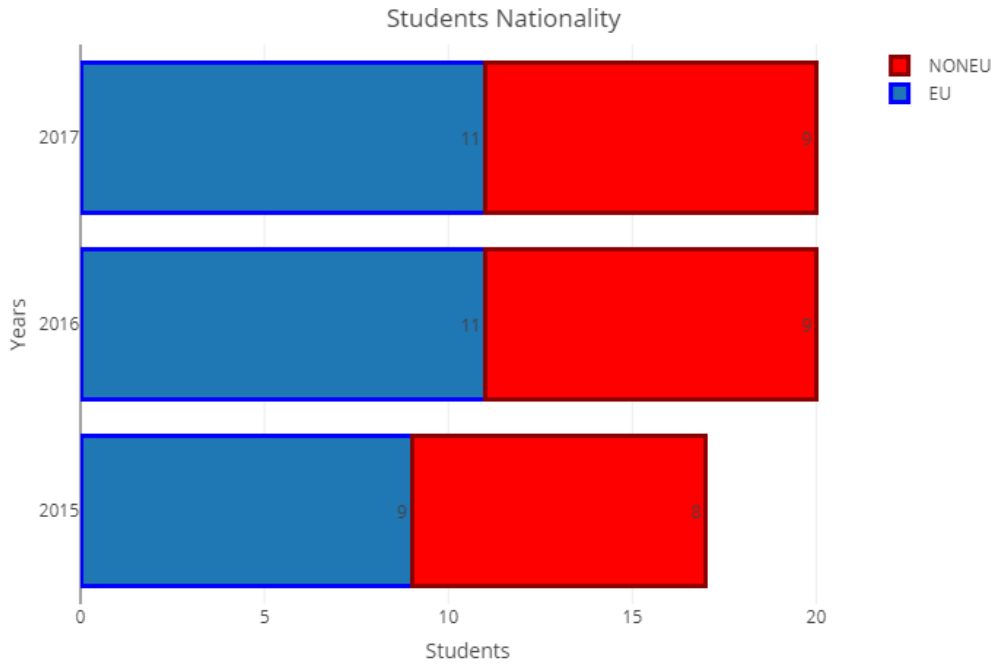


Fig. 4.6 Nationality bar plot

4.2 Implementation of the Students View page

The second important page of the Dashboard is the Students View and was implemented according to the wireframes in the subchapters' ***3.1.2 Students information CSV dataset*** and ***3.1.3 Students grades CSV dataset.***

The Students View page is separated into four different subpages, the **Students Grades** that contain the student's grade, the **Geographical Map** that contain the student's countries, the **Students Info** that contain the student's personal data, and the **Students Grades Info** that contain in details the students grades per course.

Additionally the above four subchapter will be explained into details following, with all the visualization techniques and figure from the Students View page.

4.2.1 Students Grades subpage

The Students Grades subpage is programmed to visualise the student's grades through box plots that are visualising the student's top grades, middle grades, lower grades and the average grades. These, box plots can give to the coordinator the comparison between the student's grades, the information about the top students and the students with the lower grades.

The visualisation with the student's box plots can be examine in details in the below figure ***Fig. 4.7***.

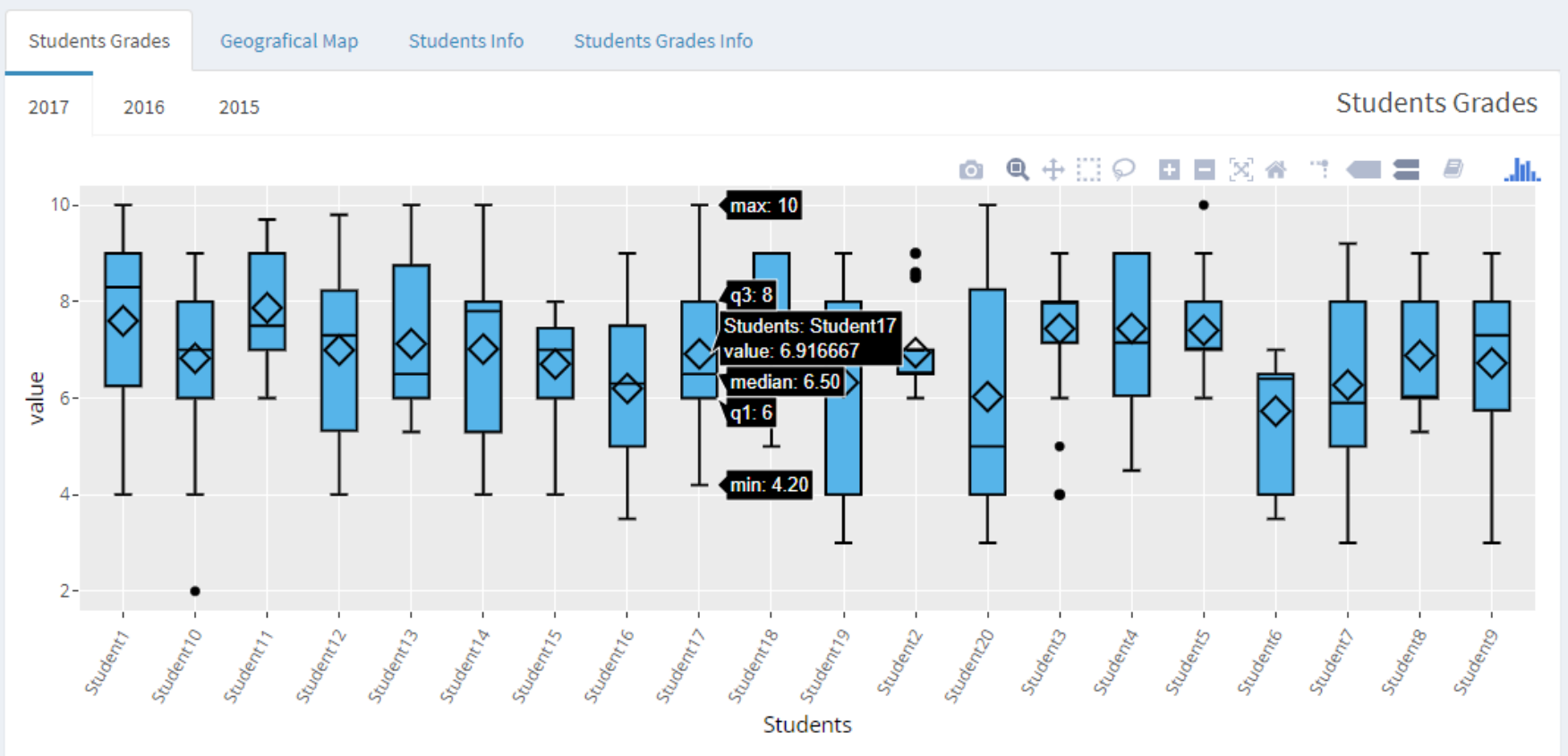


Fig. 4.7 Students Grades Box Plot

From the figure ***Fig. 4.7*** can be noticed in the upper left part that are three different box plots pages for the years 2017, 2016 and 2015. Furthermore, below in the X-axis are the student's names and in the Y-axis the grades from zero to ten. Every box plot contains the student's grades, but they are not visible from the box plot. The grades can be visible, automatically when the mouse courser is in the boxplot as it is in the figure ***Fig. 4.7***. This technique is done to avoid any misunderstanding in the student's grades, if the page was full of grades in every box plot and for aesthetic reasons also.

4.2.2 Geographical Map subpage

The Geographical Map subpage contains a geographical map, that were pointed all the countries, which the students are citizens. This visualization technique is taking the geographical coordinates from each student's country and is putting a point in these countries. Every country has specific coordinates than can be taken through the geographic latitude and longitude. These parameters were added into the ***3.1.2 Students information CSV datasets*** manually for every country.

The figure with the visualization of the Geographical Map subpage is given in the below figure ***Fig. 4.8***.

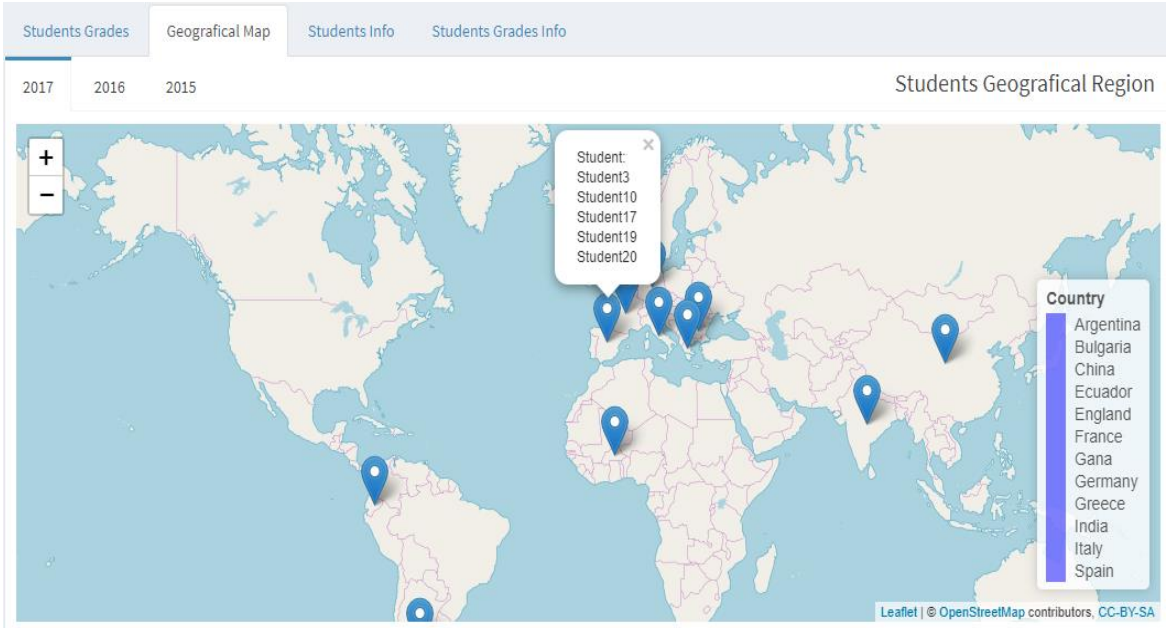


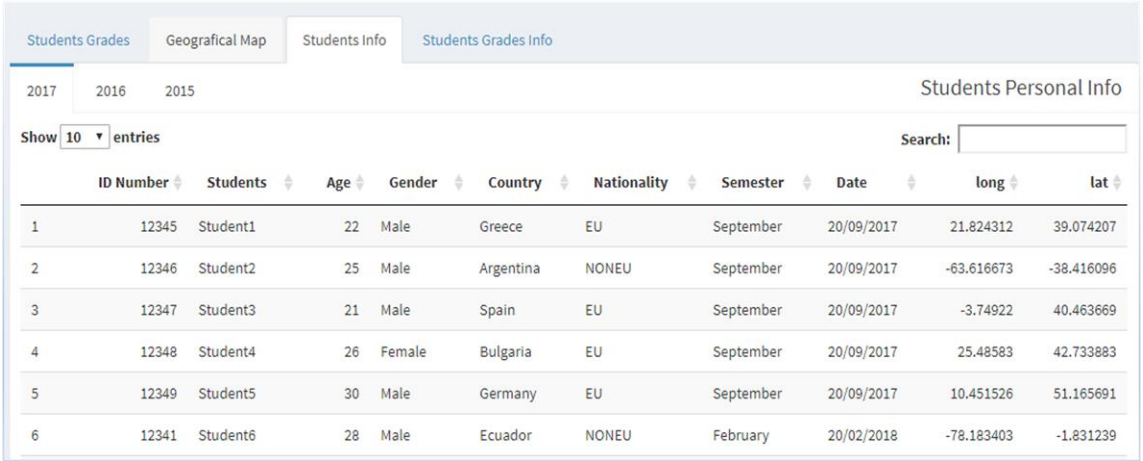
Fig. 4.8 Geographical Map

From the figure, ***Fig. 4.8*** it can be noticed three different geographical maps for the three different academicals years. Every map has the ability for zoom in and zoom out to obtain further or less details about the geographical areas that the coordinator wants to observe. The map is labelled with countries names that the students are from. Every time that a country's point is clicked, automatically is showing the student or the students that are from this country, as can be observed in the figure ***Fig. 4.8***.

4.2.3 Students Info subpage

The Students info subpage have all the personal data from each student in the MASTEAM Master separately for the three years. The subpage include the: ID numbers, student's names, ages, and genders, countries with the geographical coordinates, nationalities, semester, and the enrolment dates.

The view of the Students Info subpage can be observed into details in the below figure ***Fig. 4.9***.



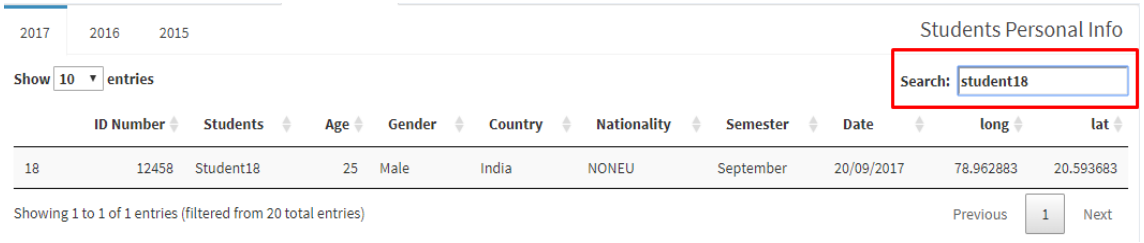
	ID Number	Students	Age	Gender	Country	Nationality	Semester	Date	long	lat
1	12345	Student1	22	Male	Greece	EU	September	20/09/2017	21.824312	39.074207
2	12346	Student2	25	Male	Argentina	NONEU	September	20/09/2017	-63.616673	-38.416096
3	12347	Student3	21	Male	Spain	EU	September	20/09/2017	-3.74922	40.463669
4	12348	Student4	26	Female	Bulgaria	EU	September	20/09/2017	25.48583	42.733883
5	12349	Student5	30	Male	Germany	EU	September	20/09/2017	10.451526	51.165691
6	12341	Student6	28	Male	Ecuador	NONEU	February	20/02/2018	-78.183403	-1.831239

Fig. 4.9 Students Info

The Students Info subpage is implemented to have the ability to sort all the data according to what the coordinator wants. For instance, sort the student names alphabetically or sort them from the age or from the gender, etc. The sorting part can be done from the small arrows that are next to each category and have the ability to sort the information downwards or upwards.

Finally, on the Students Info subpage is also important ability that the coordinator has to search for a specific name through the “Search box” that is on the top left part of the window.

The figure ***Fig. 4.10*** below can give an example of the “Search box” use.



	ID Number	Students	Age	Gender	Country	Nationality	Semester	Date	long	lat
18	12458	Student18	25	Male	India	NONEU	September	20/09/2017	78.962883	20.593683

Showing 1 to 1 of 1 entries (filtered from 20 total entries) Previous 1 Next

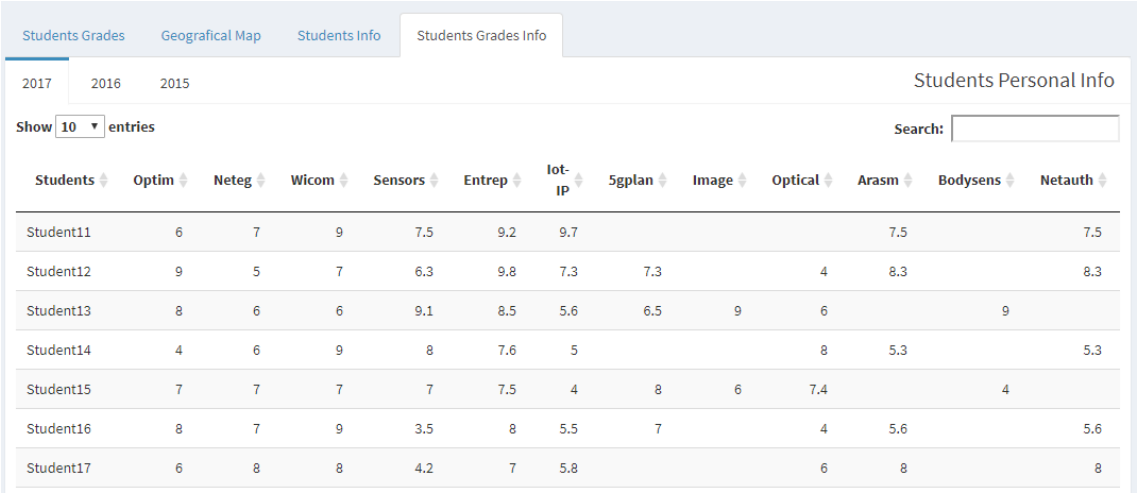
Fig. 4.10 Search box

4.2.4 Students Grades subpage

The subpage Grades from the Students View page contains the information about the grades that the students obtained from each course that enrolled.

The dataset that the subpage is using for this visualization part is the dataset that was mentioned in the subchapter ***3.1.3 Students grades CSV dataset***.

The figure ***Fig. 4.11*** is showing the Grades page, this page is programmed with the same way and has the same abilities like the ***4.2.3 Students Info subpage.*** Expect from the five first courses that are mandatory and all the students had enrolled, they are empty spaces in some courses and that is because the students had not enrolled for that courses.



Students	Optim	Neteg	Wicom	Sensors	Entrep	Iot-IP	5gplan	Image	Optical	Arasm	Bodysens	Netauth
Student11	6	7	9	7.5	9.2	9.7				7.5		7.5
Student12	9	5	7	6.3	9.8	7.3	7.3		4	8.3		8.3
Student13	8	6	6	9.1	8.5	5.6	6.5	9	6		9	
Student14	4	6	9	8	7.6	5			8	5.3		5.3
Student15	7	7	7	7	7.5	4	8	6	7.4		4	
Student16	8	7	9	3.5	8	5.5	7		4	5.6		5.6
Student17	6	8	8	4.2	7	5.8			6	8		8

Fig. 4.11 Students Grades

4.3 Implementation of the Courses View page

The third and final important page of the MASTEAM Dashboard is the Courses View. This page is programed and visualised according to the wireframes in the subchapters ***3.1.4 Courses and Grades CSV dataset*** and ***3.1.5 Number of students per course CSV dataset***.

The Courses View page is the page that contain the information about the MASTEAM courses, like grades, the average of every course, the number of students of each course and the number of the fail, pass students.

The Courses View page is separated in three different subpages, the **Courses per Year View**, the **Courses Individual Info** and the **Courses Students and Grades Info**. Furthermore, the three subpages they will be explain into details with figures in the following subchapters.

4.3.1 Courses per Year View subpage

The Courses per Year View subpage contain the number of the students that had enrolled in every course for the three years. Moreover, contain also the number of students who pass or fail on each course and the average grade, which every course has. This page is separated into two different subpages, the **Courses Students per Year** and the **Courses info.**

4.3.1.1 Courses Students per Year

The Courses Students per Year subpage is programed to contain a bar plot with all the courses of MASTEAM and the number of students that they had for every year separately.

The bar plot in the ***Fig. 4.12*** can give a first and fast view of the number of student per course to the coordinator, letting him to understand which courses are popular and which are not. The coordinator can also choose and change the years through a slider.

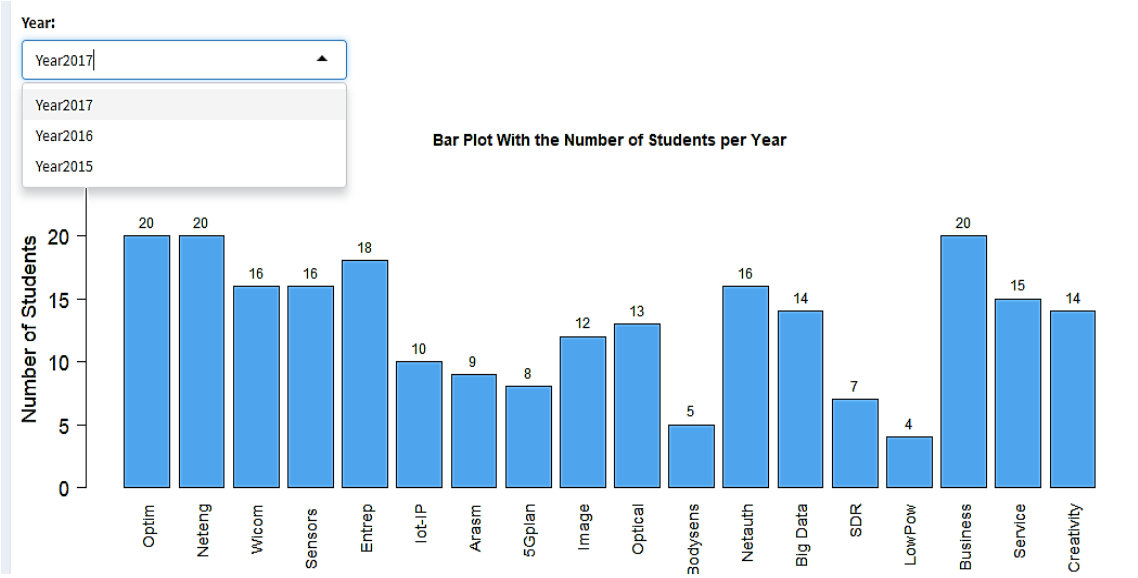


Fig. 4.12 Courses & Students bar plot

4.3.1.2 Courses Info

The Courses Info subpage holds the number of students that pass or fail the courses and the average grade per course. The programing part for this subpage was different from the other pages because for this subpage a stack bar plot and a group bar plot were visualised together as can be noticed in the figure ***Fig. 4.13***.

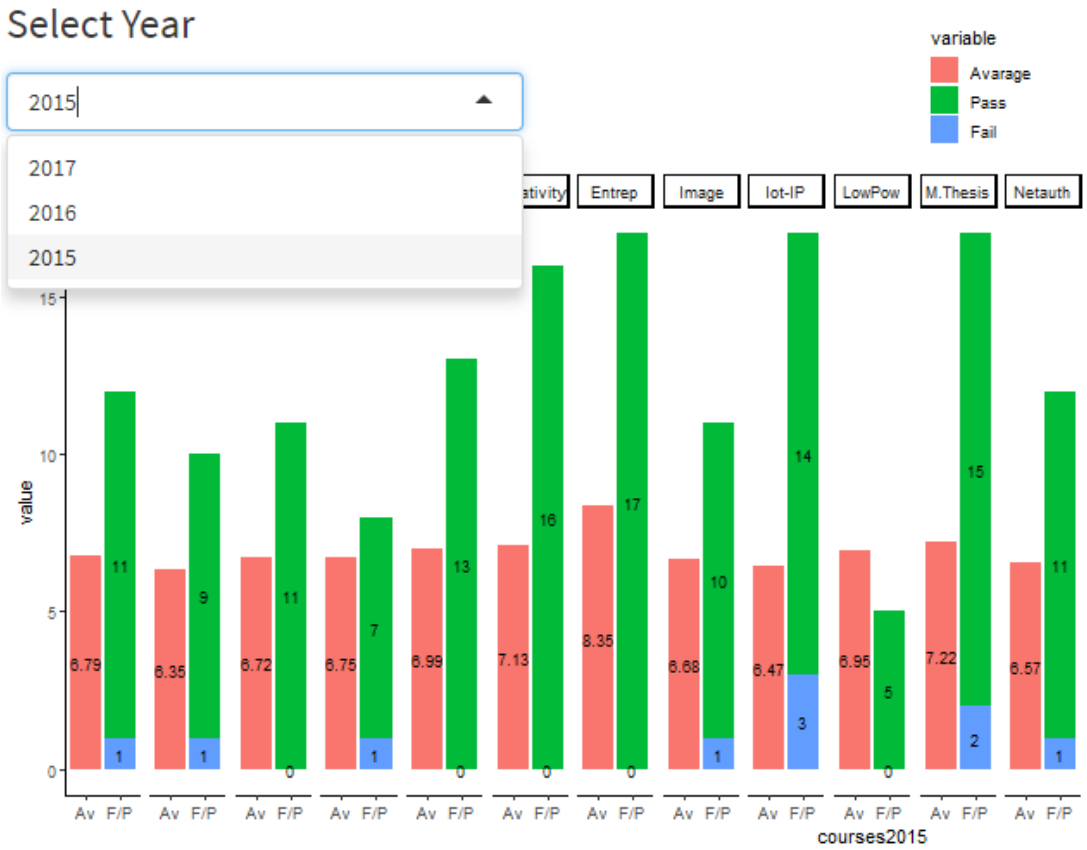


Fig. 4.13 Stack-Group bar plot

Moreover, from the figure ***Fig. 4.13*** can be observed the group and stack bar plot together for every course individual. The combination of these two bar plots together does not have any official programing algorithm so additional algorithms were combined together for this result. That is the reason that this page is different from the others.

This page is important because the coordinator can understand directly the situation of the Master. For instance if the average grade of one course is low compared to the other courses then maybe this course need to be observed further in the future, or if the number of fail students is height in one course compared to the others then something is going wrong.

Like previous visualisation techniques, also here the coordinator has the ability to change and choose the year through a slider and to make a quick comparison between the previous years, observing if any big change exist.

4.3.2 Courses Individual Info subpage

The Courses Individual Info subpage is similar to the previous subpage but is making a comparison for each individual course together for the three different years. The subpage contain for each course the number of the students that had enrolled per course with the three years together, moreover have the fail and pass students and the average of every course. This page is divided also into two different subpages, the **Number of Students per Course** and the **Fail/Pass and Grades per Course.**

4.3.2.1 Number of Students per Course

This subpage contain a bar plot with the enrolled student per course for the years 2015, 2016 and 2017, with a slider that can change and choose the course that the coordinator want to observe. Moreover, the bar blot can be more understandable in the below figure ***Fig. 4.14****.*

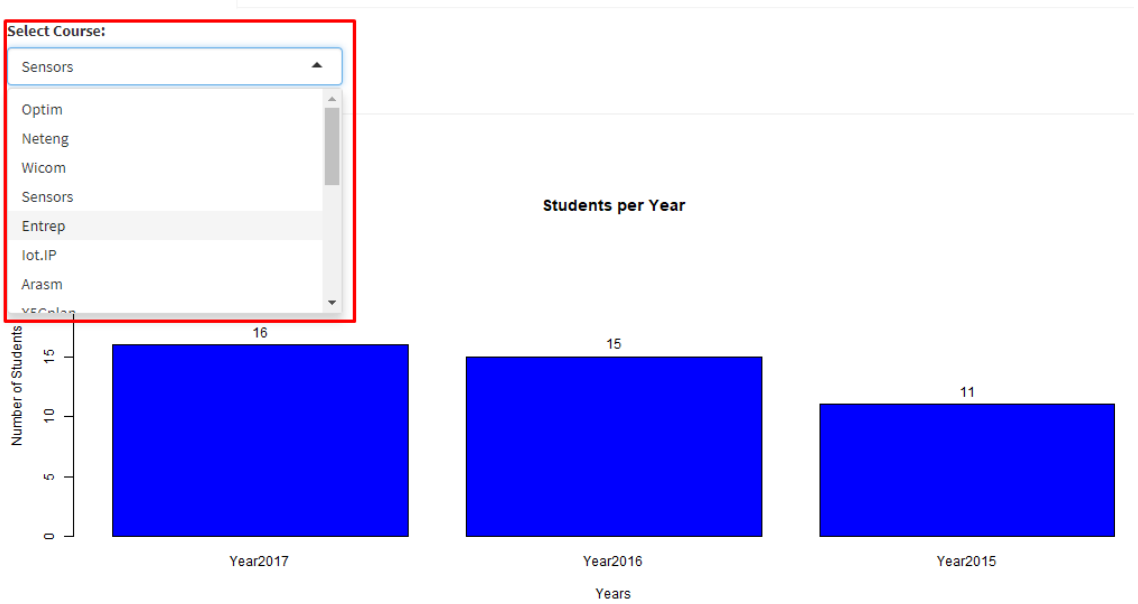


Fig. 4.14 Enrolled Students Bar plot

4.3.2.2 Fail/Pass and Grades per Course

The Fail/Pass and Grades per Course page includes two different plots, one stack bar plot with the pass and fail student per course, and one box plot with the grades per course.

The stack bar plot was programed to count all the student's grades per course that were equal or greater than five and the grades less than five. The stack bar plot have also a slider that can change the courses.

The results of the stack bar plot can be examine in the below figure ***Fig. 4.14***.

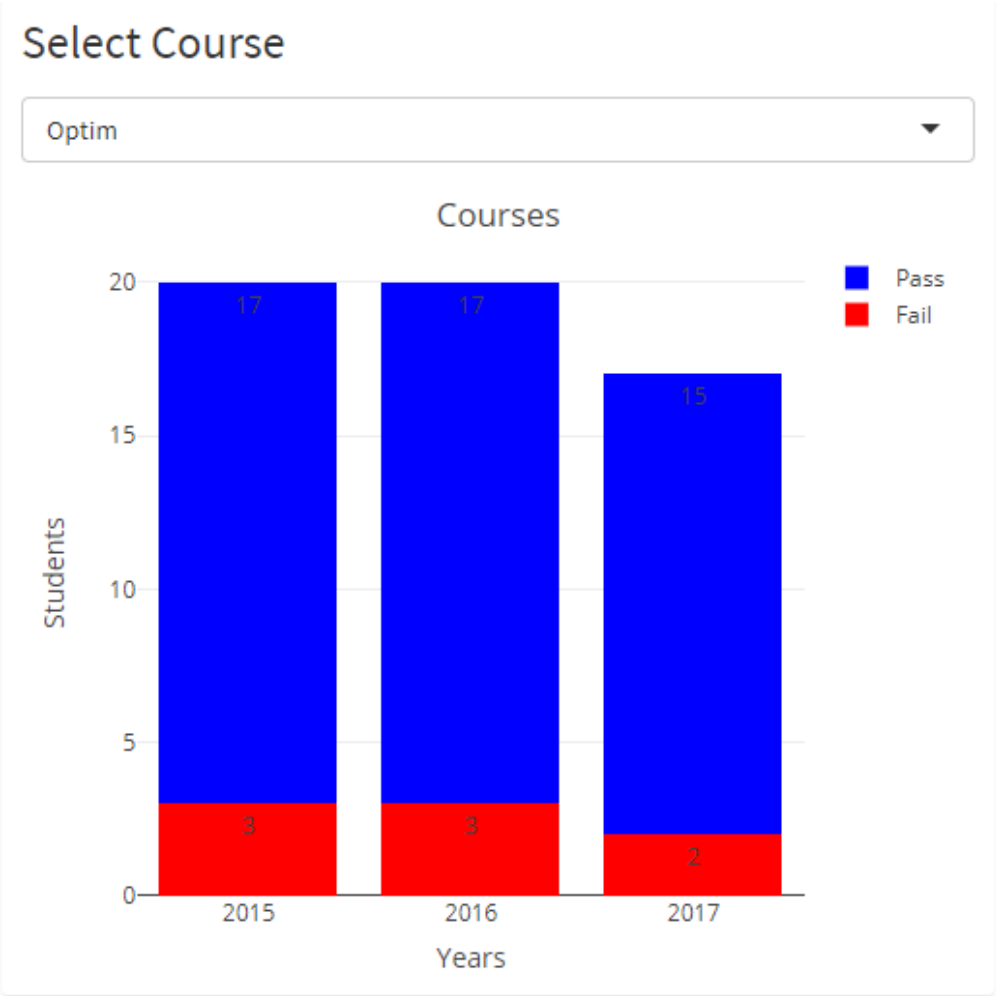


Fig. 4.15 Stack Fail/Pass bar plot

The other plot of the page is the box plot and contains the higher, lower and average grade per course compared with the three years together like stack bar plot above. The box plot is programed with the same way like the ***4.2.1 Students Grades subpage*** and when the mouse curser is above the course automatically the grades appears.

The box plot includes also the same slider to change the courses like before and can be observed better in the below figure ***Fig. 4.16***.

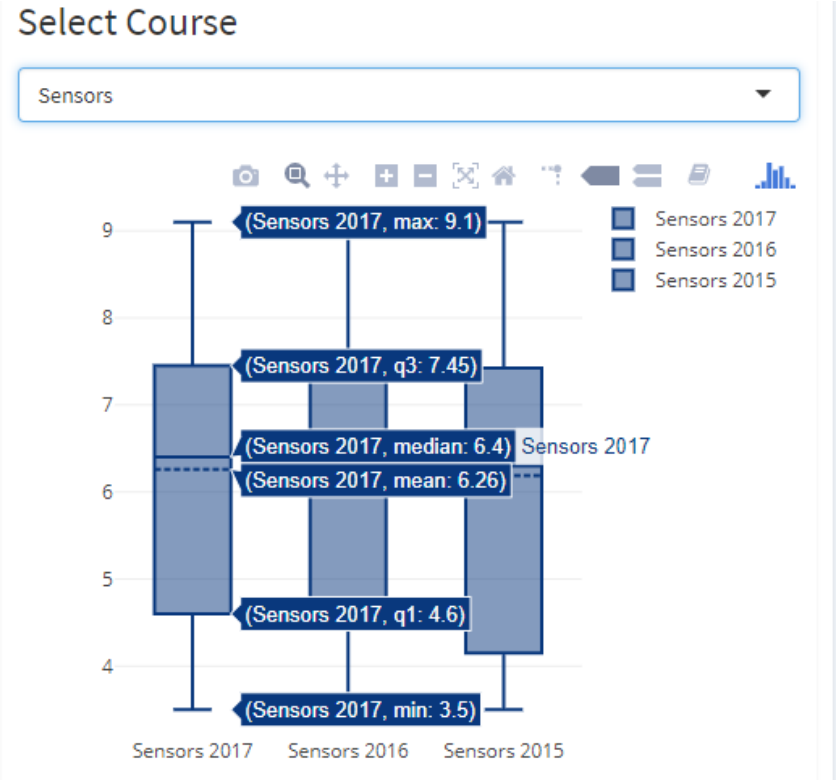
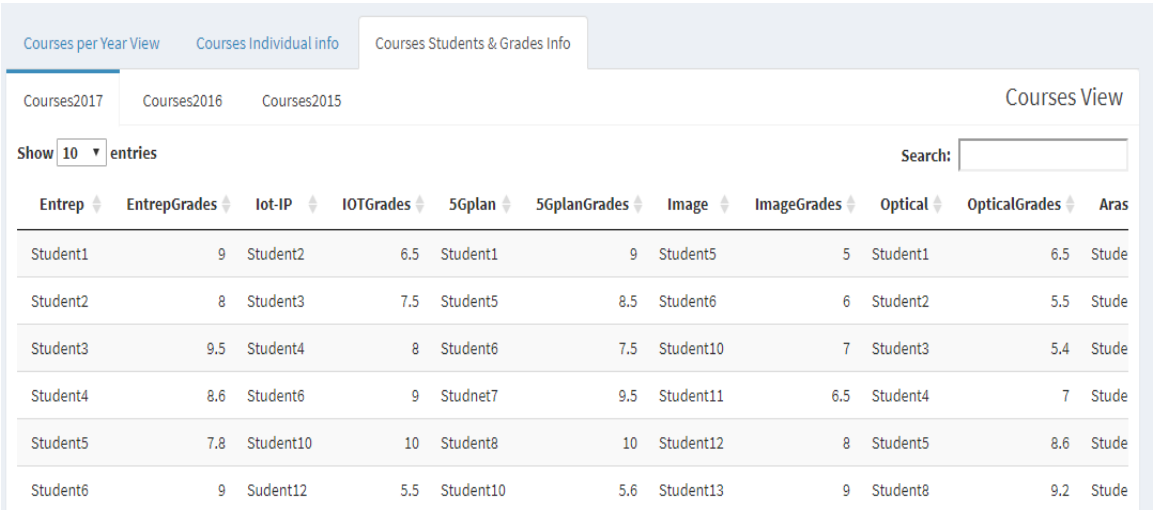


Fig. 4.16 Courses box plot

4.3.3 Courses Students and Grades Info

The last subpage of the **Courses view** page is the Courses Students and Grades Info. This subpage is consisted of the detail data tables of the enrolled students per course with the obtained grades together. The abilities of these data tables are the same like on ***4.2.4 Students Grades subpage*** furthermore the figure ***Fig. 4.17*** below is showing how the subpage looks like.



Entrep	EntrepGrades	Iot-IP	IOTGrades	5Gplan	5GplanGrades	Image	ImageGrades	Optical	OpticalGrades	Aras
Student1	9	Student2	6.5	Student1	9	Student5	5	Student1	6.5	Stude
Student2	8	Student3	7.5	Student5	8.5	Student6	6	Student2	5.5	Stude
Student3	9.5	Student4	8	Student6	7.5	Student10	7	Student3	5.4	Stude
Student4	8.6	Student6	9	Studnet7	9.5	Student11	6.5	Student4	7	Stude
Student5	7.8	Student10	10	Student8	10	Student12	8	Student5	8.6	Stude
Student6	9	Sudent12	5.5	Student10	5.6	Student13	9	Student8	9.2	Stude

Fig. 4.17 Courses Data table

CHAPTER 5. EXPLANATION OF R CODE & MASTEAM DASHBOARD MAINTENANCE

The MASTEAM Dashboard is ready for use together with all the available datasets and features. The coordinator is able to know what is the MASTEAM status and is able to take any additional decisions if is needed for making the Master better or to maintain it.

Until this part, was explained all the procedure how to create a Dashboard from the begging until the end. The procedure parts were, the interview part ***ANALYSIS OF THE MASTEAM,*** the designing part ***MASTEAM DASHBOARD DESIGN*** and the implementation part ***IMPLEMENTATION OF MASTEAM CASE***. The only thing that was not explained is the important programing parts that the MASTEAM Dashboard have and how to maintain page for the future.

In this chapter a further explanation about the important parts of the R code and how they are working will be done. The important R code parts can be useful for the coordinator to maintain the Dashboard future needs. Moreover, the coordinator can understand how the MASTEAM Dashboard is working and to be able to change or add something if is needed.

5.1 -R- code explanation

This subchapter is explaining how the R code is programed in R-studio (R versio n 3.5.1) along with the R-Shiny Dashboard interface. Furthermore, it will analyse the basic R code parts from the MASTEAM Dashboard and why were programm ed like this.

Every programing platform to make complicate calculations or to have visualization techniques need some libraries. These libraries contain inside different equations and pre-programing parts that can be used for different tasks inside the R code.

The R platform though R-Shiny is creating a webpage and needs a server input and output to be able to visualise all the datasets into the MASTEAM webpage. Additionally the R-Shiny is divided in two parts the UI part and the server output part.

The Dashboard is crated in two different programing parts the UI.R part and server.R part. The UI are acronyms from the “User Interface” and this part contain all the code about the Dashboards interface page, more specific how the MEASTEAM page looks like.

The server.R output is the part that contain all the equations and the visualization code techniques. These techniques are giving the correct visualization output to the web page, which is combined together with the UI.R part.

Moreover, the R has the ability also to visualize inside the platform all these bar plots, box plots, etc. The R-Shiny is needed only for web pages.

5.1.1 -R- Libraries explanations

The R platform contain many libraries for different computation parts. All the libraries that were used to develop the MASTEAM Dashboard they will be explained in details in this subchapter.

To use a library in R is easy, writing in the begging of the code the command *"library()"* and inside the brackets the name of the library [31] .

The libraries that the MASTEAM Dashboard use are the following one, with a brief explanation:

- **library(shiny):** The basic library to start a shiny interactive web application [32] .
- **library(shinydashboard):** The library to create an interactive Dashboard with the Shiny package [33] **.**
- **library(readxl):** The readxl package is reading the Excel datasets and is importing them into R [34] .
- **library(dplyr):** The dplyr package is transforming and summarizing data sets to be easier for use [35] .
- **library(data.table):** This package can process big amount of data and is able to manipulate them for instance to add, to delete, to order, to separate the data inside the data tables [36] .
- **library(ngram):** This package has the ability to process words and letters and to find or count them from a text [37] .
- **library(RColorBrewer):** Is a colour package that can create beautiful colour combinations for the different visualization techniques [38] .
- **library(tuple):** This package can discover any duplicated or replicated data [39] .
- **library(shinyWidgets):** This package contain more widgets for the Shiny Dashboard and can add more visualization techniques [40] .
- **library(ggplot2):** ggplot2 is one of the most know and useful package for creating graphics of any kind of datasets and is based on the Grammar of Graphics [41] .
- **library(memisc):** A package for managing data sets and transform them to data tables and data frames inside the R platform for manipulating easier the data for statistics purposes [42] .

- **library(DT):** DT is the package that can take any data table on Excel format and to visualize it directly to PHP web format. DT has the ability to manipulate and change the data in multiply ways [43] .

- **library(editData):** This package has the ability to change the datasets directly through R without any coding methods. Easy and fast edit, delete or update to every data table inside R platform [44] .

- **library(eeptools):** A package that can analyse and visualize data [45] .

- **library(ECharts2Shiny):** This package can make interactive charts (bar chart, pie chart, etc.) for all the Shiny web applications [46] .

- **library(plotly):** Plotly is a powerful online platform that can make interactive graphs and plots, together with other platforms like R, Pythons, Java script [47] .

- **library(lattice):** Is a package that is improving all the plots and graphs from the R platform and has the ability to analyse complex datasets [48] .

- **library(plotrix):** Another package for graphs and plots with emphasis to labels and axis formats including also variety of colour combinations [49] .

- **library(ggmap):** A package that can include datasets inside maps and analyse them [50] .

- **library(maps):** Maps is the package than can create map plots [51] .

- **library(ggrepel):** This package is a part of ggplot2 package and provide all the text and label variables to visualise correct plots without any missing variables [52] .

- **library(leaflet):** Leaflet package is the elite library to create interactive and three dimension maps directly from “Google maps”. This library is used from many famous web sites and online applications [53] .

- **library(reshape2)**: One of the most important libraries to reshape datasets and to give them automatically the format that is needed to analyse and plot them [54] .

5.1.2 Manipulation of Datasets

The datasets that the MASTEAM Dashboard is using are in Excel CSV format and can be maintained or edited directly from the Excel formats, or through the R platform. The CSV datasets can be imported in R directly, with the *“Import Dataset”* button that R have. The command *“read.csv (“datasetname.csv”)* is the other option to import datasets, this command is easy to be found in any R documentation webpage.

Important parameter for the datasets that are going to be imported inside the program is that need to be in the same file location with the application. This can give the ability to the program to use the datasets any time inside the code, writing only the name of the dataset without any further instructions or commands.

The MASTEAM Dashboard is analysing the datasets mostly through the "library(DT)", so in many cases is preferred to import the datasets directly in R through the *"Import Dataset"* button and manipulate them.

To manipulate and edit the datasets as was mentioned before can be done directly through the Excel CSV files. Sometimes the user might can have access only to the Dashboard page and not to the CSV files, thus a different approach need to be done for the MASTEAM Dashboard.

For the MASTEAM program, the datasets can be manipulated directly through the R studio without the need of the Excel program. The reason for that is the "library(editData)". This library is giving the ability to manipulate the datasets directly through R.

Furthermore the figure ***Fig. 5.1*** below is showing an example how to edit data with the use of "library(editData)".

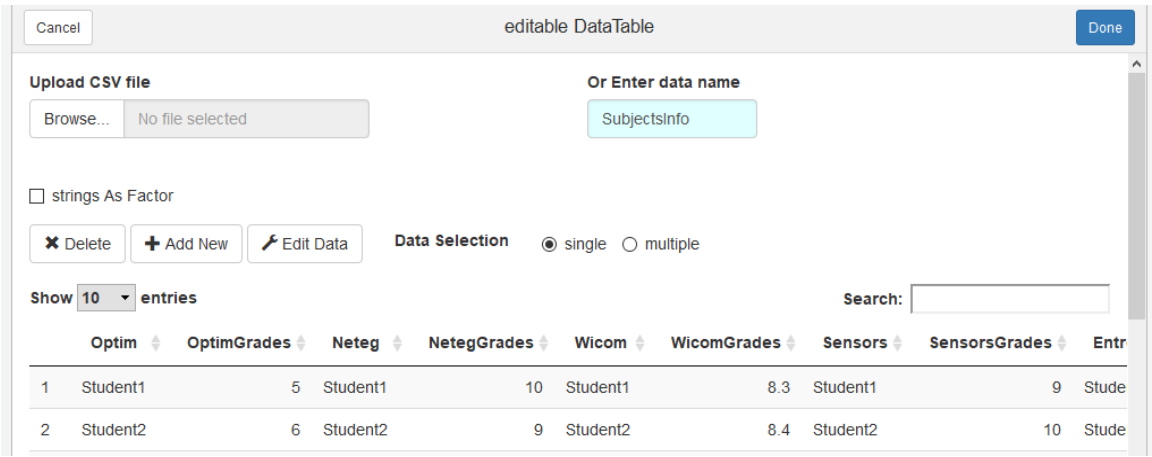


Fig. 5.1 Edit datasets -library (editData)-

The "editData" library is not the only way to edit the datasets that were imported in the application. The MASTEAM Dashboard has the ability to edit the data tables also directly from the web Dashboard page through the command "*editable = True".*

This command is giving the ability to the coordinator to change the data that are inside the data tables only by double clicking them. This technique is available when the command is in the server output part of the code.

Moreover, an example of this technique can be observed in the below figure ***Fig. 5.2*** with changing a data with my own name.

.

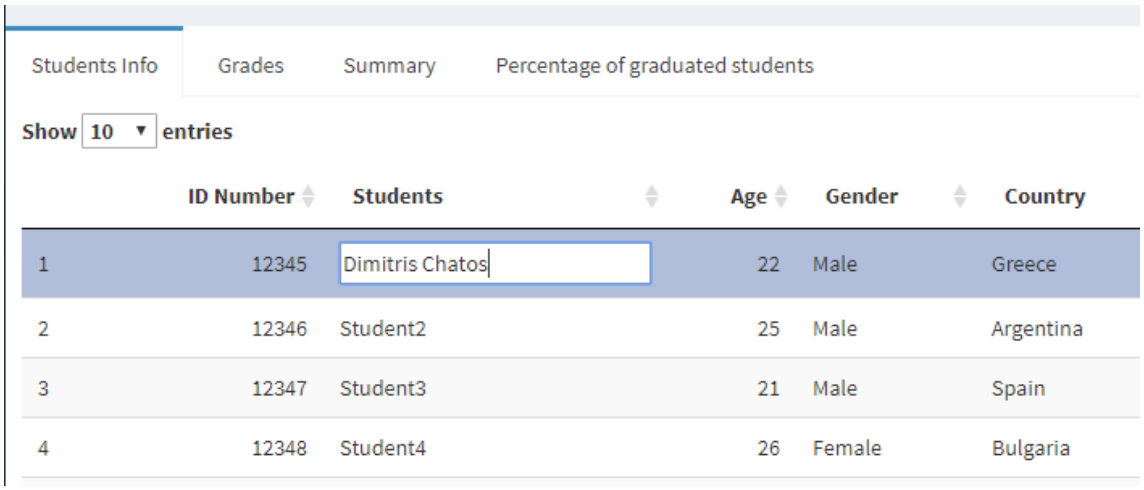


Fig. 5.2 Edit datasets -command (editable = True)-

5.2 Maintenance of the Dashboard

The maintenance of the Dashboard is the last step that the coordinator or the programmer need to do. This need to be done for keeping the MASTEAM Dashboard updated for future needs.

To maintain the datasets the coordinator just need to update the datasets CSV files. This can be done every six-month or every year when the new academic year starts and to edit new information about the new students. In addition, also when they want to manipulate the already existed datasets when something need to change. The procedure to follow is the same like was explained in ***5.1.2 Manipulation of Datasets*** subchapter.

The maintenance of the R application and the MASTEAM Dashboard is more or less the same. The coordinator need to upgrade also all the libraries to the new libraries versions when is needed. This can give new abilities to the Dashboard and different or better visualization techniques. Important for the updating part, is that the libraries and the version of the R platform need to be the same, otherwise maybe some libraries or features will not be functional.

Last but not least, all the new datasets that the coordinator want to import to the program for the new academicals years, can manipulate them and visualise them directly from the existed program. The new datasets need only to follow the same format and structure as the datasets that were explained in the subchapter ***3.1 Creation of the MASTEAM datasets in CSV format***.

Finally, if the coordinator wants to manipulate datasets that are not in the same format as the datasets in this Master Thesis, the MASTEAM Dashboard program is giving also the possibility to do that. This is because the programing part with R was made with all the main and important Dashboard parameters and techniques. Only few additional parts of the program need to be changed according to the new datasets formats and the Dashboard can be functional again.

CONCLUSION

This Master Thesis analysed the meaning of management Dashboards together with their purposes and the benefits of using them. The use of Dashboards is rapidly increasing and like every other application, they are basic designing rules that need to be followed for the correct creation of them.

The work examined all the fundamentals and designing rules that are needed for creating successful Dashboard applications. The designing part was separated into four fundamentals Content, Fonts, Layout, and Colours. Moreover, for each the fundamentals were analytically explained the correct visualisation techniques and how to implement them inside the Dashboard.

Furthermore, all the steps that someone need to follow to create useful and successful Dashboards were examined. Parts of those steps are the following 1) Specify the audience of the Dashboard and the end user, 2) Interview the audience and learn which important information need to be included inside the Dashboard, 3) Gather those datasets that contain the important information according the interview part, 5) Build the Dashboard's Wireframes 6) Dashboard's future needs.

After the definition of Dashboards, the MASTEAM use case was started and examined step by step. The goal was to create a higher educational management Dashboard for the needs of MASTEAM Master that can be used from the coordinator. The procedure to create the MASTEAM Dashboard included an interview with the coordinator through which were determined all the important areas of the Master and what kind of data is important for these areas.

Additionally, the real MASTEAM data were not possible to be included due to data privacy restrictions. Additionally non-real datasets were created into CSV format files and used to implement the Dashboard. According to those non-real datasets, the MASTEAM Wireframes were created and used inside the programing part. The implementation was done in R programing language.

Every part of the MASTEAM Dashboard was presented with figures and with explanation. The created main Dashboard pages are the **MASTEAM View**, **Students View** and **Courses View**.

The **MASTEAM View** page is giving a general view of the Master and was divided into ***Enrolment View*** subpage and ***Enrolment per year*** subpage.

The **Students View** page contain all the personal information about the students together with the grades that they achieved in each course. The page consist of four different subpages ***Students Grades***, ***Geographical Map***, ***Students Info*** and ***Students Grades Info***.

Lastly, the **Courses View** page include the information about the MASTEAM courses. The page is providing the average grade and the enrolled students per course and was separated into ***Courses per Year View***, ***Courses Individual Info*** and to ***Courses Student & Grades Info*** subpages.

The MASTEAM Dashboard should be considered as a useful and successful one. Firstly, because it is following the fundamental rules and then because it is providing all the important information about the Master that the coordinator would need to observe and analyse. The latter was proved with the interview that was done with him.

As future work, it is advisable to implement inside the Dashboard all the real data from the MASTEAM and analyse them. The information about Internships, students' mobilities and the Masters Evaluation system are not included in the Dashboard. This is because for that information are needed the real datasets from the MASTEAM. Moreover, the evaluation system of the Master is something that only the coordinator and the UPC directory knows. This information can also be included from the coordinator in the new upgraded versions of the Dashboard.

The upgrade of the Dashboard can make the use of it better and easier for the coordinator. New features and visualization techniques can be added, such as mobile Dashboard version for smartphones, interaction with live datasets or automatic future predictions for the Master.

Furthermore, the Dashboard can be used only through the computers than have installed the R platform and contain inside the R code from the MASTEAM Dashboard. This is the reason that the MASTEAM web page need to be legitimate and to obtain a standard URL link, and to be launched online. This will make the Dashboard a real wed page that the coordinator can visit only through the URL link. The legalization of the Dashboard can be done over the official R studio web page for a certain amount of money [56] .

To conclude, the last version of the MASTEAM Dashboard is available for use. Further analyses of the Thesis R code can be done through the below link that contains all the R files from the MASTEAM Dashboard.

Link: *https://github.com/Dimitrischatzos/shinydashboard-master*

Sustainability considerations: The Dashboard application of this Thesis was implemented inside a common personal computer (PC) without any significant power consumption or negative environmental impact. On the contrary, the Dashboard through its digital form can save paper from not to be used. This can have a positive environmental impact in the future. Moreover, a small economic impact can also exist from the non-printed paper in every organization.

Ethical considerations: Nowadays the data privacy restrictions are one of the biggest issues in the digital world. This Thesis Master is analysing private data and those restrictions need to be carefully considered. This is the reason why for the thesis were used non-real datasets without any private information inside for the implementation of the Dashboard. Moreover, when the coordinator of the Master will use the Dashboard to import inside real private data is authorised to do that from the directory of the UPC. The real private datasets will be used only to monitor and analyse the performance of the MASTEAM and not to point any student or to take further actions about them.

REFERENCES

[1] Pauwels, K., Ambler, T., Clark, B., LaPointe, P., Reibstein, D., Skiera, B., Wierenga, B. and Wiesel, T. (2009). Dashboards as a Service. *Journal of Service Research*, [online] 12(2), pp.175-189. Available at: https://www.researchgate.net/publication/45378514_Dashboards_as_a_Service_Why_What_How_and_What_Research_Is_Needed [Accessed 16 Oct. 2018].

[2] Yigitbasioglu, O. and Velcu, O. (2012). A review of dashboards in performance management: Implications for design and research. *International Journal of Accounting Information Systems*, [online] 13(1), pp.41-59. Available at: https://www.sciencedirect.com/science/article/pii/S1467089511000443?via%3Dihub [Accessed 16 Oct. 2018].

[3] UPC Universitat Politècnica de Catalunya. (2018). *UPC*. [online] Available at: https://www.upc.edu/en [Accessed 16 Oct. 2018].

[4] (MASTEAM), A. and (MASTEAM), M. (2018). *Applied Telecommunications and Engineering Management (MASTEAM)*. [online] UPC Universitat Politècnica de Catalunya. Available at: https://www.upc.edu/en/masters/applied-telecommunications-and-engineering-management-masteam [Accessed 16 Oct. 2018].

[5] "UPC ranked 22nd in the world in Architecture and Built Environment, and 34th in Civil and Structural Engineering," *UPC Universitat Politècnica de Catalunya*. [Online]. Available: https://www.upc.edu/en/press-room/news/upc-ranked-22nd-in-the-world-in-architecture-and-built-environment-and-34th-in-civil-and-structural-engineering. [Accessed: 21-Oct-2018].

[6] Catalunya, U. (2018). *The UPC in international rankings — Rankings Observatory — UPC. Universitat Politècnica de Catalunya*. [online] Upc.edu. Available at: https://www.upc.edu/ranquings/en/upc-at-international-rankings [Accessed 16 Oct. 2018].

[7] U. P. de Catalunya and UPC, *Castelldefels School of Telecommunications and Aerospace Engineering - UPC. Universitat Politècnica de Catalunya*, 12-Jul-2018. [Online]. Available: https://eetac.upc.edu/en. [Accessed: 21-Oct-2018].

[8] Klipfolio.com. (2018). *What is a Digital Dashboard? Definition and Examples*. [online] Available at: https://www.klipfolio.com/resources/articles/what-is-digital-dashboard [Accessed 16 Oct. 2018].

[9] The Definitive Guide to Dashboard Design. (2018). *Dashboard Design Fundamentals - The Definitive Guide to Dashboard Design*. [online] Available at: https://logianalytics.com/dashboarddesignguide/dashboard-design-fundamentals/ [Accessed 16 Oct. 2018].

[10] En.wikipedia.org. (2018). *Dashboard (business)*. [online] Available at: https://en.wikipedia.org/wiki/Dashboard_(business) [Accessed 16 Oct. 2018].

[11] Nguyen, T. (2018). *Dashboards Explained: Operational, Strategic and Analytical*. [online] Chartio Blog. Available at: https://blog.chartio.com/posts/dashboards-explained-operational-strategic-and-analytical [Accessed 16 Oct. 2018].

[12] Klipfolio.com. (2018). *Dashboard Examples and Templates*. [online] Available at: https://www.klipfolio.com/resources/dashboard-examples [Accessed 16 Oct. 2018].

[13] Okviz.com. (2018). *Dashboard Design Rules – OKViz (The Good Visuals for Power BI)*. [online] Available at: https://okviz.com/blog/dashboard-design-rules/ [Accessed 16 Oct. 2018].

[14] Klipfolio.com. (2018). *Business dashboard design: The fundamentals of data visualization*. [online] Available at: https://www.klipfolio.com/blog/business-dashboard-design-data-visualization [Accessed 16 Oct. 2018].

[15] Klipfolio.com. (2018). *Content Marketing Dashboard - How effective is your content?*. [online] Available at: https://www.klipfolio.com/content-marketing-dashboard [Accessed 16 Oct. 2018].

[16] Towards Data Science. (2018). *Working on Your Dashboard Layout? – Towards Data Science*. [online] Available at: https://towardsdatascience.com/working-on-your-dashboard-layout-9b7c38d7b61e [Accessed 16 Oct. 2018].

[17] "Dashboard Design Mistake #5: Misuse of Colour," *Klipfolio.com*, 18-Dec-2015. [Online]. Available: https://www.klipfolio.com/blog/dashboard-design-mistake-misuse-of-colour. [Accessed: 16-Oct-2018].

[18] *Color scheme types - ColorBrewer*. [Online]. Available: http://colorbrewer2.org/learnmore/schemes_full.html. [Accessed: 16-Oct-2018].

[19] "A Guide to Creating Dashboards People Love to Use Part 3: Information Design," *A Guide to Creating Dashboards People Love to Use - Page 3*. [Online]. Available: http://www.dashboardinsight.com/articles/digital-dashboards/fundamentals/a-guide-to-creating-dashboards-people-love-to-use-part-3.aspx?page=3. [Accessed: 16-Oct-2018].

[20] E. O. T. Grid, “5 rules for a dashboard color palette,” *Excel off the grid*, 19-Apr-2018. [Online]. Available: https://exceloffthegrid.com/dashboard-color-palette/. [Accessed: 16-Oct-2018].

[21] “Using the Right Visualizations,” *The Definitive Guide to Dashboard Design*. [Online]. Available: https://logianalytics.com/dashboarddesignguide/using-the-right-visualizations/. [Accessed: 16-Oct-2018].

[22] “Viewing Dashboards,” *Amazon*. [Online]. Available: https://docs.aws.amazon.com/mobileanalytics/latest/ug/viewing-dashboards.html. [Accessed: 16-Oct-2018].

[23] “Validating Your Design (Before It's Too Late),” *The Definitive Guide to Dashboard Design*. [Online]. Available: https://logianalytics.com/dashboarddesignguide/validating-your-design-before-its-too-late/. [Accessed: 16-Oct-2018].

[24] “Dashboard Wireframe Template,” *Lucidchart*, 25-May-2017. [Online]. Available: https://www.lucidchart.com/pages/templates/wireframe/dashboard-wireframe-template. [Accessed: 16-Oct-2018].

[25] “Home,” *Justinmind*. [Online]. Available: https://www.justinmind.com/blog/how-to-build-a-social-media-monitoring-dashboard-prototype/. [Accessed: 16-Oct-2018].

[26] “The Future of Dashboard Design,” *The Definitive Guide to Dashboard Design*. [Online]. Available: https://logianalytics.com/dashboarddesignguide/the-future-of-dashboard-design/. [Accessed: 16-Oct-2018].

[27] “The Future of Information Dashboards,” *The Future of Information Dashboards | UX Magazine*. [Online]. Available: https://uxmag.com/articles/the-future-of-information-dashboards. [Accessed: 16-Oct-2018].

[28] “The R Project for Statistical Computing,” *R*. [Online]. Available: https://www.r-project.org/. [Accessed: 16-Oct-2018].

[29] “Shiny,” *Shiny*. [Online]. Available: http://shiny.rstudio.com/. [Accessed: 16-Oct-2018].

[30] “Home,” *RStudio*, 24-Sep-2018. [Online]. Available: https://www.rstudio.com/. [Accessed: 16-Oct-2018].

[31] “How to Install, Load, and Unload Packages in R,” *dummies*. [Online]. Available: https://www.dummies.com/programming/r/how-to-install-load-and-unload-packages-in-r/. [Accessed: 16-Oct-2018].

[32] "Web Application Framework for R [R package shiny version 1.1.0]," *The Comprehensive R Archive Network*. [Online]. Available: https://cran.r-project.org/web/packages/shiny/index.html. [Accessed: 16-Oct-2018].

[33] *Getting started with Shiny Dashboard*. [Online]. Available: https://rstudio.github.io/shinydashboard/get_started.html. [Accessed: 16-Oct-2018].

[34] "Read Excel Files [R package readxl version 1.1.0]," *The Comprehensive R Archive Network*. [Online]. Available: https://cran.rproject.org/web/packages/readxl/index.html. [Accessed: 16-Oct-2018].

[35] R. Irizarry and M. Love, "Data: mammals sleep," *Sitewide ATOM*. [Online]. Available: http://genomicsclass.github.io/book/pages/dplyr_tutorial.html. [Accessed: 16-Oct-2018].

[36] M. Dowle, "data.table v1.11.4," *data.table package | R Documentation*. [Online]. Available: https://www.rdocumentation.org/packages/data.table/versions/1.11.4. [Accessed: 16-Oct-2018].

[37] "Fast n-Gram 'Tokenization' [R package ngram version 3.0.4]," *The Comprehensive R Archive Network*. [Online]. Available: https://cran.r-project.org/web/packages/ngram/index.html. [Accessed: 16-Oct-2018].

[38] *R: ColorBrewer palettes*. [Online]. Available: http://ugrad.stat.ubc.ca/R/library/RColorBrewer/html/ColorBrewer.html. [Accessed: 16-Oct-2018].

[39] E. Lazaridis, "Find every match, or orphan, duplicate, triplicate, or other replicated values [R package tuple version 0.4-02]," *The Comprehensive R Archive Network*. [Online]. Available: https://cran.rproject.org/web/packages/tuple/index.html. [Accessed: 16-Oct-2018].

[40] "Custom Inputs Widgets for Shiny [R package shinyWidgets version 0.4.3]," *The Comprehensive R Archive Network*. [Online]. Available: https://cran.r-project.org/web/packages/shinyWidgets/index.html. [Accessed: 16-Oct-2018].

[41] "Create Elegant Data Visualisations Using the Grammar of Graphics [R package ggplot2 version 3.0.0]," *The Comprehensive R Archive Network*. [Online]. Available: https://cran.rproject.org/web/packages/ggplot2/index.html. [Accessed: 16-Oct-2018].

[42] *CRAN - Package memisc*. [Online]. Available: https://cran.rproject.org/web/packages/memisc/index.html. [Accessed: 16-Oct-2018].

[43] *DT: An R interface to the DataTables library*. [Online]. Available: https://rstudio.github.io/DT/. [Accessed: 16-Oct-2018].

[44] K.-W. Moon, “package editData : An RStudio Addin for Editing A 'data.frame',” 06-Oct-2017. [Online]. Available: https://cran.rproject.org/web/packages/editData/README.html. [Accessed: 16-Oct-2018].

[45] J. E. Knowles, “Convenience Functions for Education Data [R package eeptools version 1.2.0],” *The Comprehensive R Archive Network*. [Online]. Available: https://cran.rproject.org/web/packages/eeptools/index.html. [Accessed: 16-Oct-2018].

[46] X. DENG, *Introduction to ECharts2Shiny*, 24-Feb-2017. [Online]. Available: https://cran.rproject.org/web/packages/ECharts2Shiny/vignettes/intro.html. [Accessed: 16-Oct-2018].

[47] “plotly,” *R Graphing Library | Plotly*. [Online]. Available: https://plot.ly/r/. [Accessed: 16-Oct-2018].

[48] *CRAN - Package lattice*. [Online]. Available: https://cran.rproject.org/web/packages/lattice/index.html. [Accessed: 16-Oct-2018].

[49] *CRAN - Package plotrix*. [Online]. Available: https://cran.rproject.org/web/packages/plotrix/index.html. [Accessed: 16-Oct-2018].

[50] “ggmap,” *The Comprehensive R Archive Network*. [Online]. Available: https://cran.r-project.org/web/packages/ggmap/README.html. [Accessed: 16-Oct-2018].

[51] *CRAN - Package maps*. [Online]. Available: https://cran.rproject.org/web/packages/maps/index.html. [Accessed: 16-Oct-2018].

[52] K. Slowikowski, “Automatically Position Non-Overlapping Text Labels with 'ggplot2' [R package ggrepel version 0.8.0],” *The Comprehensive R Archive Network*. [Online]. Available: https://cran.r-project.org/web/packages/ggrepel/index.html. [Accessed: 16-Oct-2018].

[53] *Leaflet for R - Using Leaflet with Shiny*. [Online]. Available: https://rstudio.github.io/leaflet/shiny.html. [Accessed: 16-Oct-2018].

[54] *CRAN - Package reshape2*. [Online]. Available: https://cran.r-project.org/web/packages/reshape2/index.html. [Accessed: 16-Oct-2018].

[55] "Types of Colour Blindness," *Colour Blind Awareness*. [Online]. Available: http://www.colourblindawareness.org/colour-blindness/types-of-colour-blindness/. [Accessed: 22-Oct-2018].

[56] "Pricing," *RStudio*, 17-Oct-2018. [Online]. Available: https://www.rstudio.com/pricing/. [Accessed: 22-Oct-2018].