

FACULDADE DE ENGENHARIA DA UNIVERSIDADE DO PORTO

Drill-down Dashboard for Chairing Online Master Programmes

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Resumo

A coordenação de Cursos de Mestrado online exige acompanhamento e uma constante tomada de decisões, baseado num grande conjunto de dados e processos contínuos, o que é desafiador.

Uma grande parte desses dados e processos são encontrados ou ocorrem em sistemas de gerenciamento de aprendizagem (Learning Management Systems ou LMS). Normalmente, estes possuem grandes quantidades de informações. Se estas não forem bem compreendidas e interpretadas, pode levar a decisões tomadas erroneamente e oportunidades de apoiar os alunos podem ser perdidas. A tomada de decisão dos coordenadores de Curso de Mestrado online pode ser apoiada por painéis de instrumentos, sendo que anteriormente já foi produzido um protótipo inicial.

O foco desta dissertação está na identificação e prototipagem de métodos eficientes de visualização e interação para o painel de instrumentos, de acordo com estratégias de Interação Humano-Computador e conhecimento em Visualização de Informação.

Desta forma, os coordenadores de Cursos de Mestrado Online terão mais oportunidades para fazerem melhores análises dos dados e tomadas de decisão melhor informadas.

Abstract

The chairing of online Master Programmes requires constant monitoring and decision-making, amidst a diversified set of data and ongoing processes, which is challenging.

A large part of these data and processes are found or take place in learning management systems (LMS). These are large amounts of information. If not well understood and interpreted, it can lead to poor decisions and lost opportunities to support the students enrolled in the Program. Decision-making for online Master Programmes chairing can be supported by dashboards, with previous efforts having produced early prototypes.

The focus of this thesis is on identification and prototyping of efficient visualization and interaction methods for such a dashboard, according to strategies of Human-Computer Interaction and current knowledge on Information Visualization.

This will offer online Master Program chairs opportunities for better analysis and decision-making.

Keywords: E-learning Dashboards, Learning Management Systems, Data Visualization, Program Coordination

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*“Do all the good you can,
by all the means you can,
in all the ways you can,
in all the places you can,
at all the times you can,
to all the people you can,
as long as ever you can.”*

John Wesley

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Abbreviations

LMS	Learning Management Systems
KPI	Key Performance Indicator
HCI	Human-Computer Interaction
DS	Design Science
IS	Information System
MEIW	Mestrado em Engenharia Informática e Tecnologia Web
UTAD	Universidade de Trás-os-Montes e Alto Douro
UAb	Universidade Aberta
DOM	Document Object Model

Chapter 1

Introduction

1.1 Context

The chairing of online master programs has raised some challenges due to their remote nature. Program chairs have to make sure that the students experience runs evenly and according to expectations [22][17].

The successful management of this type of programs is based on the constant monitoring of large amounts of information, which usually take place in LMS (Learning Management Systems). This information needs to be constantly updated and analyzed in order to detect irregular variances and intervene, if necessary.

If poorly presented, the information will be misinterpreted and some decisions may not be made in the best way or not made at all, which can lead to students not being supported in a timely manner.

There has already been previous efforts in producing a dashboard for this end [22][17] and that prototype is the foundation of the work that we are going to develop. Furthermore, there is a dissertation ongoing at UAb (Universidade Aberta) which was sourced towards identifying relevant indicators for visualization and interaction, as explained in section 2.5.

1.2 Motivation

For most students attending a master program worldwide, the previous two years were an example of how online master programs are relevant due to the pandemic. While also being an engineering student during that time, I could also feel the accumulation of work reach almost unbearable quantities. This could get to a point where students do not know what course they should study or work for and eventually, drop out.

The constant analysis of individual and collective indicators by program chairs is crucial to prevent situations like this. Dashboards made for this end require a more general vision of all courses in the program and a very well organized structure with efficient ways of visualizing the data to accomplish a better informed decision-making.

1.3 Objectives

The major objective of this dissertation, is to support master program chairs decision-making, contributing to faster and better-decision making.

Amidst that, the goals are to improve the visualization prototype, improve interaction with information, improve analysis of information, quickly identify problems and better decision-making.

1.4 Document Structure

This document starts by analysing the background of this thesis in chapter 2, where some basic concepts evolved in the area are described followed by the technologies that may be used and the existing similar systems. In chapter 3 the problems are stated and an early proposed solution. In chapter 4 the methodology that is going to be used is described as well as the work plan. In chapter 5 there is a brief explanation of the original prototype, an identification of its problems and recommended solutions. In chapter 6 the implemented corrections on the original prototype are explained as well as its evaluation by program chairs and the solutions recommended for the problems found. In chapter 7 the implemented corrections on the previous prototype are explained as well as a new evaluation by some professors and the solution recommended for the new problems found. Finally, in chapter 8 are presented the conclusions and the future work.

Chapter 2

Background

In this chapter, will be all the information needed to understand the theme of program chairing and data visualization and interaction with dashboards for program chairs.

2.1 Program chairing

With the constant growing of on-line programmes, distance learning is also increasing. As a consequence, many variations of those courses arise and the model of education changes according to the necessities of eventual approaches for those programmes. Thus, knowing what really makes a dashboard useful for the management of those programmes is essential, and for that there is the need to know what program chairs do. [40]

There are terms that can be mistaken with 'Program Chair', such as 'Program Coordinator' or 'Program Director'. To differentiate them, these three jobs and their functions were fully analysed in three different countries (USA, UK and Australia), to see which of them are used in the administrative area or which actually have the job to act as a coordinator of a program. As a conclusion, program chairs have the most plausible characteristics to do the tasks that we are looking for, program directors do those tasks as well but with some administrative functions and less of coordination and program coordinators have fully administrative tasks and there is no need for them to be a professor or have a high academic degree. To complement that, a search in some Portuguese universities also confirmed that Portuguese program chairs perform the same tasks as in the studied foreign universities, making the term 'Program chair' the most appropriate to address in this dissertation. [40]

The roles of program chairs are very extensive and vary a lot from university to university but there are some that are a common denominator between the analysed universities in [40] such as the act of proposing the creation or dissolution of program courses, ensuring compliance with the objectives defined for the program, its courses and academic activities while meeting the criteria of

scientific and pedagogical effectiveness and efficiency and contributing to the proper functioning of the program, its courses and academic activities. [40]

2.2 Data Visualization

Data Visualization has been among humans since pre-historic time. Without it there would be a lot of information that would not be understood or last in time.

Data visualization is defined as "a graphical, animated, or video presentation of data and the results of data analysis" in [15] but it can also be regarded as information visualization or scientific visualization [34].

As there are enormous amounts of data being generated everyday, and whenever users look at raw data their brain first needs to read the information, then try to comprehend it and finally try to understand it depending on the context, making them have a hard time analysing and using it [10].

Humans, who are constantly being influenced by their surroundings and who have a constant need to understand it, there are some patterns that are instant to identify such as:

- when things are closer or further away from one another;
- when things move up and down;
- when things are bigger or smaller;
- when things are taller or shorter.

All of those interpretations from their everyday life can also be transferred to the analysis of graphs [10].

Even though data visualization usefulness, it is imperative that it is clear what information needs to be shown as it can become misleading. The right data wrongfully displayed can lead to incorrect analysis and conclusions [10].

Therefore, data visualization is essential, as it brings more efficient ways of displaying data, making it easier for users to understand it: it allows them to recognize patterns and trends, making its comprehension better and forming a more informed opinion. However, it is crucial to present data in a non-biased way to prevent wrong conclusions [27].

2.2.1 Data Visualization as decision-making tool

Aesthetics, clarity and expressiveness have a high impact on whether dashboards are a success or a failure [15]. As such, for each of the several KPIs (Key Performance Indicators) that need to be in the dashboard, there needs to be an effective display of the data so users can interpret the data quickly and make some conclusions.

There are some ways that data visualization can improve the process of decision-making [1]:

- The fast speed that valuable conclusions can be drawn from massive amounts of information;

- The information is simplified, reducing the probability of having biased opinions;
- The simplification of communication, as when a decision is made it will be necessary to effectively let other people know;
- Raw data is transformed into a universal language that anyone can understand. When providing more people with relevant information, more perspectives will be available and, therefore, even better-informed choices.

Another important matter of data visualization when it comes to dashboards is that dashboards are meant to be viewed at-a-glance, so all the displays need to be seen all at once and only from there go into detail [32].

2.3 Data Interaction

Static visualizations (e.g. images or static graphs) do not allow users to explore data, what is there is what the user gets. When analysing a data set there are questions that arise and could be solved with a simple interaction. Thus, adding interacting techniques will solve this problem, also leveling up the general visualization. [29]

It is very important to know the users of the dashboard so that it is known what type of actions they want or need such as: adding more information with communication systems, hyperlinks to see more information, drill-down or drill-through capabilities to obtain more details, making comparisons etc. [32]

As seen, interaction with data helps to show all the information the user needs, with the benefit of not adding more space to the display. There are different types of interactions, such as [32]:

- Tooltips: these appear when the graph or certain components of the graph are hovered with the mouse pointer. With this, additional details about the information can be added.
- Expansion or collapsing of visuals: these come in handy when there is the need to expand a visual but there is not space in the original view for it. It allows the display of much more information in a bigger display area and help users focus on the information they really need.
- Data brushing: when the user changes a selection of data in one display and the linked data in other views is highlighted. This allows the user to choose what is displayed, making the dashboard much more personalized.
- Interactive highlighting: when a user can highlight the desired data. This helps the user to focus on data they want to focus.

2.4 Learning Analytics Dashboards

Over the last few years, the educational industry has benefited from the constant evolving of learning analytics and technology. These areas have come together creating dashboards to improve and understand better the learning process.

Learning Analytics (LA) is defined as "the measurement, collection, analysis and reporting of data about learners and their contexts" [30]. Apart from the gathered data, it also includes the development of metrics and the different techniques of displaying the data [30].

Dashboards, which are defined as "a single display that aggregates different indicators about learner(s), learning process(es) and/or learning context(s) into one or multiple visualisations.", are a common way of reporting this data [38]. The main goals of dashboards are to deliver feedback about learning processes and activities, giving the opportunities of better decision-making, helping students by gaining motivation and preventing drop-out [29].

2.5 Literature Review on visualization and interaction techniques for program chairing dashboards

A literature review is a way of selecting, evaluating and analysing all the existing information with the objective of answering a particular research question. [28].

With the aim of finding data visualization techniques and interaction techniques for program chairing dashboards, two literature reviews were done. The guideline followed for both of them is in [28], and the platform used was Publish or Perish [24].

2.5.1 1st Literature Review

The first literature review started from the results and criteria of Viegas, M. [39], which was made by him from the years 2016-2020 and which I updated for years 2020-2021.

The search for the articles was done with the search strings "("higher education" OR "academic programme" OR "academic programmes" OR "university" OR "college" OR "faculty") AND ("course management" OR "programme coordination" OR "programme chair" OR "programme chairing" OR "programme coordinator" OR "programme director" OR "programme direction" OR "programme coordinating") AND ("analytics" OR "indicators" OR "metrics" OR "dashboard" OR "dashboards" OR "instruments" OR "measures" OR "kpi" OR "analysis")" and "("higher education" OR "academic program" OR "academic programs" OR "university" OR "college" OR "faculty") AND ("course management" OR "program coordination" OR "program chair" OR "program chairing" OR "program coordinator" OR "program director" OR "program direction" OR "program coordinating") AND ("analytics" OR "indicators" OR "metrics" OR "dashboard" OR "dashboards" OR "instruments" OR "measures" OR "kpi" OR "analysis")".

The platform used the results only from Google Scholar. Merging Viegas 2016-2020 results with my own for 2020-2021, 36 articles were found which were all discarded due to being duplicates of the already made literature review.

From the final corpus of Viegas, M., **all of the 29 articles were discarded after full text analysis**, as they did not mention data visualization and interaction techniques, being out of scope.

2.5.2 2nd Literature Review

Still with the same objective, a second literature review was done. Once again, the platform only used the results from Google Scholar, searching for results from the years 2016-2021, limiting the results for the first 1000.

This time, the search for the articles was done with the search string "allintitle: (("higher education" OR "academic program" OR "academic programs" OR "university" OR "college" OR "faculty") AND ("analytics" OR "indicators" OR "metrics" OR "dashboard" OR "dashboards" OR "instruments" OR "measures" OR "kpi" OR "analysis")) OR "course management" OR "program coordination" OR "program chair" OR "program chairing" OR "program coordinator" OR "program director" OR "program direction" OR "program coordinating"").

The following exclusion criteria were defined to analyse the results:

1. Not accessible online
2. Title or abstract in a language I do not know
3. Not from the field evaluation by title
4. Not from the field evaluation by abstract

According to these criteria, several results were excluded, as follows:

1. 24 papers, which leaves 975 results to analyse
2. 8 papers, which leaves 967 results to analyse
3. 706 papers, which leaves 264 results to analyse
4. 235 papers, which leaves 26 results to analyse

From these results, 26 articles were fully read and studied. From those, 2 were related with tools for developing dashboards in academic setups, 20 were related to data visualization/interaction tools and techniques, 2 were related with problems with data visualization and the final 2 were related to the interpretation of the data.

In the next sections and subsections the knowledge extracted from the literature review will be presented.

2.6 Tools and techniques

2.6.1 Visualization of the dashboard

The most common uses of visualization are through graphs, charts, plots, etc. which can take many variations. In figure 2.1 there is some examples of possible visualizations.

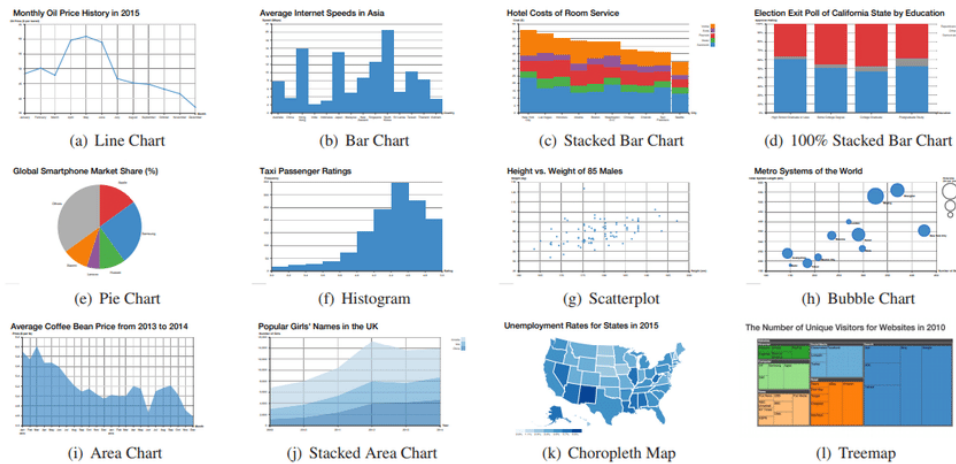


Figure 2.1: Examples of data visualizations [21]

Although there is a lot to choose from, the visualizations have to be relevant to show the data in order to be well understood. Next, a summary of them will be done based on [16] and [11].

- Line Charts: great for visualizing data through time and see the evolution;
- Bar Charts: best to analyse different data categories in the same chart;
- Pie Charts: best to show the percentage of different data in the same chart;
- Area Charts: similar with the Line Charts but with more information inside;
- Bubble Charts: best to visualize data sets in three dimensions;
- Scatter Charts/Scatterplot: data is displayed as group of points and each of the them has a value for the horizontal axis and vertical axis.

2.6.1.1 Relation between visualization techniques and KPIs

As referred in section 2.2, the KPIs present in the dashboard should have a clear and effective display so that users can understand data quickly and make informed decisions.

In [21], a study to a dashboard was done based on the Visual Literacy Assessment Test (VLAT), which consists of 12 data visualizations and 53 multiple-choice questions covering 8 data visualizations tasks.

Each data visualization has linked several tasks based on dataset types and task taxonomies. The data visualizations were linked to a KPI from the dashboard under study. The eight task visualizations were the following:

1. Retrieve value
2. Find extremum
3. Determine range
4. Characterise distribution
5. Find anomalies
6. Find clusters
7. Find correlations/trends
8. Make comparisons

The results are presented in table 2.1.

Table 2.1: Comparison of data visualization with KPIs [21].

KPI	Visualization	Tasks Finished (%)
Program Registration	Line Chart	62.5
Module Comparative Difficulty	Scatterplot	100
Results Banding	Histogram	24
Module Marks	Boxplot	0
Retentions and Graduations	Stacked Bar Chart	62.5
Module Registration Comparison	Density Plot	0
Module Pass/Fail Ratios	Stacked Bar Chart	24
Grade Categories Over-time	Stacked Area Chart	62.5

Analysing the results, the the visualizations "Boxplot" and "Density Plot" for the KPIs "Module Marks" and "Module Registration Comparison" are not well suited, since 0% of the tasks were concluded. However, when joining the KPI "Module Comparative Difficulty" with the visualization "Scatterplot", the choice is the appropriate one as tasks were 100% finished.

These are mere examples of how users can have the right data but if not well visualized no right conclusions can come out of it.

2.6.2 Interaction with the dashboard

Even when users are presented with a visualization of a data set, that is not enough for them to understand what it is trying to report and want to explore more than what it directly displayed. As a result, users would want to do the following [27]:

- vary views;
- delete clutter;
- adjust mapping;
- zoom;
- panning to explore neighbourhoods;
- brushing or highlighting to see correspondence in multiple views;
- label to get original data.

2.6.3 Data visualization websites and tools

In table 2.2, extracted from Avella et al. [13], are presented some websites that allow the creation of visual approaches of data.

Table 2.2: Data Visualization Websites and Tools [13].

Name	Description	URL
Gapminder	reduces datasets into few	https://www.gapminder.org/
IBM Many Eyes	creates data visualization	https://boostlabs.com/blog/ibms-many-eyes-online-data-visualization-tool/
FlowingData	uploads the data and creates visualization	https://flowingdata.com/
Visualization Community	includes data visualization tools and websites	http://vacommunity.org/

2.6.4 Dashboard design

Although the visualization of the data is the most important part for a good analysis, the environment of the whole dashboard also affects the way users understand data. Thus, there are four fundamentals of dashboard design that should be taken into consideration: Content, Layout, Color, and Fonts [16].

2.6.4.1 Content

The content refers to the information that the dashboard is displaying. Content presented should always be relevant to the target audience, so everything that does not fit its purpose can be discarded. Furthermore, the dashboard should not be overloaded with information to the point where the users are lost and cannot interpret what they are doing or looking for. Finally, and to help users to navigate the dashboard, iconography should also be used as it is a very intuitive tool to apply [16].

2.6.4.2 Layout

The layout refers to the way information is organized: if it is in the correct order, size, if the dashboard has blank spaces that are not being correctly filled. Principles such as related data should always be grouped together, the sizing of icons or graphs should be similar amongst them or limiting the data presented are good tips to have a eye pleasing layout [16].

2.6.4.3 Colours

Choosing the correct displayed colours might be something that most people would not consider thinking about. However, it should be one of the most important factors taken into consideration when designing a dashboard. For starters, the combination of colours need to be decided very carefully as in some cases, when together, they need to be distinguished very easily. Colours should also be used for specific reasons (e.g. when wanting to separate information that is in the same chart or when something needs to be highlighted). Another important aspect is that colors have a connotative meaning that people refer to (e.g. red can be hot but it can also be used to highlight something bad whereas blue can be cold and green can be used to highlight something good). Finally, colours should also be tested to colour blindness. This means that color blind users cannot distinguish some colours from each other so using some tools appropriate for that case should be a concern when designing a dashboard [16].

2.6.4.4 Fonts

The fonts and letters used in a dashboard are also very important. Normally the font size standard for Times New Roman is 12 and for Arial is 10. These font sizes should remain standard through the whole dashboard which means that there should not be much variation unless something it is something that needs to be highlighted. Finally, combining fonts and colours together is crucial as they need to fit together and colours can give different meanings to the text [16].

2.7 Technologies

There are several tools that are developed and prepared with the aim of helping with the visualization for academic purposes. In this section, some of them will be presented.

2.7.1 *JasperReports*

JasperReports is an open source reporting machine, developed by *JasperSoft*. This tool generates report templates that can be filled with data retrieved from other sources. It also offers tools for integration with software applications through shared web services. [20]. Its main functionalities include dashboards, tables, crosstabs, charts and gauges [23].

2.7.2 *Tableau*

Tableau is an interactive tool which its main purpose is to be used as a visualization tool to analyze data. The visualizations are displayed in real-time and is based on interactive dashboards. It requires no programming language and can import data from several types of sources. However, it cannot be integrated with other software platforms [36][35].

2.7.3 *D3.js*

D3.js is a *JavaScript* library which is a help when trying build interactive data visualizations in modern web browsers. It has the ability of creating a wide range of visualizations. However, this library is facing performance problems when working with large amounts of data as well as some incompatibilities with browsers (e.g. Internet Explorer) [35].

2.7.4 *Microsoft Power BI*

Power BI is a business analytics service, mostly based on the cloud but with a single-user desktop version, with the aim of providing data visualization. When compared to other tools, it has a particular function which is the usage of natural language to query the data. It also does not programming knowledge and multiple data sources can be merged to create models [12].

2.7.5 *Plotly*

Plotly was developed using *Django* and *python*, and it can analyse and visualize data. It allows the creation of dashboards and charts, with a vast variety of them available. However, it has some limitations, which can only be resolved with a membership [12].

2.7.6 *Gephi*

Gephi is an open-source network analysis, with the aim of managing large and complex sets of data and information. Although it does not require programming skills, some graph knowledge is necessary for its correct handling [12].

2.7.7 **Conclusion**

Table 2.3 summarizes all the tools above with comparisons between them.

Table 2.3: Comparison of data visualization tools [12].

	Open Source	Integration with popular sources	Interactive visualization	MOOCS¹	API
JasperReports	Y	Y	Y	Y	Y
Tableau	N	Y	Y	Y	Y
D3.js	Y	Y	Y	Y	Y
Microsoft Power BI	N	Y	Y	Y	Y
Plotly	Y	N	Y	Y	Y
Gephi	Y	N	Y	Y	N

2.8 Similar Systems

2.8.1 LATch (Learning Analytics Tool for chief decision making bodies)

LATch [20] is a software tool that was created to correspond to the needs of decision making bodies (program managers, deans, rectors) in Bulgaria. It allows the monitoring of the learning processes to make data-driven decisions in time, improving their institutional and educational processes.

This tool was developed with the integration of the existing solutions *JasperReport Server* and *JasperSoft Studio* which are visualization tools already approached in 2.7.1 and the framework *Dynamic Presentation Framework*, which is a software framework for visualising dynamic user-driven views of digital objects in a web browser [20].

2.8.2 Academic decision making model

This academic decision making model [37] was created with the objective of serving as a support tool to solve academic problems for the managers of higher education institutions in Latin America.

The system information model was implemented with the Unified Process and deployed through the web application UDLearn. [37]

2.8.3 Drill-down Dashboard for Coordination of Master Programmes in Engineering

The previous developed prototype [22][17] was created with the aim of bringing something new to the educational area and learning processes: a learning analytics dashboard specially directed to program chairs. It involved the exploration of the tasks asked of them, looking for the data that supports those tasks and developing simple visualizations for that information. In short, the objective was to create a dashboard focused on the job of a program chair.

¹MOOCs are Massive Open Online Courses, which are available for everyone. They allow an easier way to progress in professional careers, while also being affordable. [5]

2.8.4 Comparison between similar systems

As seen in the previous sections,

On the one hand, the LATch system in 2.8.1 provides different type data depending on the user's role (Program manager, deans and rectors). When it comes to deans and rectors, LATch generates reports of the results of several indicators, which allows them to [20]:

- comparison of those indicators with previous years;
- identify trends in the students activities and grades in each program;
- track the students rate of drop-out.

Moreover, it also allows program managers to [20]:

- track the students' activity and their visits to the resources in the courses they are responsible for;
- compare the students' activity to previous years students' in the courses they are responsible for;
- track the students' progress in the activities;
- track the teachers' activity and their feedback in the courses they are responsible for;
- control the scheduling of the materials and completion of activities;
- track students grades and compare them to the other students and previous year's students;
- monitor the students' and teachers' workload;
- evaluate the variety of learning activities and resources in the courses.

On the other hand, the academic decision making model's [37] features are for the general managers of higher education institutions. This project can be divided in two models the Graduation Project Management Model and the Academic Performance Module.

The first model is more related to the documental management of graduation projects, the assignment of the supervisors and examiners to those projects and the monitoring of their evaluation.

However, in the Academic Performance Module, it allows the managers to see:

- courses passed per student;
- level of progress made by student;
- students' average mark by semester, course, teacher;
- comparison of the progress made by a student to the rest of the students;

- comparison of the student grade average to the rest of the students;

Although the system mentioned in 2.8.1 has much more information to display than the system mentioned in 2.8.2, both systems have features that are important when the subject is program chairing but both are very broad and general.

When comparing these two systems to the system in 2.8.3, it is known that the last one is focused on three of the most important tasks of program chairs, which are the oversee absenteeism, prevent dropout and create and review students results [22][17].

As such, several indicators are used to display the correct information that program chairs need to see. Thus, the system described in 2.8.3 allows program chairs to see:

- the distribution of the students' grades and participation in the courses;
- the percentage of activities done in each course by week;
- the distribution of students by percentage of participated activities;
- when were the students' last accesses to the learning platform;
- a timeline of activities of each student and their statuses;
- a comparison of the activities done by a student to the rest of the students;
- the grades of each evaluated activity done by the student;
- where the student is located on each type of activities, comparing him to the other students;
- a timeline of the courses' activities and their percentage of completion respectively;
- a comparison of the activities done in a course to the rest of the courses;
- the distribution of students by percentage of participated activities in the course;
- the distribution of the students' participation in each activity type and the students' grades in each activity evaluated in the course;

To summarize, this system is entirely developed with the program chairs and their tasks at its center, having indicators specifically studied to show what is strictly needed for the the program chairs evaluation.

2.8.5 Conclusion

From the research made, there are not many similar systems that are aimed at program chairs (and when they do they are very broad and include other roles of the higher institutions managers), but rather teachers and students. Reasons could include a slip of nomenclature when doing the literature review or even articles not being written about developed prototypes [22][17].

Chapter 3

Problem Definition

In this chapter, will be made an approach to the problem. First, in section 3.1 the problem will be carefully described. Finally in section 3.2, the approach to the problem will be shortly described.

3.1 Problem Statement

Learning analytics have been proved to increase student retention, improving their success and ease the burden of accountability for everyone involved in the education environment. However, most tools with the aim of gathering and analysing data from learners and all the processes involved are mostly directed to students and teachers, which do not fulfil the additional tasks that a chair of a master program has.

Previous efforts have developed a dashboard that is focused on the data that supports the tasks of program chairs, with simple visual elements showing that data [22][17]. However, there was a limited evaluation of this dashboard, as this type of job deals with large amounts of information and has a diversified amount of functions, there is no knowledge about the efficiency and quality of the dashboard in the light of diversity of those said functions.

3.2 Proposed System

This work will develop a prototype dashboard to support master program chairing. It will be based on the first prototype developed earlier [22][17], and on a KPI survey being developed in tandem, as put forward in section 1.1. This work will analyse the prototype in view of HCI and visualization/interaction knowledge for this field, and apply that knowledge to the KPI survey outcomes, as a base to developing the new dashboard prototype.

Chapter 4

Methodology

In this chapter, will be made an approach to the methodology that is going to be used during the development of this dissertation followed by the description of the process followed. In section 4.1 is presented the research paradigm and in section 4.2 explains the process that is going to be used. Finally, in 4.3 is presented and explained the process followed.

4.1 Design Science

Design Science (DS) is one of the characterizations of the research made about the Information Systems (IS) discipline. It pushes people out of their comfort zones by creating new and innovative artifacts, reaching its goal: utility [26].

DS contributions in IS research are constantly being evaluated as they are integrated in the business need. Its utility usually comes as a form of unknown truth, which can become flaws in theory or artifact and there will be the need to reassess them [26].

In [26], the common problems that DS research addresses in IS are characterized by:

- *"unstable requirements and constraints based upon ill-defined environmental contexts*
- *complex interactions among subcomponents of the problem and its solution*
- *inherent flexibility to change design processes as well as design artifacts (i.e., malleable processes and artifacts)*
- *a critical dependence upon human cognitive abilities (e.g., creativity) to produce effective solutions*
- *a critical dependence upon human social abilities (e.g., teamwork) to produce effective solutions"*

Table 4.1: Design-Science Research Guidelines [26].

Guideline	Description
Guideline 1: Design as an Artifact	Design-science research must produce a viable artifact in the form of a construct, a model, a method, or an instantiation.
Guideline 2: Problem Relevance	The objective of design-science research is to develop technology-based solutions to important and relevant business problems.
Guideline 3: Design Evaluation	The utility, quality, and efficacy of a design artifact must be rigorously demonstrated via well-executed evaluation methods.
Guideline 4: Research Contributions	Effective design-science research must provide clear and verifiable contributions in the areas of the design artifact, design foundations, and/or design methodologies.
Guideline 5: Research Rigor	Design-science research relies upon the application of rigorous methods in both the construction and evaluation of the design artifact.
Guideline 6: Design as a Search Process	The search for an effective artifact requires utilizing available means to reach desired ends while satisfying laws in the problem environment.
Guideline 7: Communication of Research	Design-science research must be presented effectively both to technology-oriented as well as management-oriented audiences.

Furthermore, according to [26], there are seven steps that are advised to be followed when doing a DS research, in order for it to be complete. In table 4.1, extracted from Hevner et al. [26], they are summarized.

4.2 Design Science Research: a three cycle view

As any research, there is the need to raise the understanding of how important it is to do high quality design research in IS. That is because there is the need of gaining credibility among researchers from different areas and to also support acceptance among IS professionals. [25]

As we can see in figure 4.1 , there is the IS research framework found in [26], overlaid with three research cycles in [25] that need to be included and identifiable in a DS research project:

- **Relevance Cycle:** connects the contextual environment of the research project to the design science activities
- **Rigor Cycle:** bridges the design science activities to the knowledge base of scientific foundations, experience, and expertise that informs the research project.
- central **Design Cycle:** iterates between the core activities of building and evaluating the design artifacts and processes of the research.

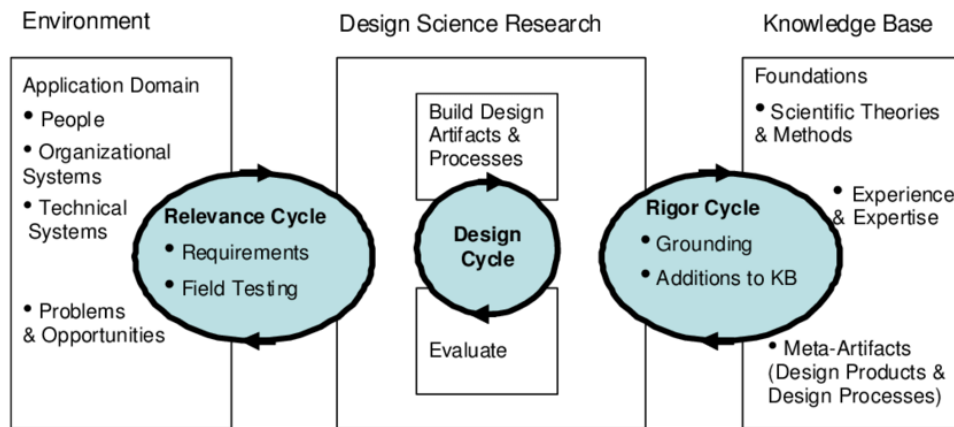


Figure 4.1: Design Science Research Cycles [25].

4.3 Design Science Research Methodology (DSRM)

To follow the DS research methodology, six steps need to be included in the process, as seen in table 4.2:

Table 4.2: Design-Science Research Methodology Six Steps [33].

Step	Description
Problem identification and motivation	Definition of the research problem and justification of the value of a solution.
Define the objectives for a solution	Deduce the objectives of the solution.
Design and development	Create the artefact.
Demonstration	Demonstration that the use of the artifact solves the problem(s).
Evaluation	Observation and measurement of how the artifact supports the solution to the problem.
Communication	Communication of the problem, its significance, the artifact, its usefulness, the rigor of its design, and its efficacy to relevant audiences.

As such, there is the need to connect the tasks that will be developed in this thesis to the six steps mentioned before. This is done in table 4.3.

To summarize, the relation of this work and DS is based on the work plan described in section 4.3 and the relevance and rigour it is going to bring to the educational system through the background of the thesis in chapter 2 and the evaluation of the already developed prototype [22][17], which will be the base for this work’s visualization and interaction models.

Table 4.3: Connecting the tasks of the thesis to the steps of the DSRM.

Step	Description
Problem identification and motivation	In chapters 1 and 3 is provided the motivation and the problem statement, respectively.
Define the objectives for a solution	In section 1.3 are described the objectives of this thesis.
Design and development	In section 5.1 is explained the original prototype and how it works. In chapters 5, 6, 7 describes how the various prototypes were developed, how the problems were identified through interviews with program chairs, followed by the identification of concrete problems, the solutions recommended for those problems and the process of implementing those solutions. All of this, through the three prototypes developed.
Demonstration	In chapter 7 is demonstrated the final prototype, which resulted from the iterations through the previous prototypes, as well as the changes made to the implementation.
Evaluation	In chapters 6 and 7 is described the evaluation of the prototypes through the master program chairs interviews.
Communication	This thesis document communicates the necessary information about the artefact.

Chapter 5

Evaluation of original prototype

This chapter includes a description of the already implemented prototype [22][17] in 5.1, its identified problems in 5.2.1 and recommended rectifications 5.2.2.

5.1 Original prototype

The original prototype contains three views (Program, Course and Student view), fully explained in subsections 5.1.1, 5.1.2 and 5.1.3.

5.1.1 Program view

The Program view contains four displays that help Master Program chairs visualizing how the overall Program and its courses are doing as well as all the students enrolled in all courses. This view is represented in Figure 5.1.

5.1.2 Course view

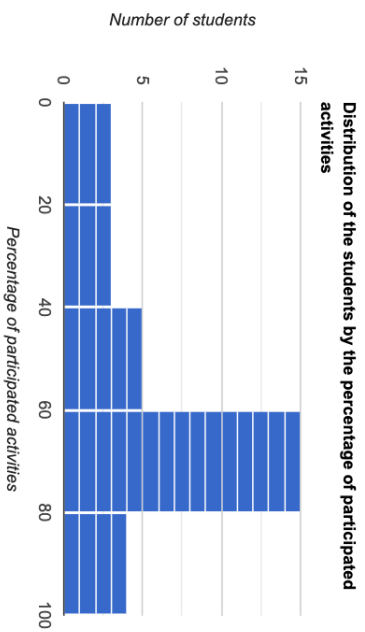
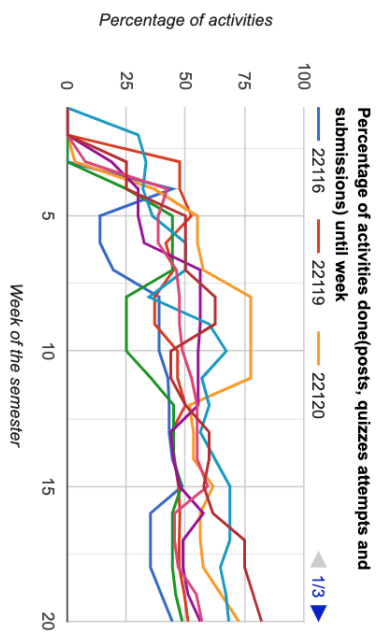
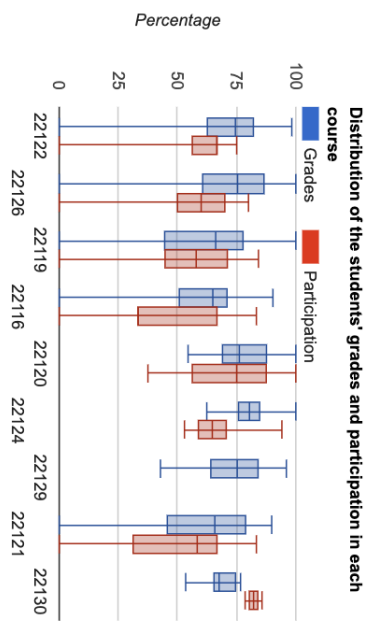
The Course view is composed of five displays, allowing the monitoring of a course, comparing it to other courses and visualizing its timeline. This view is represented in Figure 5.2.

5.1.3 Student view

The Student view is composed of four displays, allowing the monitoring of a particular student, how they are behaving compared to their colleagues and in each course. This view is represented in Figure 5.3.

5.1.4 Implementation

To make the original prototype functional, there were several resources used.



Student	Days since last access	Mean of the Percentage of open activities done	Percentage of open activities done
Serena Goulão	0	0	0
Tabanez	3	26.423	40
Angélico Alencar Malheiro	26	11.458	0
Sol Cruz Letras	0	0	0
Nuna Sales Vidal	0	24.558	66.667
Dulce Casado Garcez	0	19.679	50
Luisa Belchior Barrico	0	14.669	25
Pavel Caminha Ufas	0	27.492	100
Teresa Gama Parata	0		

Figure 5.1: Original prototype: Program view

Course: Visualização de Informação

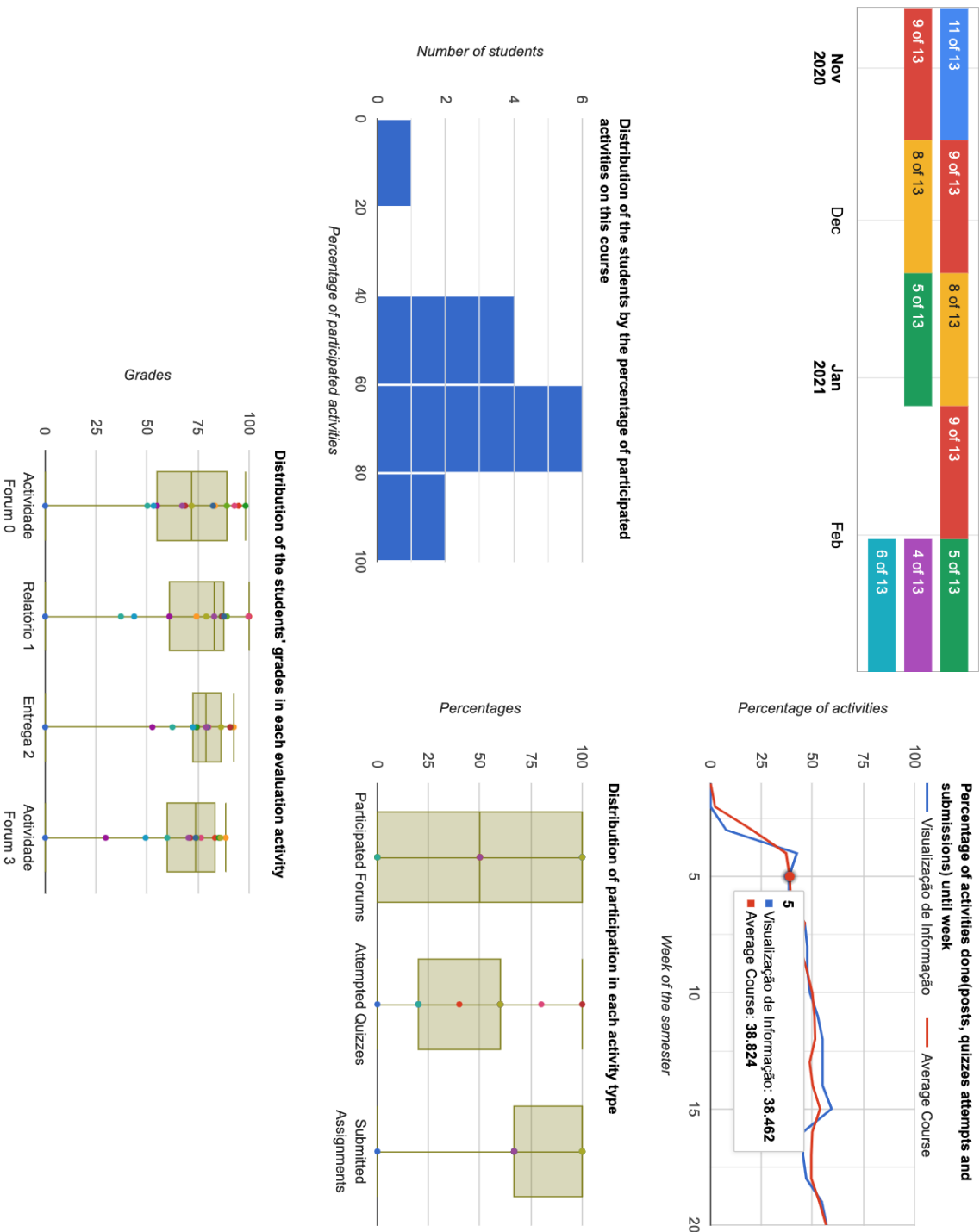
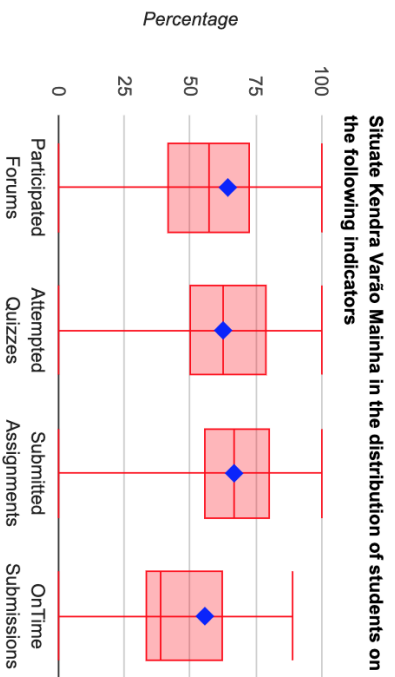
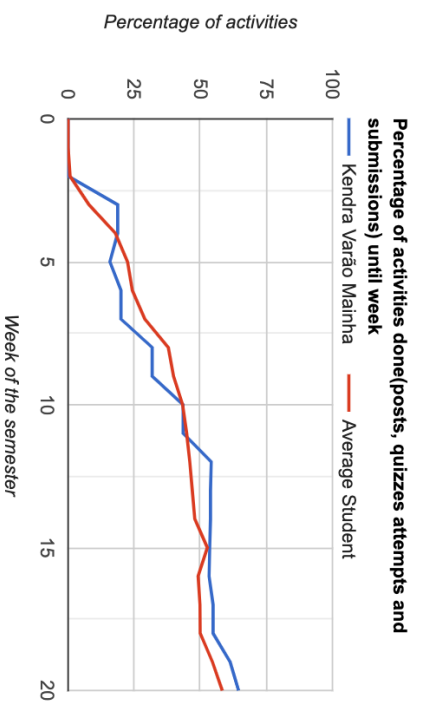


Figure 5.2: Original prototype: Course view

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Student: Kendra Varão Mainha



Course	Evaluation	Grade	Percentile
22116	Actividade Forum 0	76.2	0.88
22116	Relatório 1	75.372	0.75
22116	Relatório 2	83.352	1
22119	Actividade Forum 0	100	1
22119	Teste 1	72.009	0.67
22119	Actividade Forum 2	86.321	1
22119	Relatório 3	99.527	1

Figure 5.3: Original prototype: Student view

5.1.4.1 Moodle

Modular Object-Oriented Dynamic Learning Environment (Moodle) is an open source learning management system that helps educators to manage several courses, facilitating interaction with online students worldwide, by also allowing their access to tools, resources and enrolled courses [6].

5.1.4.2 Moodle Web Services

The prototype is a dashboard that is based on data that is only present in Moodle, so the required data needs to be extracted somehow. For this end are used the Moodle Web Services, which consist in a group of functions that gets the data from Moodle and reorganizes and shows it from the program chair point of view [22][17].

5.1.4.3 Database

To store the information needed, a SQLite database was created, with its UML diagram depicted in figure 5.4.

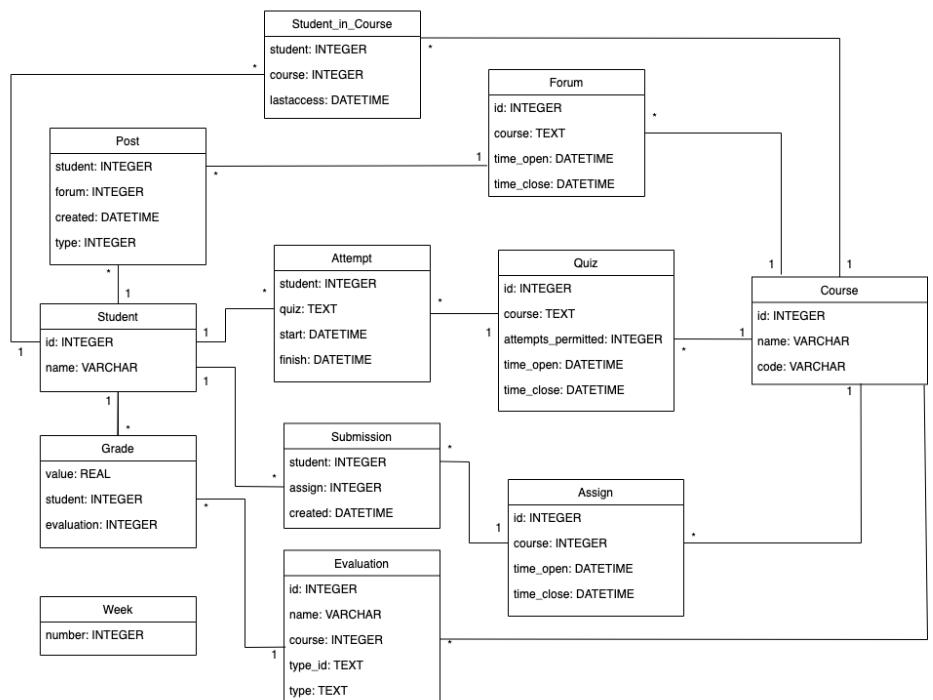


Figure 5.4: UML Diagram of the original database.

5.1.4.4 Node.js

Node.js is a JavaScript execution environment developed with Chrome's V8 JavaScript engine. It was designed to build scalable network applications [8].

The connection between the prototype and Moodle is done through the Moodle Web Services [22][17].

5.1.4.5 Express.js

Express.js is a Node.js framework that facilitates the usage of HTTP requests and designed to build web applications [8].

5.1.4.6 Pug.js

Pug.js is a high performance template engine implemented with Node.js, that can create faster solutions [9]. It allows to write simpler Pug code, in which the Pug compiler compiles into HTML code, and also supports JavaScript natively, allowing the usage of JavaScript expressions.

5.1.4.7 Google Charts

To display the charts in the prototype the Google Charts Tool was used. This tool allows the implementation of interactive charts and their customization [22][17].

5.1.4.8 D3.js

D3.js is used to manipulate documents based on data. In this case, it was used to alter the DOM of the web page [22][17].

5.2 Evaluation

Based on my current knowledge of data visualization and interaction of dashboards as well as all the knowledge described in chapter 2, on the 15th of November 2021, I evaluated the original prototype and identified some problems in 5.2.1 and recommended some solutions for each one in 5.2.2.

5.2.1 Identified problems

When evaluating the prototype several flaws were detected right away in the several displays of each view. This flaws are described in Table 5.1.

PROB01, PROB05, PROB06, PROB07, PROB08 and PROB11 were identified as problems as they did not make the user able to identify what the axis, the graphs or the colours were referring to.

Table 5.1: Identified deficiencies on the original prototype

Problem	View	Figure	Description
PROB01	Program	A.1	X axis without caption
PROB02	Program	A.1	Courses' ids make chairs not able to identify each course right away
PROB03	Program	A.1	Courses' ids in tool-tip make chairs not able to identify each course right away
PROB04	Program	A.2	Courses' ids in caption make chairs not able to identify each course right away
PROB05	Course	A.5	No title
PROB06	Course	A.5	X axis without caption
PROB07	Course	A.5	No Y axis
PROB08	Course	A.5	No colour caption
PROB09	Course	A.5	Chairs are not able to identify what the ratio seen in the tooltip means
PROB10	Student	A.10	Courses' ids in table make chairs not able to identify each course right away
PROB11	Student	A.10	No title
PROB12	Student	A.13	Courses' ids in table make chairs not able to identify each course right away

5.2.2 Recommended solutions

For each problem identified, the solution found is described in Table 5.2.

Table 5.2: Solutions for identified deficiencies on the original prototype

Problem	Solution
PROB01	Add 'Course' caption to x axis
PROB02	Change each ID to course code
PROB03	Change each ID to course full name
PROB04	Change each ID to course code
PROB05	Add 'Course activities timeline' title
PROB06	Change chart to Gantt chart
PROB07	Change chart to Gantt chart
PROB08	Change chart to Gantt chart
PROB09	Change chart to Gantt chart
PROB10	Change each ID to course code
PROB11	Add 'Activities timeline' title
PROB12	Change each ID to course code

In Chapter 6, the correction and explanation of all the problems identified can be observed.

Chapter 6

Revised Prototype

In this chapter, in section 6.1, are presented, explained and shown the implemented corrections to the original prototype. In section 6.2 is a brief explanation of the conducted interviews with the master program chairs and the pointed out problems which resulted from the evaluation of the revised prototype in those interviews. In section 6.2.2 are listed the recommended solutions for each problem identified.

6.1 Implemented corrections

Using the recommended solutions found in 5.2, all of the problems were resolved. PROB01, PROB02, PROB03 and PROB04, all related to the Program view, can be seen rectified in Figure B.1 and B.2. The overall result of the Program view is depicted in Figure 6.1.

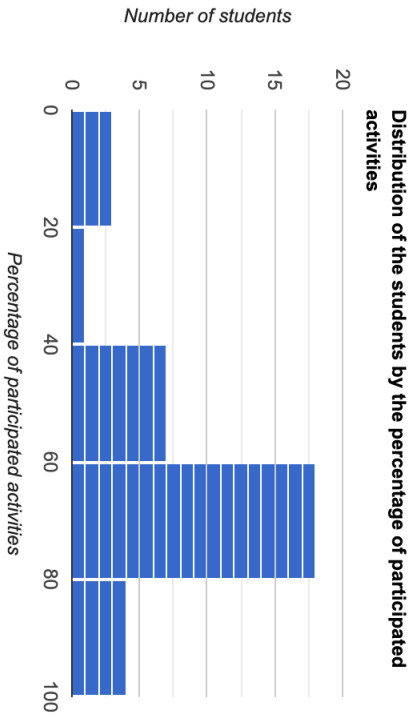
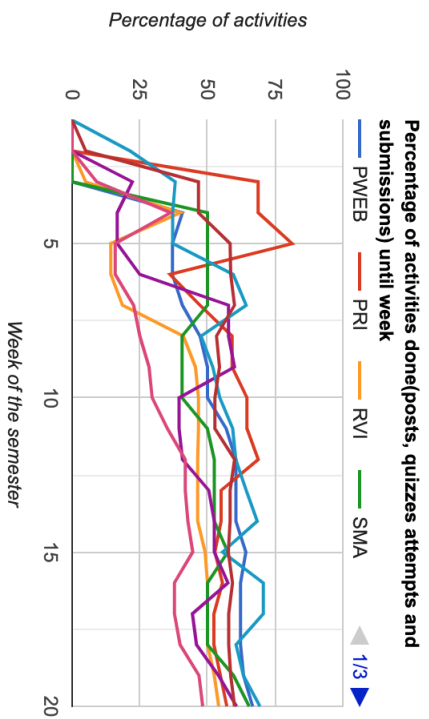
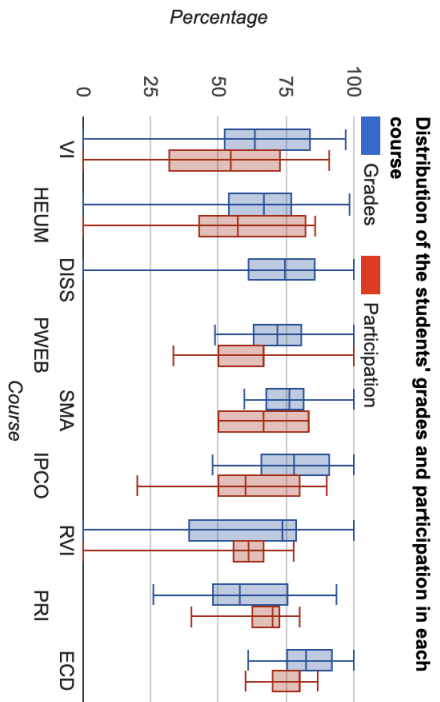
PROB01 was related to the missing caption of the x axis, which was resolved by adding the 'Course' caption; PROB02, PROB03 and PROB04 were all related to the fact that courses are being displayed by their id, which is resolved by changing it either to their code or to their full name, making them easier to identify.

The overall result of the Course view is depicted in Figure 6.2. In this view were identified PROB05, PROB06, PROB07, PROB08, PROB09 all related to the same display, it was decided that the original chosen graph was not the most suitable to display the desired information, and therefore the solution to all of these problems is to convert the previous graph to a Gantt chart. This chart displays the timeline of activities of the course, showing when each activity starts and ends, as well as the percentage of students who have done each activity, fixing PROB09.

However, in order to display the name of each activity in the new chart created, the original database had to be modified. To the tables Assign, Forum and Quiz the attribute name had to be inserted in all of them.

The remaining problems were related to the mislabel of the previous visualization and resolved with the implementation of the new chart. The result of this change can be seen in Figure B.3.

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Student	Days since last access	Mean of the Percentage of open activities done	Percentage of open activities done
Imran Zagalo Casado	20	0	0
Avelino Matos Vides	0	7.813	0
Rute Ferrão Marçal	0	22.167	50
Mickaël Quintana Mariz	0	22.708	66.667
Victoria Fitas Fitas	0	18.137	100
Kendra Ferrão Quinta	0	11.714	80
Telmo Carvalhal Gama	0	0	0
Rute Ventura Silvestre	2	21.405	75

Figure 6.1: Revised prototype: Program view

Course: Visualização de Informação

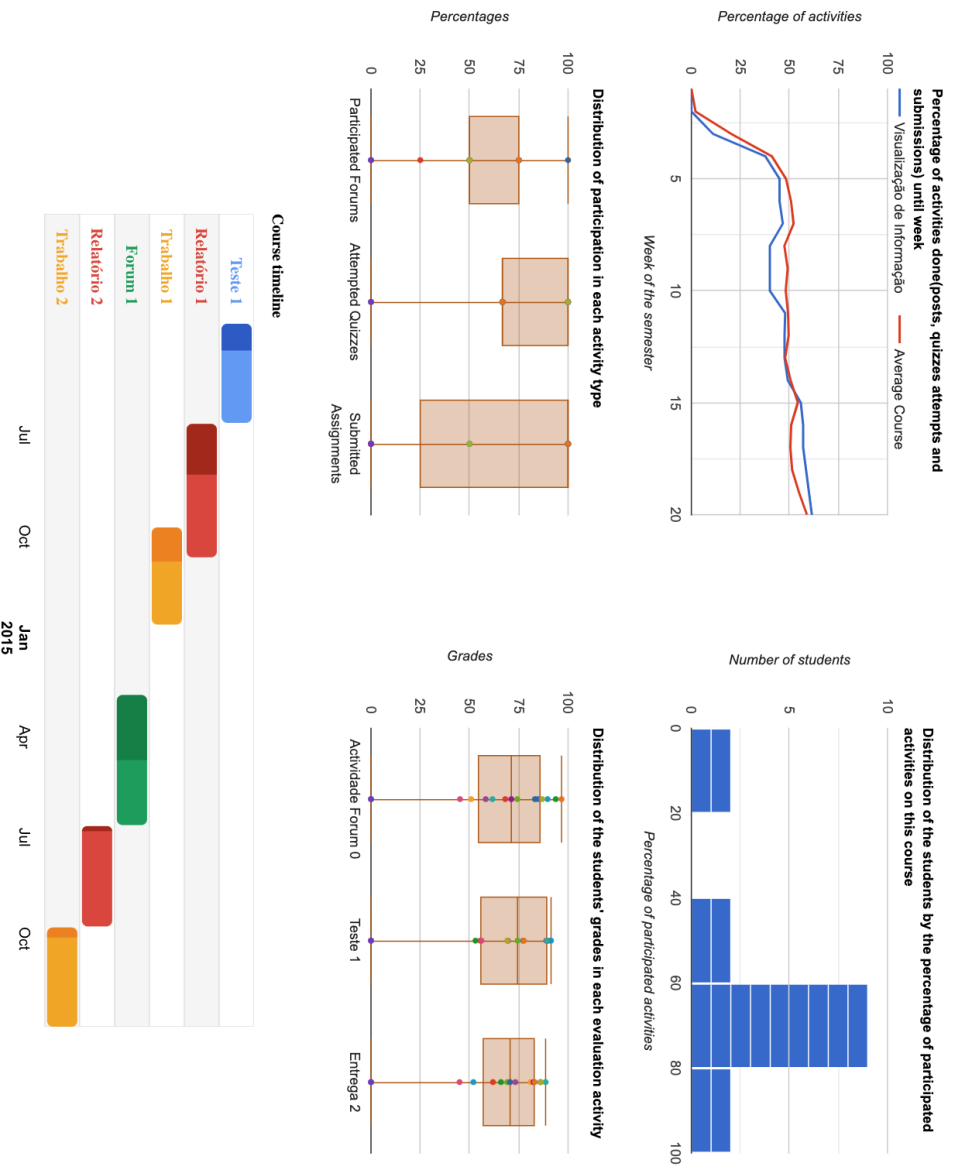


Figure 6.2: Revised prototype: Course view

PROB10, PROB11 and PROB12, which were all related to the Student view, which can be seen fixed in Figure B.4 and B.5. The overall result of the Student view is depicted in Figure 6.3.

PROB10 and PROB12 were related to the fact that courses are being displayed by their id, which is resolved by changing it to their code, making them easier to identify. PROB11 was the missing title, which was fixed by adding the 'Timeline Activities' title above the visualization.

6.2 Evaluation

6.2.1 Interviews with Master Program chairs

To evaluate the revised prototype, which resulted of the various changes that I did, some Master Program chairs (Appendix C) from two universities (UTAD and UAb) were chosen and invited by email to have a video-conference interview on the 15th of November 2021. The selection process of the interviewees was due to their extensive experience when it comes to the chairing of Master Programmes, as seen in Appendix D, E, F and G.

Until the 23rd of November of 2021, four interviews were scheduled. In these interviews, the authorization to include their name and personal opinions in this dissertation was provided.

The interviews were conducted between the 25th of November of 2021 and the 13th of December of 2021. The protocol of the interview can be seen in Appendix H, as well as its translation in appendix I. This protocol was derived from [22][17].

To deploy the prototype so that the master program chairs could use and visualize it, was used the Ngrok [7] technology which allows the creation of a secure tunnel to share a server or site running on a local machine. [7]

Apart from evaluating the revised prototype, this interview was conducted with the objective of extracting data (the interviewees' requirements and necessities) that could have been missed on the first attempt of development of the original prototype. Therefore, the interview is divided in three parts where the first one the questions are related with the activities that a Master Program chair does, the second is the evaluation of the prototype and the third about indicators that were not considered in the development of the original prototype and whether or not they should be included in the development of this prototype. The results from the conducted interviews are provided in appendix J, K and L.

Regarding other indicators to be included, it was unanimous that the enrollment regimes of students are important to take into consideration, as well as a longitudinal follow-up of students, agreed by three out of four chairs. There were no other indicators considered important to be included.

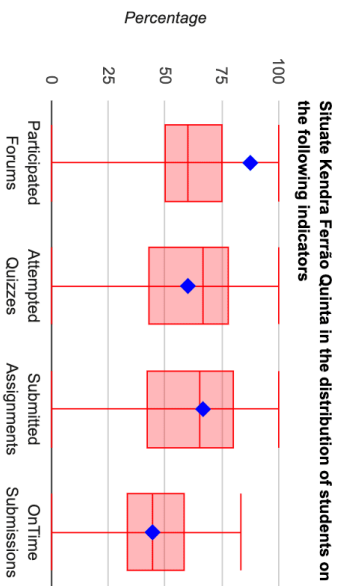
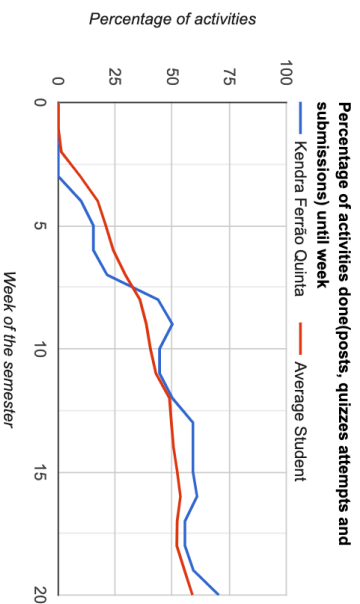
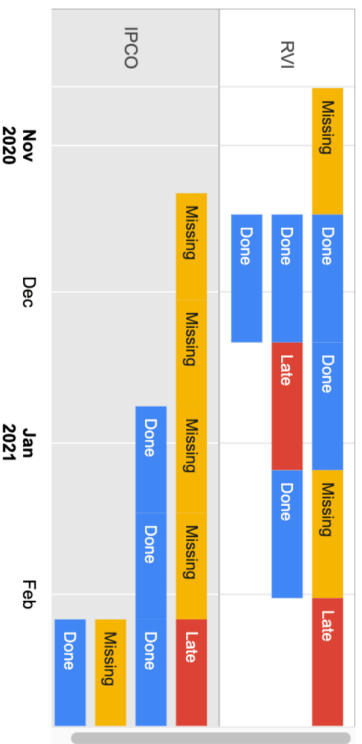
From the evaluation of the prototype, 51 pieces of evidence were extracted (their full transcript and categorization are available in Appendix K, along with each respective display and chair who mentioned it). The categorization of each piece of evidence resulted in 8 categories, which are described in table 6.1.

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Student: Kendra Ferrão Quinta

activities timeline



Course	Evaluation	Grade	Percentile
IPCCO	Actividade Forum 0	66.196	0.25
IPCCO	Entrega 1	84.466	0.63
IPCCO	Actividade Forum 2	100	0.88
RVI	Relatório 0	77.542	0.78
RVI	Teste 1	75.612	0.67
RVI	Relatório 2	77.692	0.44

Figure 6.3: Revised prototype: Student view

In table 6.2 is shown the translated transcript and the respective problem, which in the end resulted in 31 different problems. In table 6.3 each problem is described.

Category	Description
Layout improvement	General feedback about the aspect of the whole prototype and the navigation between pages.
Missing information	Information that would be useful to take into consideration when analysing the prototype and is missing in the prototype.
Distracting information	Information that can divert the attention from other important data.
Graph improvement	Improvements that need to be made to the graph so that data can be more easily understood.
Lack of coherence	When information presented or components do not connect and have the same meaning between graphs.
Colour mislabelling	When colours which naturally have a connotative meaning are wrongly labeled and misinterpreted.
Extra feature	Suggested extra features.
Phrase mislabelling	When a phrase is poorly done.

Table 6.1: Categories resulted from the evaluation of the prototype.

Table 6.2: Identified problems

ID	Translated Transcript	Problem
01	"Indicators do not increase to take advantage of the available screen space"	Static size of graphs
02	"I need to know immediately which courses need my attention"	Need of immediate information about courses
03	"If there are students whom I should worry about, their name and contact must show up"	Need of immediate information about students
04	"Report with a more professional look"	Non-professional looking page
05	"Header with three views so I would know they exist"	Page not intuitive to navigate to other pages
06	"General view with every student from every edition"	Non-existent general student view
07	"This many significant figures do not make a different when reading"	Too many significant figures
08	"There are so many numbers here"	Too many significant figures
09	"By clicking on the indicator in the graph, it would lead me to the course page"	Lack of ability to navigate to other pages through the graph
10	"The flow between the views is not very intuitive"	Page not intuitive to navigate to other pages

11	"The navigation is hidden"	Page not intuitive to navigate to other pages
12	"It would be important to have some kind of degree of comparison"	Degree of comparison missing in graph
13	"There are also too many significant figures"	Too many significant figures
14	"It looks like the graph would go on with the legend"	Graph content seems to move according to legend
15	"The course DISS is NaN and it does not appear"	Lack of ability to interpret the meaning of Nan
16	"I do not know if this can handle so many courses"	Too much information in the graph
17	"In this graph we should be able to navigate to the course page too"	Lack of ability to navigate to other pages through the graph
18	"I know the number of students but the percentage would be more interesting"	Suggestion of a different measure of the indicator
19	"There are students who did not participate in the same group as the ones who participated a little bit"	Students not grouped optimally
20	"There are also too many significant figures"	Too many significant figures
21	"These values have a very high precision"	Too many significant figures
22	"There are also too many significant figures"	Too many significant figures
23	"These colours are somewhat aggressive to read"	Colours too vibrant
24	"There is no indication that there is a link to the student page"	Lack of indication to navigate to other pages
25	"Important information that I do not have: the students' enrollment regime and their course edition"	Student information missing
26	"The name of the course should look more professional"	Non-professional looking name of course
27	"I would need to know immediately if this course needs my attention and where"	Need of immediate information about the course
28	"There are also too many significant figures"	Too many significant figures
29	"There are also too many significant figures"	Too many significant figures
30	"There are also too many significant figures"	Too many significant figures
31	"There are also too many significant figures"	Too many significant figures
32	"It is not clear the meaning of the darker and lighter colours"	Misinterpretation of the bar about assignment delivery
33	"I did not understand it was the students who did and did not do the assignment"	Misinterpretation of the bar about assignment delivery

34	"The colours are confusing I thought they meant the assignments were late or not being delivered on time"	Colours are associated with a non-intentional connotative interpretation
35	"I would like to know how many students saw the activity, how many clicked in the activity"	Missing information about activity access
36	"The follow-up of the dissertations is not as simple as other courses"	Dissertation has different follow-up
37	"Should not that 'done' be green?"	Colours are mislabeled
38	"Colours are mislabeled here"	Colours are mislabeled
39	"I do not know the meaning of red, blue and yellow"	Colours are associated with a non-intentional connotative interpretation
40	"My doubt is why three lines of information"	No activity differentiation
41	"This has three lines, it is a bit confusing"	No activity differentiation
42	"I do not understand why there are two lines for some and others only one"	No activity differentiation
43	"I do not know which activity this refers to"	Lack of information about the activity
44	"If the activity was named I would understand better"	Lack of information about the activity
45	"Theoretically there is only one task during this week, in this week he does not have 100% of participation the data is not consistent"	Defect of the test process
46	"I do not know if 'OnTime Submissions' is not distracting from the 'Submitted Assignments'"	Distracting indicator
47	"'They' should be 'The student is'"	Individual student mislabel
48	"There is a legend missing saying that the red is the whole class and the blue is the student"	Misinterpretation of the meaning of each component of the graph
49	"These colours are somewhat aggressive to read"	Colours too vibrant
50	"In the other graph I have the same colour with a different meaning"	Colours are associated with a non-intentional connotative interpretation
51	"It says 'Evaluation' but it refers to he type of activity"	Column mislabelling

Table 6.3: Problem Description

ID	Problem	Description
PROB01	Static size of graphs	When the browser window is resized, the graph do not change their size and adapt to the window size.

PROB02	Need of immediate information about courses	When opening the main page there is the need to know right away which courses are having trouble and need attention.
PROB03	Need of immediate information about students	When opening the main page there is the need to know right away which students are having trouble and need attention, as well as their contact.
PROB04	Non-professional looking page	There is the need of a more professional looking page for it to be included in reports.
PROB05	Page not intuitive to navigate to other pages	Accesses to other existent views are not obvious and not found sometimes.
PROB06	Non-existent general student view	There is the need of a general page with every student (and their information) of every edition of the course.
PROB07	Too many significant figures	The degree of detail of the numbers is greater than necessary.
PROB08	Lack of ability to navigate to other pages through the graph	When there are references to courses inside the graph or in the legend, it should be able to go to that course's page from the graph or the legend.
PROB09	Degree of comparison missing in graph	There is the need of a reference value to have a sense of what are the normal values for comparisons to be made.
PROB10	Graph content seems to move according to legend	The movement of the legend makes the user interpret that the graph moves as well
PROB11	Lack of ability to interpret the meaning of Nan	Nan is misinterpreted.
PROB12	Possibility of too much information in the graph	If any more courses are added to the graph it can become too hard to read the lines and the graph would overflow.
PROB13	Suggestion of a different measure of the indicator	The measure of the indicators is not the optimal to understand the data globally.
PROB14	Students not grouped optimally	Students who have different types of participation are in the same group.
PROB15	Colours too vibrant	Colours are too bright and aggressive to read.
PROB16	Lack of indication to navigate to other pages	There are no indications of how it is possible to navigate to the students and course pages.
PROB17	Student information missing	Important information for the student follow-up is missing.
PROB18	Non-professional looking name of course	There is the need of a more professional looking name of the course for it to be included in reports.

PROB19	Need of immediate information about the course	When opening the course page there is the need to know right away if it is having trouble and where.
PROB20	Misinterpretation of the bar about assignment delivery	Meaning of the two different colors presented in the bar was not associated to the right one.
PROB21	Missing information about activity access	Information about the students who saw the activities and clicked on them is missing.
PROB22	Colours are associated with a non-intentional connotative interpretation	The colours red, green and yellow are interpreted with a connotative meaning.
PROB23	Dissertation has different follow-up than normal courses	The type of follow-up that teacher and students have during Dissertation is not the same as the other courses, and therefore the Dissertation page should differ from the other courses.
PROB24	Colours are mislabeled	Colours are wrongly associated with labels.
PROB25	No activity differentiation	In each line of activities, each block of each activity is together, giving the sense that it refers to only one activity.
PROB26	Lack of information about the activity	Timeline does not show the name of the activity represented.
PROB27	Defect of the test process	Information is not consistent through some graphs, making their analysis and interpretation all together more difficult.
PROB28	Distracting indicator	Indicator that potentially can distract the attention from more important ones.
PROB29	Individual student mislabel	Student mislabeled.
PROB30	Misinterpretation of the meaning of each component of the graph	Difficulty in understanding the meaning of various components of a graph.
PROB31	Column mislabelling	Title of column is wrongly labeled

In the table 6.4 is represented the number of times each problem was mentioned. By analysing this information, the problem that was most mentioned was PROB07 (Too many significant figures - 10 times mentioned), due to the fact that this problem was mentioned as one in several displays of each view.

The second most mentioned problems were PROB05 (Page not intuitive to navigate to other pages), with a total count of 3 mentions and PROB24 (No activity differentiation) with also 3 mentions. PROB05 was related to the difficulty that the chairs had to navigate from one view to the other as for them it was not intuitive and could not find the links for the redirection. PROB24, related to figure B.4, where it was not understood why there were several lines with a continuous colour, even though there were different activities represented when hovering each activity.

All of the other problems were either mentioned once or twice.

Table 6.4: Problem analysis of first interviews

ID	Number of times mentioned	ID	Number of times mentioned
PROB01	1	⋮	⋮
PROB02	1	PROB17	1
PROB03	1	PROB18	1
PROB04	2	PROB19	1
PROB05	3	PROB20	2
PROB06	1	PROB21	1
PROB07	10	PROB22	2
PROB08	2	PROB23	1
PROB09	1	PROB24	2
PROB10	1	PROB25	3
PROB11	1	PROB26	2
PROB12	1	PROB27	1
PROB13	1	PROB28	1
PROB14	1	PROB29	1
PROB15	2	PROB30	1
PROB16	1	PROB31	1
⋮	⋮	TOTAL	51

6.2.2 Recommended solutions

In table 6.5 the recommended solution for each problem is described. All of these solutions are based on the chapter 2, more specifically the subsection 2.6.4, along with the approval of my supervisors Professor Leonel Morgado and Professor António Coelho.

What was not found in chapter 2 was carefully analysed and discussed also with my supervisors.

Table 6.5: Solutions for the problems found in the revised prototype

ID	Problem	Solution
PROB01	Static size of graphs	As the value of the height and width of the graphs are static, the solution is to alter those values dynamically according to the size of the window of the user.
PROB02	Need of immediate information about courses	When the prototype is opened in the program page, a pop up appears with the courses which need intervention (if they exist) and their status.
PROB03	Need of immediate information about students	When the prototype is opened in the program page, a pop up appears with the students who are in risk and their contact.
PROB04	Non-professional looking page	Add a header with the logos from the program, UAb and UTAD.

PROB05	Page not intuitive to navigate to other pages	Add a menu with the several views and links for lists of the existent courses and students.
PROB06	Non-existent general student view	Add the option to expand the visualization of the students table from the program view in a modal with a bigger screen.
PROB07	Too many significant figures	Reduce the number of significant figures to 1.
PROB08	Lack of ability to navigate to other pages through the graph	Add the possibility to go to the courses' page through the content of the graph as well as though the legend and adding the active link to the legend to be perceptible it is a link) and the pointer button.
PROB09	Degree of comparison missing in graph	Add a line to the graph where each user can input the its value (the reference value), depending on their point of view.
PROB10	Graph content seems to move according to legend	Change legend's position to the side of the graph.
PROB11	Lack of ability to interpret the meaning of Nan	Change 'Nan' to 'N/A'.
PROB12	Possibility of too much information in the graph	Add possibility of removing or adding lines from the line by clicking in each course code.
PROB13	Suggestion of a different measure of the indicator	Change the y axis from 'number of students' to 'percentage of students'.
PROB14	Students not grouped optimally	Change the intervals of the x axis of the histogram 'Percentage of participated activities' from 20 to 10.
PROB15	Colours too vibrant	Change colour palette to a more soft one.
PROB16	Lack of indication to navigate to other pages	Add the pointer button to let the user know it is a route to navigate to other pages.
PROB17	Student information missing	Add the information missing in the expanded visualization of the students.
PROB18	Non-professional looking name of course	Highlight course name and move it to the center of the page.
PROB19	Need of immediate information about the course	When the course page is opened, a pop up appears with the status of the course, and if it needs an intervention it should display where it is needed (participation, evaluation, etc).
PROB20	Misinterpretation of the bar about assignment delivery	Add legend with the meaning of both colours.

PROB21	Missing information about activity access	Adding another bar with the percentage of students who saw the activity below the existing one for each activity.
PROB22	Colours are associated with a non-intentional connotative interpretation	Remove all colours and make all neutral.
PROB23	Dissertation has different follow-up than normal courses	This problem requires an in-depth analysis for a solution to be recommended.
PROB24	Colours are mislabeled	Label the colours right: 'done' is green, 'missing' is yellow and 'not done' is red.
PROB25	No activity differentiation	Add a border to each rectangle of activity to separate them.
PROB26	Lack of information about the activity	Add the activity name to the tooltip.
PROB27	Defect of the test process	It is necessary to run tests with real data.
PROB28	Distracting indicator	To solve this problem, a survey to the chairs needs to be made, in order to ask them if, in their opinion, the distracting indicator should be eliminated or not.
PROB29	Individual student mislabel	Change the mislabel of an individual student from 'they' to 'the student is'.
PROB30	Misinterpretation of the meaning of each component of the graph	Add legend to show what the colours and components of the graph mean.
PROB31	Column mislabelling	Change the name of the column from 'Evaluation' to 'Activity'.

In Chapter 7, the correction and explanation of all the problems identified can be observed.

Chapter 7

Final Prototype

In this chapter, in section 7.1, are presented, explained and shown the implemented corrections to the revised prototype. This code is available on <https://github.com/realMariaviana/FEUP-DISS>.

In section 7.2 is a brief explanation of the conducted interviews with the master program chairs and the pointed out problems which resulted from the evaluation of the revised prototype in those interviews. In section 7.2.2 are listed the recommended solutions for each problem identified.

7.1 Implemented corrections

Using the recommended solutions found in 6.5, most of the problems were resolved. In this section all of the corrections of the problems will be explained (including the ones which were not implemented and the ones which got another solution rather than the recommended one). In appendix M are presented all the close-ups of the implemented corrections of the final prototype.

7.1.1 General corrections

Starting off with the more general problems which had nothing to do with the already existent views (program, course and student), the problems mentioned were PROB01, PROB04 and PROB05. Although PROB07 is related to most of the displays in every view, it can be considered a general correction as it was fixed equally everywhere it was mentioned, as planned.

PROB01 was successfully fixed with the already recommended solution. As seen in figures M.1 and M.2, where in the first one the screen size is smaller and bigger in the second one, the graphs adapt dynamically to it.

When it comes to PROB04 and PROB05, the header was successfully inserted, as seen in M.1 and seen more in detail in figure M.3, where the in the left the program logo was added (also with the link to the program page), the link 'Students' which leads to a list of all the students enrolled in the program, which can be viewed in figure 7.1 and the list 'Courses' which lists all the courses

that exist in the program, with the direct link to the page to each of them, which can be seen in figure M.4.

7.1.2 Program view corrections

The overall result of the Program view is depicted in figure 7.2.

For PROB02 and PROB03, related to the need of instant information about courses and students, the suggestion of a pop-up with the necessary information was made. However, this was not possible to implement due to the fact there would be the need to study the criteria that would choose what information should be shown, which makes this problem a matter of future work.

When it comes to PROB06, a button was added to the top of the display in question (originally in figure A.4), which allows the user to open a modal with the information of the original display plus some more information that will be talked about when PROB17 is mentioned. The close-up of the display can be seen in figure M.10 and the close-up of the modal opened can be seen in figure M.11.

PROB08 and PROB09 were both related to the same graph (figure B.1), where the implementation went as planned. In figure M.5 there is a example of how the 'SMA' course appears with the active link when hovered with the mouse. In the same figure M.5 it is seen that there was a line to the graph added, in which its value is modifiable below the x axis of the graph. The default value of 70 was defined between my supervisors Professor Leonel Morgado and Professor António Coelho to be a reasonable input to start with.

When it comes to PROB10, PROB11 and PROB12, all related to the same graph (originally figure B.2), only PROB11 was not implemented. This was due to a limitation of the framework which does not allow the edition of the tooltip and therefore the 'Nan' term could not be modified to 'N/A'. However, PROB10 was solved successfully, by changing the position of the legend to the right side of the graph which ends up showing all the courses at once. This can be seen in figure M.6. PROB12 was also fixes successfully, and users now can select and deselect which courses they want to see or not, by clicking on the course in the legend. An example of this can be seen in figure M.7, by comparing to figure M.6, only 'PWeb', 'ECD' and 'IHC' are selected.

PROB13 and PROB14 were related to the original figure A.7. It was not possible to resolve PROB13 through the way it was originally intended because the feature of seeing the percentage of participation of each student and the direct route to each of them would be lost. However, it was resolved by adding a button 'Alternate graph' that changes the histogram to a pie chart, where the user can see, in the same intervals of the histogram, the percentage of students located in that interval. As such, no feature would be lost and the user can choose which display helps them see the information clearly and both displays complement each other. The histogram visualization can be seen in figure M.8 and the pie chart visualization can be seen in figure M.9.

To solve PROB14 instead of having intervals of 20 in the 'percentage of participated activities' axis (as seen in figure A.3), they turned into intervals of 10 which allows a more fair distribution of the students, as seen in figure M.8. These intervals of 10 were also incorporated in the pie chart graph (figure M.9).

Student	Days since last access	Mean of the Percentage of open activities done	Percentage of open activities done	Course Edition	Enrollment Regime
Mercês Marinho Filipe	0	32.8	75	2ª	tempo parcial
Avelino Lousã Imperial	1	20.5	100	3ª	tempo parcial
Eliel Borja Alencar	0	0	0	2ª	tempo parcial
Avelino Moreira França	15	9.6	0	5ª	tempo parcial
Victoria Saraiva Proença	0	23.1	66.7	6ª	tempo parcial
Ryan Calçada Marçal	0	20.2	100	6ª	tempo parcial
Emilie Quintana Baptista	0	16.2	66.7	6ª	tempo parcial
Raúl Matos Figueiredo	16	6.7	0	6ª	tempo parcial
Andressa Moreira Malheiro	25	4.7	0	6ª	tempo integral
Teresa Cruz Proença	0	22.4	50	6ª	tempo integral
Camila Espinosa Uhoa	0	19	100	6ª	tempo parcial
Imran Rosário Caminha	0	34	66.7	6ª	tempo parcial
Telmo Baptista Robalo	0	21	50	6ª	tempo parcial
Mercês Barrico Carvalhal	0	17.8	50	6ª	tempo parcial
Jordan Moreira Tabanez	14	16.6	0	6ª	tempo parcial
Mercês Proença Tabanez	0	17.2	50	6ª	tempo integral
Kendra Café Figueira	24	15.4	0	6ª	tempo integral
Luisa Garcez Meireles	1	22.5	75	6ª	tempo integral
Andressa Azambuja Marinho	2	29.6	0	6ª	tempo parcial
Kailany Saraiva Cisneiros	6	7.7	0	6ª	tempo parcial
Alexandro Caminha Carvalho	0	25.6	50	6ª	tempo parcial
Silvia Caminha Tabanez	0	0	0	4ª	tempo parcial
Emilie Robalo Garcez	0	34.2	100	6ª	tempo parcial
Enrique Zagalo Baptista	4	35.7	100	6ª	tempo integral

Figure 7.1: Final prototype: Student view in header

7.1 Implemented corrections

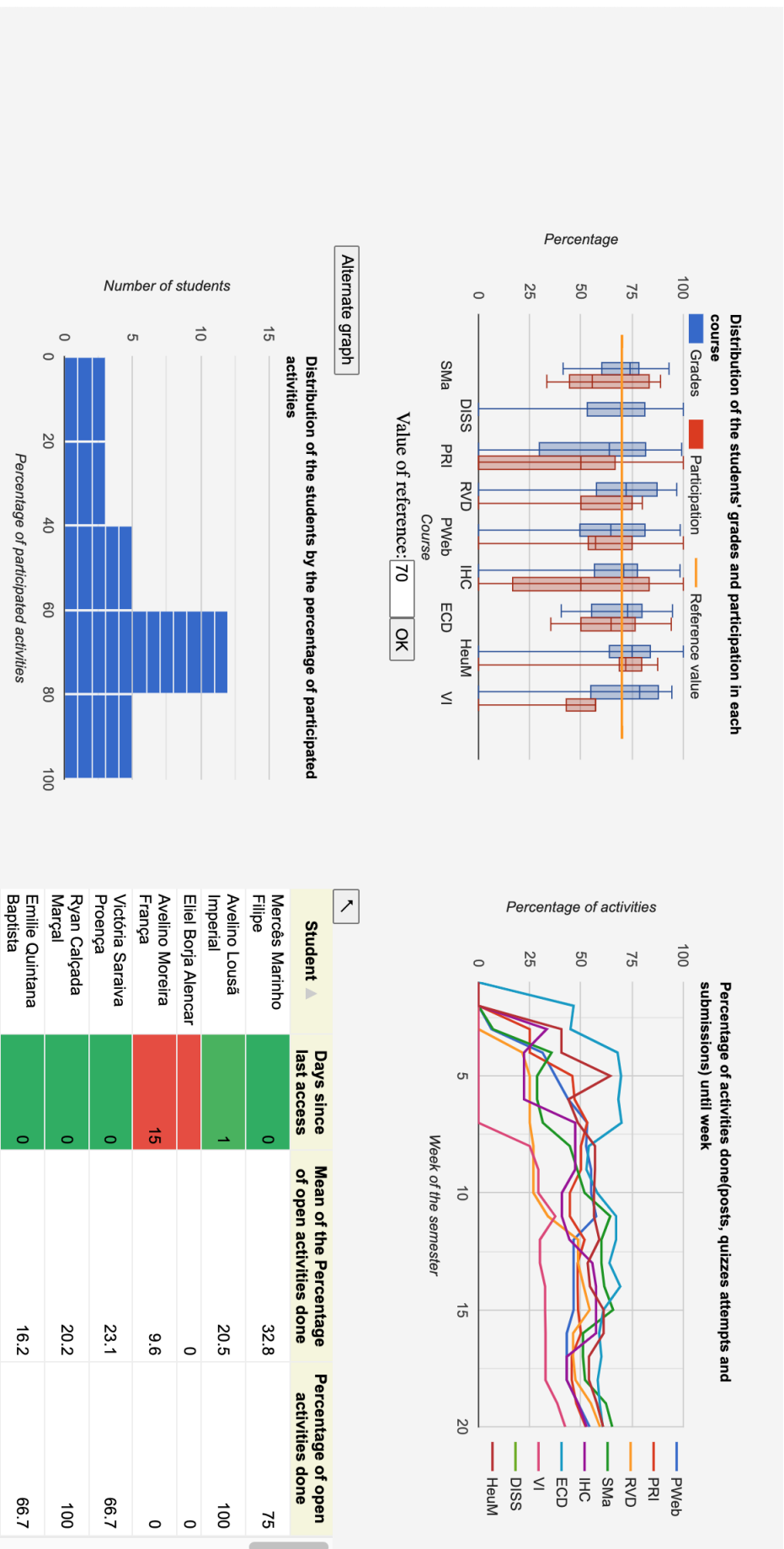


Figure 7.2: Final prototype: Program view

From the figure A.4, PROB15, PROB16 and PROB17 were generated. PROB15 and PROB16 were fixed successfully. The first one, related to the vibrant colours presented in the table was resolved with replacement of more soft colours, which are not too aggressive to the user trying to read the text. PROB16 was fixed as recommended, by adding the pointer button when hovering the table. The close-up of the display can be seen in figure M.10.

In consequence of fixing PROB06, so was PROB17. In PROB06 a modal was added with an expanded version of the table, and as PROB17 mentioned that some information about students was missing, that information was added to the modal. In the final version, the expanded modal includes the information of the original display plus the enrollment regime and course edition of each student. This can be seen in figure M.11.

Moreover, to add this information, the database had to be modified. Both attributes 'courseEdition' and 'enrollmentRegime' had to be added to the table Student. As no other alterations to the database were done, the UML diagram of the final prototype is depicted in figure 7.3.

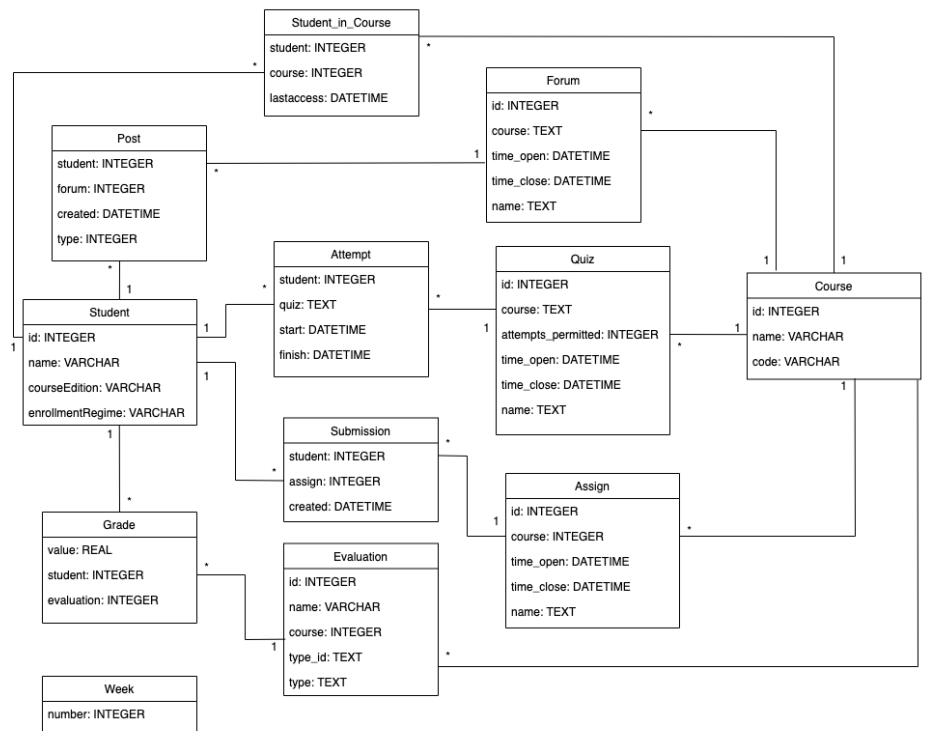


Figure 7.3: Database UML Diagram of the final prototype

7.1.3 Course view corrections

The overall result of the Course view is depicted in figure 7.4.

PROB18 was resolved successfully and as expected, as seen in figure 7.4. The name of the course is highlighted and at the center of the page.

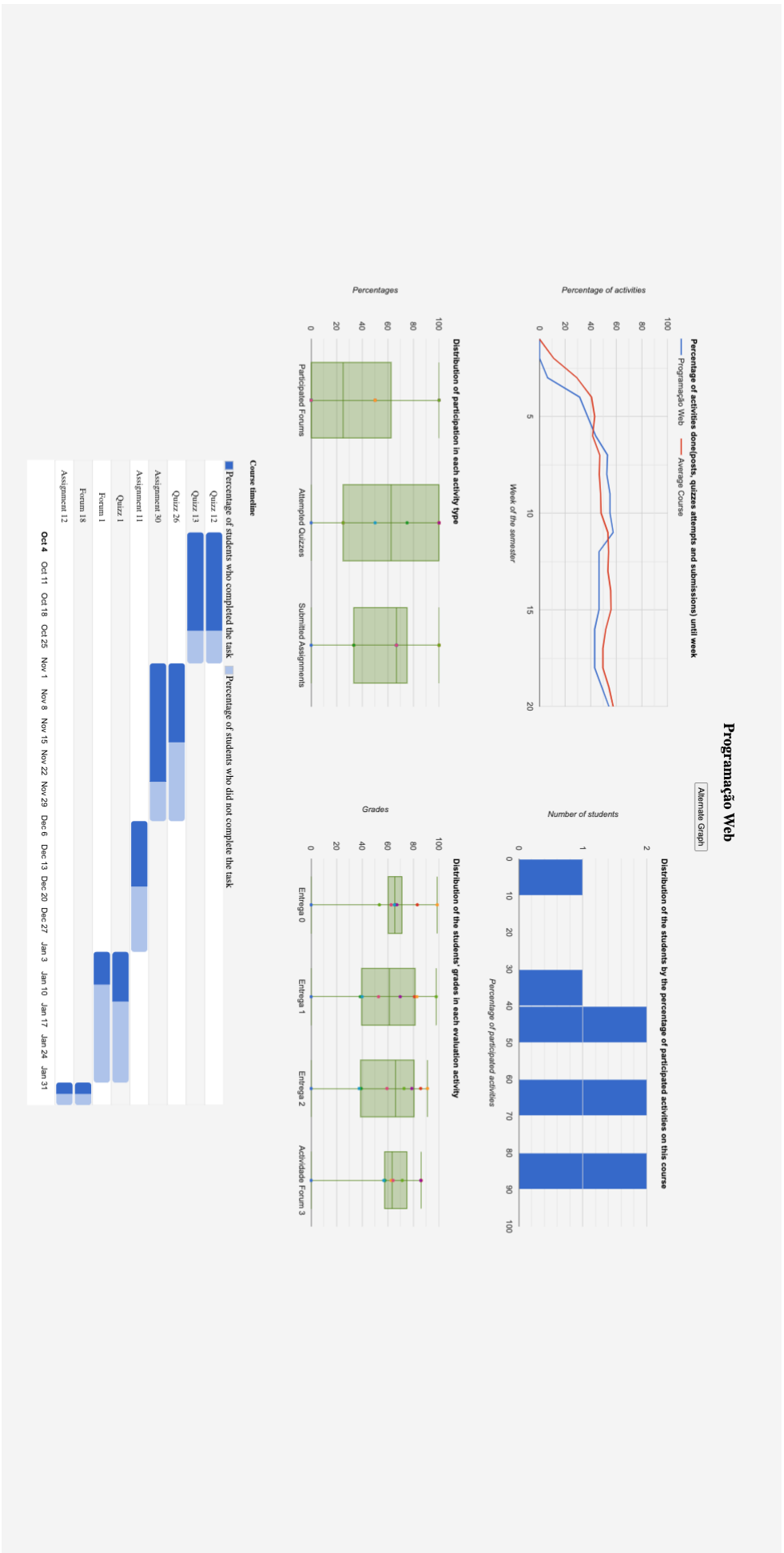


Figure 7.4: Final prototype: Course view

For PROB19, related to the need of instant information about the course, the suggestion of a pop-up with the necessary information was made. However, this was not possible to implement due to the fact there would be the need to study the criteria that would choose what information should be shown, which makes this problem a matter of future work.

The following improvements were not detected as problems but as the graph in figure A.7 is similar to the graph in figure A.3, for reasons of coherence between them, the same improvements were implemented. As such, it was added a button 'Alternate graph' to the top of the graph that would change the graph to a pie chart to see the percentage of students placed in each interval. Furthermore, the 20 interval was also swapped to a 10 interval. The result of the histogram on the course page can be seen in figure M.13 and the pie chart on the same page in figure M.14.

PROB20, PROB22 and PROB23 were all related to the graph presented in figure B.3. To solve PROB20, and as recommended a legend was added to clarify the meaning of the darker and lighter colour. PROB22 was also resolved as expected, by turning all colours into one, in this case, blue. The results of the modifications of this graph can be seen in figure M.17.

When it comes to PROB23, and as described in section 6.2.2, this problem requires an in-depth study for a solution to be recommended. Therefore, this problem is a matter of future work.

Nonetheless, PROB21 did not get fixed. The information needed to implement this feature is not available through the API, only through the reports, and all the data which is exported is from the web services. As there is no way to obtain the reports automatically, a web search was done to try to find a way to get this done. Although a Moodle plugin was found [4], through a conversation with my supervisors Professor Leonel Morgado and Professor António Coelho, it was decided that the feature would not be implemented as the cost-benefit was very low.

7.1.4 Student view corrections

The overall result of the Student view is depicted in figure 7.5.

PROB24, PROB25 and PROB26 are all related to the original graph depicted in figure B.4. In PROB24, the colors green, red and yellow (which have a connotative meaning in this context of being good, bad and intermediate) were corresponding to the wrong labels (e.g. the fact that a student did not do an activity was labeled as green and the delivered activity was labeled as red). The problem was fixed with the colors being labeled correctly, accordingly to the recommended suggestion. This can be seen in figure M.18.

In the same graph if, for example, in the same line all the activities were not done, there would exist a continuous red line which would not have a separation between the activities, which leads to PROB25. To solve this, a white border was added to each activity (as recommended), so it would be noticeable that there were different activities on the same line. This can also be seen in figure M.18.

Related to the previous problem is PROB26, which is the fact that there was no indication whatsoever of which activity each rectangle was referring to. To solve this according to the recommendation, the name of the activity was added to the tooltip. This can be seen in figure M.19.

Emilie Quintana Baptista

Enrollment Regime: tempo parcial

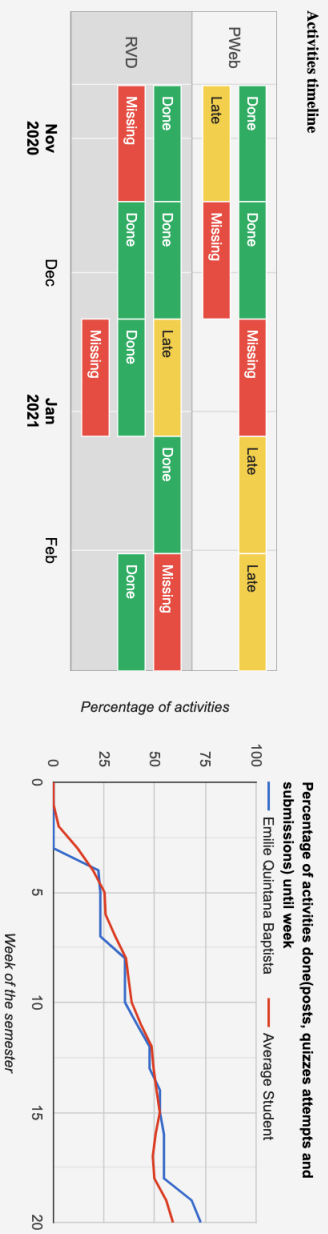


Figure 7.5: Final prototype: Student view

PROB27 is related to the dummy data added to the original prototype where some information in some graphs is not coherent with other information in other graphs. To solve this, it is necessary to run more tests with real data which was not done due to the lack of time and so this problem is a matter of future work.

PROB28, PROB29 and PROB30 are related to the original graph represented in A.12. PROB28 is related to an issue that appeared in one interview where the indicator 'OnTime Submissions' would be distracting from the indicator 'Submitted Assignments'. As recommended in the solution, a survey to all the interviewed chairs was done: 4 e-mails were sent on the 5th of January 2022 explaining the problem, and there were 3 responses until the 6th of January 2022. 66% of the responses were to not eliminate the indicator, with the other 33% agreeing with the elimination. As the majority of the responses were to keep the indicator, the indicator was not eliminated and no other change related to the indicators was made, as seen in figure M.21.

PROB29 was related to the fact that one student was mislabeled with the pronoun 'they' in the tooltip of the graph. The recommended solution to this problem was followed, and the final result can be seen in figure M.22.

PROB30 was related to the fact that the colours and components of the graph were not easily understood and interpreted. As recommended, a legend was added as seen in figure M.21.

PROB31 is related to the graph represented in B.5, where the third column was incorrectly labeled as 'Evaluation' while the appropriate name to it would be 'Activity', as recommended. This correction can be seen in figure M.23. In this graph, PROB22 was also identified in the first and second columns, so, as recommended, the colours in both columns were changed to neutral ones with different shades so the courses would be easily differentiated.

7.2 Evaluation

7.2.1 Interviews with Master Program chairs

To evaluate the final prototype, the same Master Program chairs presented in chapter 6 and two more professors (Appendix N) were invited by email to have a video-conference interview on the 8th of January 2022. Until the 13th of January 2022, six interviews were scheduled. As well as in the first interviews, the authorization to include their name and personal opinions in this dissertation was provided.

Similarly to the first interviews, the deployment of the prototype was through the Ngrok [7] technology.

The interviews were conducted between the 13th of January 2022 and the 27th of January 2022. The protocol of the interview can be seen in Appendix O, as well as its translation in Appendix P. This protocol was derived from the first interviews, where only the part about the evaluation of the prototype was included.

From the conducted interviews, 32 pieces of evidence were extracted (their full transcript and categorization are available in Appendix Q, along with each respective display and professor who

mentioned it). The categorization of each piece of evidence resulted in 4 categories, which are described in table 7.1.

Category	Description
Missing information	Information that would be useful to take into consideration when analysing the prototype and is missing in the prototype.
Graph improvement	Improvements that need to be made to the graph so that data and its interaction can be more easily understood.
Non-scalable component	Graphs or components of graph not suitable for classes or courses with hundreds of students.
Extra feature	Suggested extra features that are out of the scope of this thesis.

Table 7.1: Categories resulted from the evaluation of the final prototype.

In table 7.2 is shown the translated transcript and the respective problem, which all together resulted in 24 different problems. In table 7.3 each problem is described.

Table 7.2: Analysis of the transcripts

ID	Translated Transcript	Problem
01	"As all the graphics are the same size, none of them have any visual impact and I don't know which one to look at. The ideal would be to have a complete vision right away so that I can direct my attention there and not have to think about where I have to direct my attention. "	Need of immediate information about the current view
02	"The tooltip sometimes hides the graph information and that is very annoying."	Tooltip overlaps graph
03	"Maybe an 'activate all' and 'deactivate all' button here would be interesting."	Missing button of activation and deactivation
04	"Allowing me to navigate in each of the disciplines on the other graph, I was expecting a similar behavior in this one."	Lack of coherence
05	"I am not able to distinguish the lines that are active from those that are not."	Missing differentiation in legend
06	"Given the similarity of the colors, it is difficult for me to understand which is which, especially with red and pink."	Difficulty in differentiating colours
07	"Would this work with 100 students? Maybe the bars are too thin."	Non-scalable graph

08	"I don't understand the order of this, if I want to look for a student how do I do it? Maybe it should be sorted alphabetically by student name."	Non-ordered graph
09	"With many more students it would be impractical to find a student here on this chart."	Non-scalable graph
10	"It would be better if there were progressive colours so that there would exist a logical evolution and i could understand easily them, not having to be looking at the legend all the time"	Missing colour differentiation
11	"These are not easy numbers to read, whereas if it had a color it would be able to attract a little more attention to that person who starts to be at risk."	Missing colour differentiation
12	"If these voids are the ones who have never accessed to the platform it should say 'Never'."	Lack of labelling of students who have never accessed the platform
13	"It would be nice to be able to filter by edition, and within this edition sorting by another indicator."	Missing filter within another filter
14	"I would like to be able to compare not only the percentage of activities but also the average of the grades of the course with the other courses."	Missing course grades comparison to other courses
15	"Here the 'average course' should be 'program average' because average course induces to an expectation of what it should be and not the actual average of the program."	Legend mislabelling
16	"If I want to see a particular student here, it's not very easy to see where he is."	Non-scalable graph
17	"When clicking on the student, instead of going to a different page, it would be interesting to open a pop-up of the student."	Overview of student in pop-up page
18	"It would be useful if I wanted to see several students I could see them individually but I could keep a list of the students I wanted to see."	Missing a queue of students to analyse
19	"Here I have some difficulty in seeing the tooltip to see the students because the points are very small."	Difficulty to make tooltip pop-up
20	"This way of consulting the information may not be very viable when the list of students becomes extensive."	Non-scalable tooltip
21	"I'd like to see the activities, their dates... Show a list of activities and I could eventually click on the activity to find out more about it."	Missing information about activity

22	"This has a problem that when we have 20 or 30 students it starts to get a little complicated."	Non-scalable tooltip
23	"There are inverted bars here"	Bar colours sometimes invert
24	"I would like to have a table with a summary of the students within each course."	Missing information about students
25	"There could be a way here to expand the view of this graph to allow for more detailed information about the activity."	Missing information about activity
26	"If each bar had a direct link to the activity in the Moodle it would be very helpful."	Missing redirection to activity in Moodle
27	"It was useful to be able to click on each activity and go straight to that activity in Moodle."	Missing redirection to activity in Moodle
28	"This graph is not very intuitive to read, therefore it would make sense to have something that would help me understand this graph."	Difficulty in understanding components of graph
29	"By clicking here I was expecting to go to the activity and not to the course."	Misleading view navigation
30	"When setting a reference value it might make sense that the colors here would reflect this."	Lack of coherence
31	"I would like to have demographic information about each student to assess the student and try to understand how the student engages with learning, a picture of the student if possible, a presentation about the student, male or female, from which country, which goals they have when taking the course, if they have experience taking online courses, etc."	Missing information about students
32	"From the moment you realize that the student is at risk, having an automatic or manual mechanism that allows you to send a message to the student to alert the student, to encourage him."	Missing way of contacting students

Table 7.3: Problem Description

ID	Problem	Description
PROB01	Need of immediate information about the current view	When the prototype or any view is opened there is the need to show up a summary of the status of everything to know right away what is happening and only from there analyse the graphs.

PROB02	Tooltip overlaps graph	While hovering the graph, sometimes the tooltips overlaps the graph and the data present in it covered by the tooltip, not allowing the simultaneous analysis of the graph and the tooltip.
PROB03	Missing button of activation and deactivation	The graph allows the activation and deactivation of the appearance of each course individually and not all at once.
PROB04	Lack of coherence	In other graphs when clicking in the name of the course it would redirect to the page of the course, however in this graph the same action allows the activation and deactivation of the appearance of each course respectively in the graph. Another problem found was the fact that the value of reference was only used in one graph and other graphs could use this functionality.
PROB05	Missing differentiation in legend	After activating and deactivating the appearance of each course there is no way to tell the status of that course (if activated or deactivated), only by comparing the colours in the legend and the colours of the lines in the graph.
PROB06	Difficulty in differentiating colours	As there are many courses, some of the colours which represent each course may be a little similar and therefore users have some difficulty in differentiating them.
PROB07	Non-scalable graph	Graphs not suitable for classes or courses with hundreds of students as it would be hard to see each student individually in the middle of all the rest of the students.
PROB08	Missing colour differentiation	When reading all the statistics about the students it can become confusing and with colour differentiation it would be easier to read.
PROB09	Non-ordered graph	Students are not added in any specific order to the graph, therefore the user has to run through all of them, making it difficult to find a specific student.
PROB10	Lack of labelling of students who have never accessed the platform	Students who have never accessed the Moodle platform are not identified.

PROB11	Missing filter within another filter	In the table where all students are listed there is only the possibility of ordering each indicator, missing the possibility of ordering them inside another ordering of another indicator.
PROB12	Missing course grades comparison to other courses	In the course page there is only the comparison of the percentage of participated activities with the other courses of the program, and there is also the need to compare the grades of that course with the other courses of the program.
PROB13	Legend mislabelling	Error in legend of graph.
PROB14	Overview of student in pop-up page	There is the need to see an overview of the student in that particular course and not redirecting to the general view of the student.
PROB15	Missing a queue of students to analyse	When seeing a group of students who are in risk in the middle of the other students the only way is to see them individually is to go to each view of them and going back to the list of all the students. It has not the ability to choose the students which are in need of analysis and then see each of them without losing track of the ones who have been analysed or not.
PROB16	Non-scalable tooltip	Tooltip not suitable for classes or courses with hundreds of students as it lists each student individually.
PROB17	Missing information about activity	There is almost no detailed information about each activity.
PROB18	Difficulty to make tooltip pop-up	There is difficulty in making the tooltip appear because the points in the graph are very small.
PROB19	Bar colours sometimes invert	Colours in bar indicating the percentage of students who completed or did not complete the task sometimes invert their side, with the lighter blue staying in the left side of the bar and the darker blue staying in the right side of the bar.
PROB20	Missing information about students	There is the need to have a summary of everything of each student in each course and also demographic information about the students so teachers can know more about their environment outside of the program.

PROB21	Missing redirection to activity in Moodle	There is the need to have a redirection link in the graphs which refer to activities to the activity page in Moodle.
PROB22	Difficulty in understanding components of graph	There is a difficulty in understanding what the box-plot means and its distribution of numerical data.
PROB23	Misleading view navigation	when clicking on each line of the table of activities in the student view, the redirection is to the respective course and not the activity.
PROB24	Missing way of contacting students	There is no indirect or direct way to contact the desired student.

In table 7.4 is represented the number of times each problem was mentioned. By analysing this data, the problem that was most mentioned was PROB07 (Non-scalable graph - 3 times mentioned), due to the fact that this problem was mentioned in several displays. The second most mentioned problems were PROB04 (Lack of coherence), PROB08 (Missing colour differentiation), PROB16 (Non-scalable tooltip), PROB17 (Missing information about activity), PROB20 (Missing information about students) and PROB21 (Missing redirection to activity in Moodle). All of these problems were mentioned 2 times each.

PROB08 is about the missing colours to differentiate certain values included in the graphs; PROB16, similar to PROB07, was mentioned in several displays.

Although PROB04 was related to some existent gaps in two graphs, PROB17, PROB20 and PROB21 are about extra features that need to be included and not exactly about the visualization and interaction of the prototype.

All of the other problems were only mentioned once.

7.2.2 Recommended Solutions

In table 7.5 the recommended solution for each problem is described. Equally to section 6.2.2, these solutions are based on chapter 2, more specifically the subsection 2.6.4, along with some based in discussions with the professors during the interviews.

Table 7.5: Solutions for the problems found in the final prototype

ID	Problem	Solution
PROB01	Need of immediate information about the current view	When each view is opened, a pop up appears with the important information referring to that page in a summary.
PROB02	Tooltip overlaps graph	Make tooltip smaller to not occupy as much space.

PROB03	Missing button of activation and de-activation	Add button to activate and deactivate all courses.
PROB04	Lack of coherence	Instead of having to click in the course code to activate and deactivate each line course from the graph, add a checkbox to that do that action and when clicking the courses' code it would redirect to each individual course code.
PROB05	Missing differentiation in legend	When PROB04 is fixed, the differentiation is the checked box as activated or empty box as deactivated.
PROB06	Difficulty in differentiating colours	Add a different colour palette where colours are not similar.
PROB07	Non-scalable graph	Increase the height of each bar on the graphs.
PROB08	Missing colour differentiation	Add colour palette with gradient from red (0) to green (100).
PROB09	Non-ordered graph	Order each interval of the graph alphabetically.
PROB10	Lack of labelling of students who have never accessed the platform	Label the column 'Days since last access' for this students as 'Never'.
PROB11	Missing filter within another filter	Add the capability of ordering an indicator within another indicator.
PROB12	Missing course grades comparison to other courses	Add another graph to compare the grade of the students enrolled in the course with the average student of the program.
PROB13	Legend mislabelling	Change legend from 'Average Course' to 'Program Average'.
PROB14	Overview of student in pop-up page	When clicking in a student in the course page, a pop-up would appear with a status summary about the student in that course.
PROB15	Missing a queue of students to analyse	Option to choose the selected students to analyse and when some of them is clicked a pop-up would appear with the other students who were on the list.
PROB16	Non-scalable tooltip	Increase the size of each tooltip and add a scroll bar so that every name can be seen.
PROB17	Missing information about activity	When hovering the activity a tooltip appears with some more information about the activity.
PROB18	Difficulty to make tooltip pop-up	Increase the size of the points of the graph that make tooltip visible.

PROB19	Bar colours sometimes invert	Change the darker blue to always be on the left side of the bar and the lighter blue to always be on the right side of the bar.
PROB20	Missing information about students	Adding a shortcut to a page where the student demographic information is and adding a new graph with a summary about the students situation in the course.
PROB21	Missing redirection to activity in Moodle	When clicking in the activity it would redirect to the activity page in Moodle.
PROB22	Difficulty in understanding components of graph	Adding an information icon near the title that when hovering it would tell what the box-plot is and what its distribution of numerical data is and means.
PROB23	Misleading view navigation	As there is no activity page in the prototype, the navigation would be removed from the columns that refer to the activity and it would only be possible to navigate to the course page through the column that lists the course code.
PROB24	Missing way of contacting students	Adding an email icon next to the name of the student that, when hovering, their contact (e-mail, phone number) would appear as well as a button which would redirect to an email page with their contact already filled.

Although some visualization solutions were recommended for PROB01, PROB14, PROB20, PROB21 and PROB24 this problems would not be possible to solve in the scope of this thesis as there would be the need to study criteria that would define the information that would have to be displays, which make all of these problems a matter of future work.

Due to the fact that some problems would be easily solved, PROB08 and PROB13 were fixed after the final interviews, following the recommended solutions. For PROB08 was added a colour palette with a gradient from red to green to easily differentiate the intervals of the graph and for PROB13 the legend was changed to 'Program Average'.

The final result of PROB08 can be seen in figure 7.7 and figure 7.6 and the final result of PROB13 can be seen in figure 7.8.

Table 7.4: Problem analysis of second interviews

ID	Number of times mentioned	ID	Number of times mentioned
PROB01	1	⋮	⋮
PROB02	1	PROB13	1
PROB03	1	PROB14	1
PROB04	2	PROB15	1
PROB05	1	PROB16	2
PROB06	1	PROB17	2
PROB07	3	PROB18	1
PROB08	2	PROB19	1
PROB09	1	PROB20	2
PROB10	1	PROB21	2
PROB11	1	PROB22	1
PROB12	1	PROB23	1
⋮	⋮	PROB24	1
		TOTAL	32

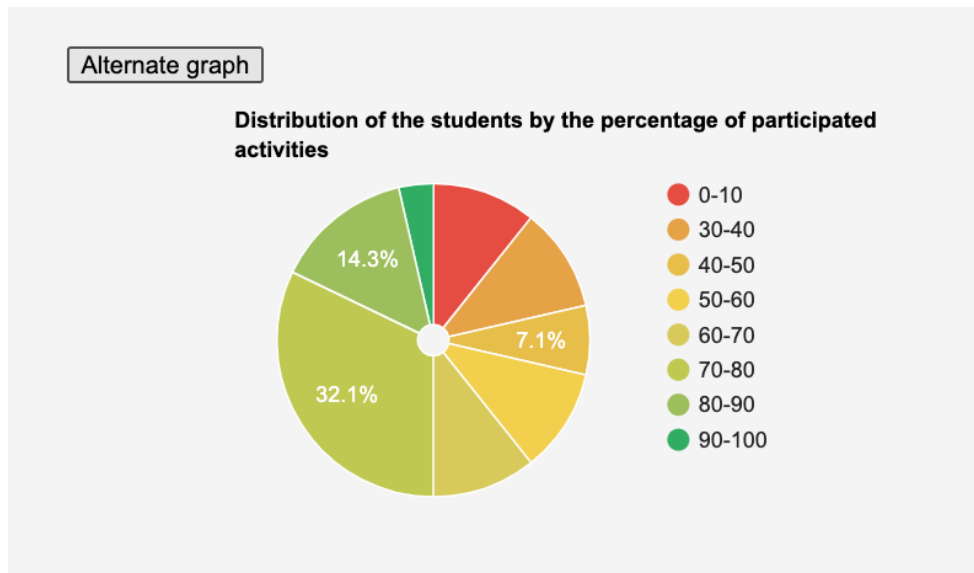


Figure 7.6: Final prototype: Pie chart close-up of the students’ distribution of participation in Program View.

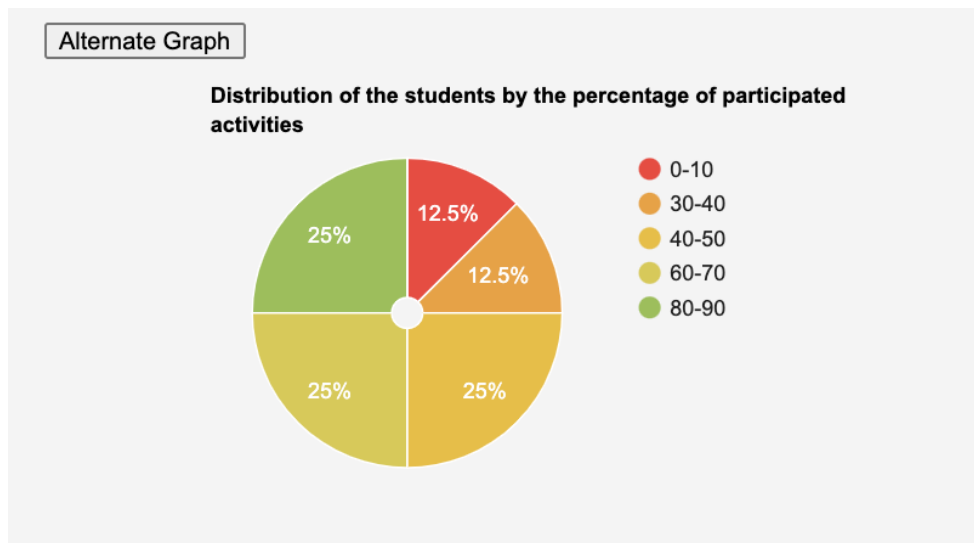


Figure 7.7: Final prototype: Pie chart close-up of the students' distribution of participation in Course View.

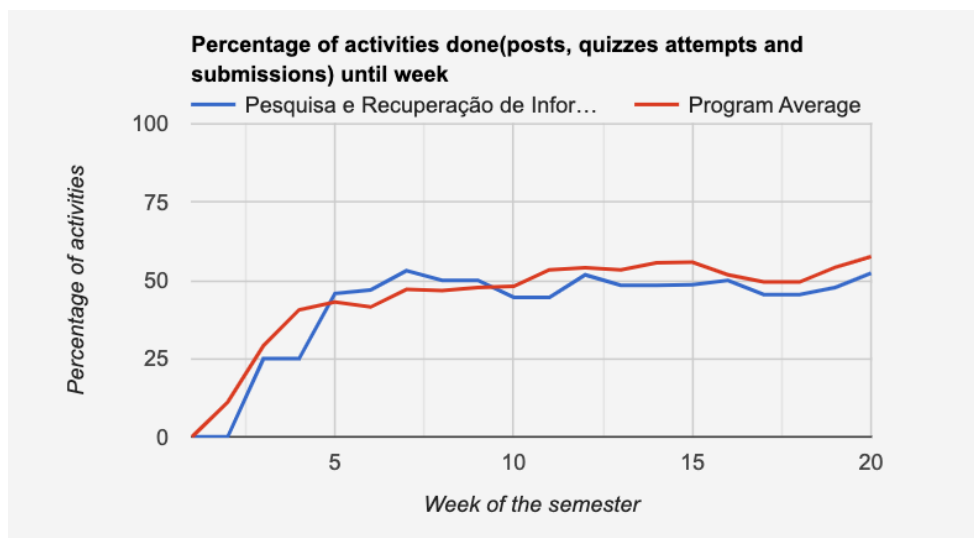


Figure 7.8: Final prototype: Close-up of the change in the percentage of participation throughout the weeks of the semester in Course View.

Chapter 8

Conclusion

8.1 Conclusions and Future Work

In this last chapter, conclusions will be drawn about the prototype obtained. In a second part, future work and possible improvement of the system will be approached.

8.1.1 Conclusion

The objective of this thesis was to better the visualization and interaction of the displays of the previous developed prototype. To do this, two literature reviews on learning dashboards, analytics and program chairs were done. Apart from this, a deep search about visualization and interaction techniques inside and outside learning dashboards was done to understand its concepts to efficiently apply to the prototype.

Through the total of three iterations of the prototype in which two of them included interviews with experienced Master Program chairs, the evolution of the prototype is clear in terms of interaction and visualization techniques: the chairs were very pleased with the final version of the prototype, having a very positive review about the way the changes made them understand much better the data, leading to much more informed decisions, supporting the students enrolled in the program.

In terms of contributions, there was an abstract that was submitted to the Frontiers in Education 2022 conference [3] which was approved on the 4th of March 2022 and its paper is a work in progress, titled as *Program Chairing Dashboards – a Systematic Literature Review*, which will summarize the state of the art about the visualization and interaction techniques with information for program chairing dashboards, which resulted from this thesis.

There was also a paper that was submitted to the Electronic Journal of e-Learning [2], titled *Drill-down and drill-through dashboard for Master Program Chairing in e-learning*, which demonstrates the whole process and iterations done from the original prototype to the final prototype.

8.1.2 Future Work

As with all systems, there is always room for improvements and new features.

Due to the fact that there are so few learning dashboards directed to program chairs, there is even more less available information about visualization and interaction techniques directed to this theme, making it harder to connect both matters and perceive the most efficient solutions.

When it comes to improvements of what is already implemented, in section 7.2, where the evaluation of the final prototype is made, several notes are made that could be an approach to continue the enhancements related to visualization and interaction techniques.

Another approach for future work would be extra features that need further study of the criteria that would choose the information shown in those features. These are mentioned in both feedback interviews, in section 7.1 and section 7.2.2.

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Appendix A

Original Prototype Close-ups

A.1 Program View

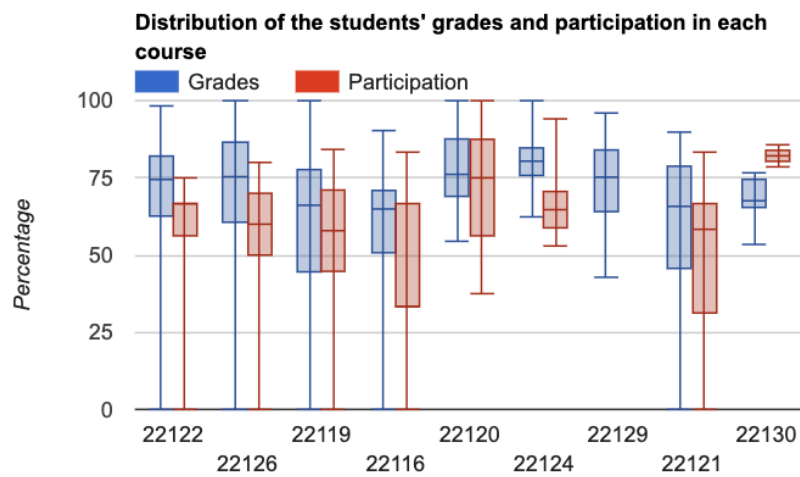


Figure A.1: Close-up of the distribution of students' participation and grades in each course.

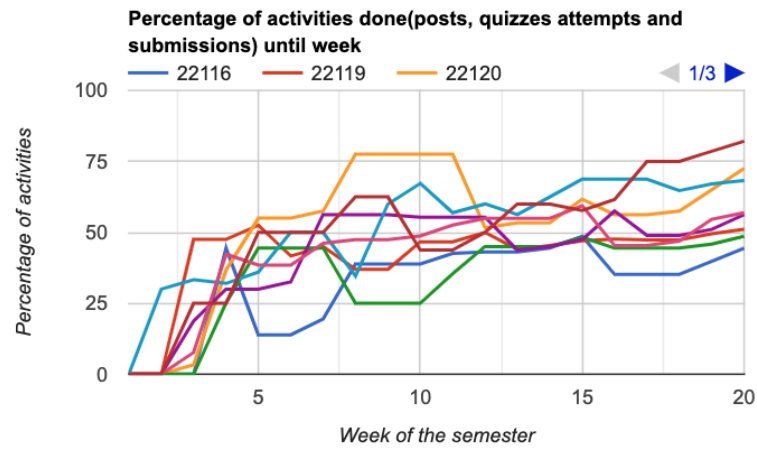


Figure A.2: Close-up of the change in the percentage of participation in each course throughout the weeks of the semester.

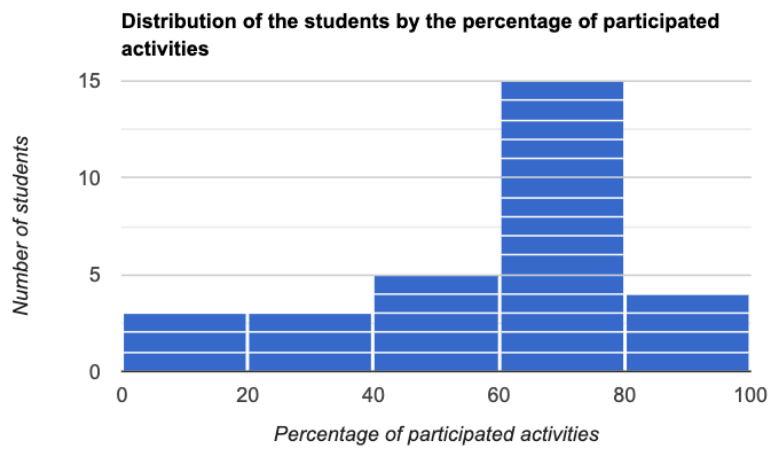


Figure A.3: Close-up of the students' distribution of participation.

Student ▲	Days since last access	Mean of the Percentage of open activities done	Percentage of open activities done
Serena Goulão Tabanez		0	0
Angélico Alencar Malheiro	3	26.423	40
Sol Cruz Letras	26	11.458	0
Nuna Sales Vidal		0	0
Dulce Casado Garcez	0	24.558	66.667
Luisa Belchior Barrico	0	19.679	50
Pavel Caminha Urias	0	14.669	25
Teresa Gama Barata	0	27.492	100

Figure A.4: Close-up of overall view of students in the program.

A.2 Course View

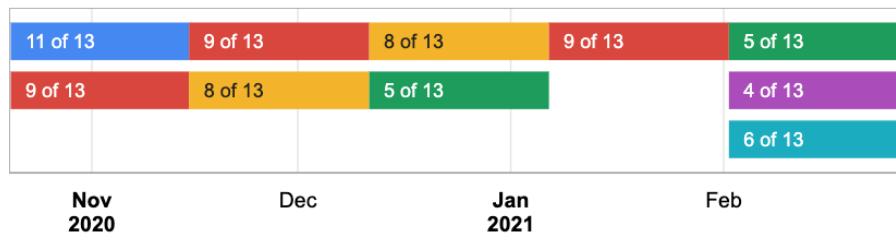


Figure A.5: Close-up timeline activities.

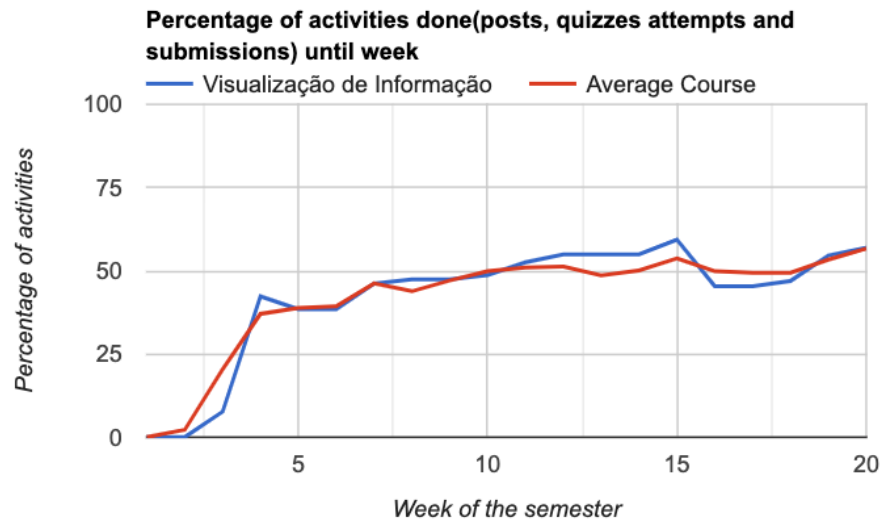


Figure A.6: Close-up of the change in the percentage of participation throughout the weeks of the semester.

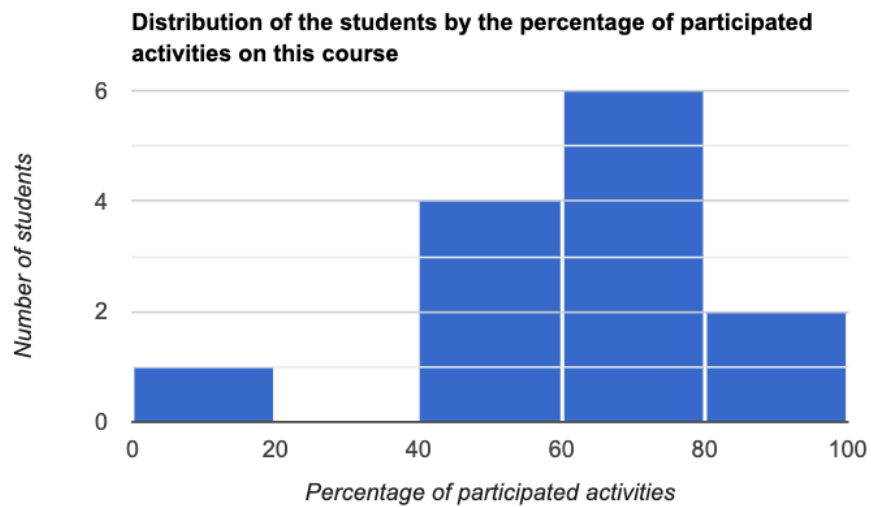


Figure A.7: Close-up of the students' distribution of participation.

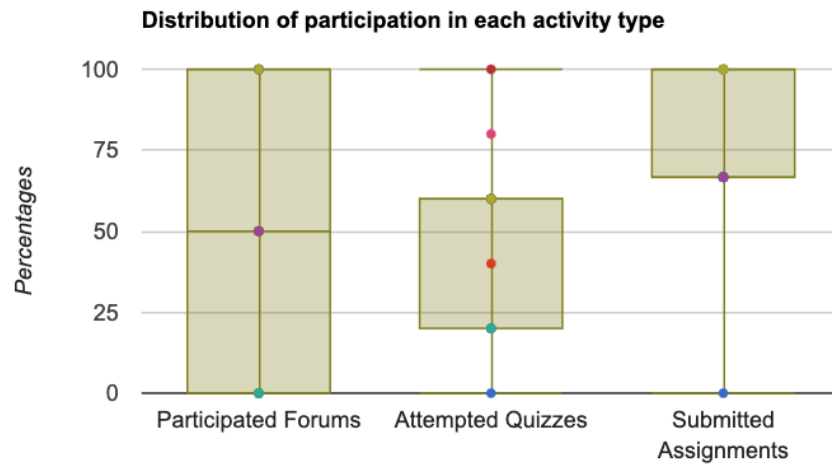


Figure A.8: Close-up of the distribution of the percentages of participation in each activity.

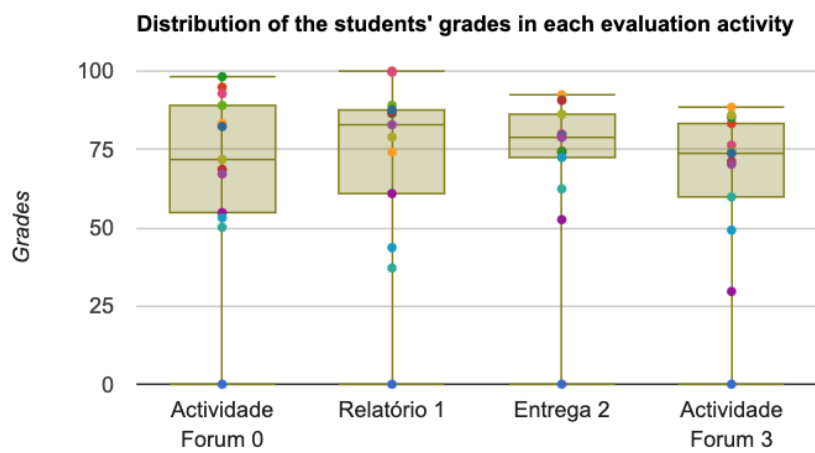


Figure A.9: Close-up of the distribution of the grades in each evaluation.

A.3 Student View

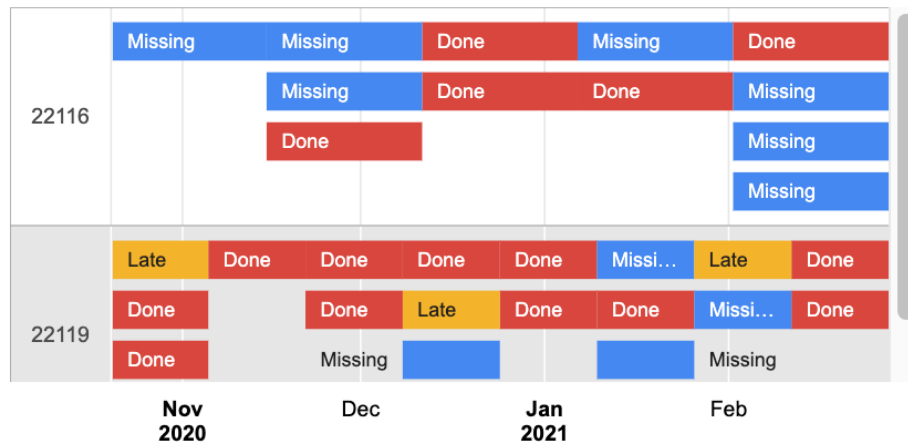


Figure A.10: Close-up timeline activities in each course enrolled.

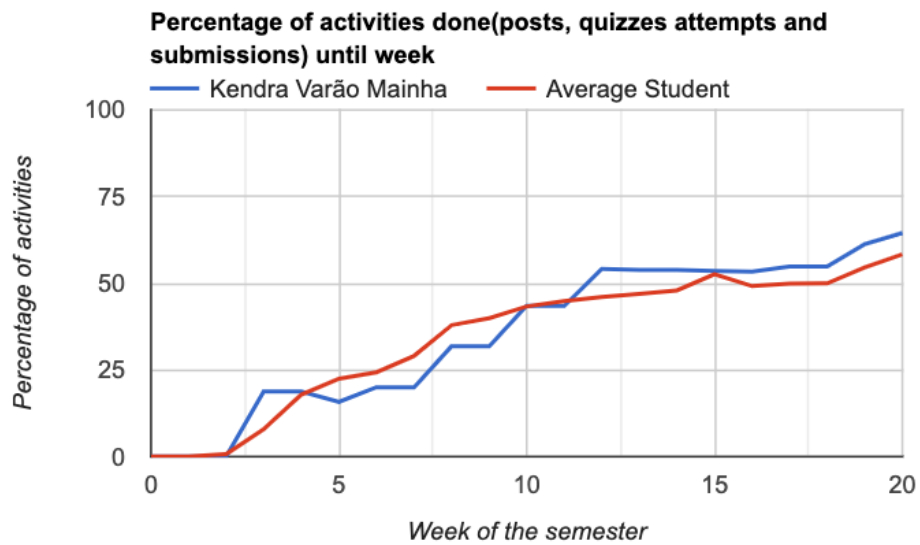


Figure A.11: Close-up of the change in the percentage of participation throughout the weeks of the semester.

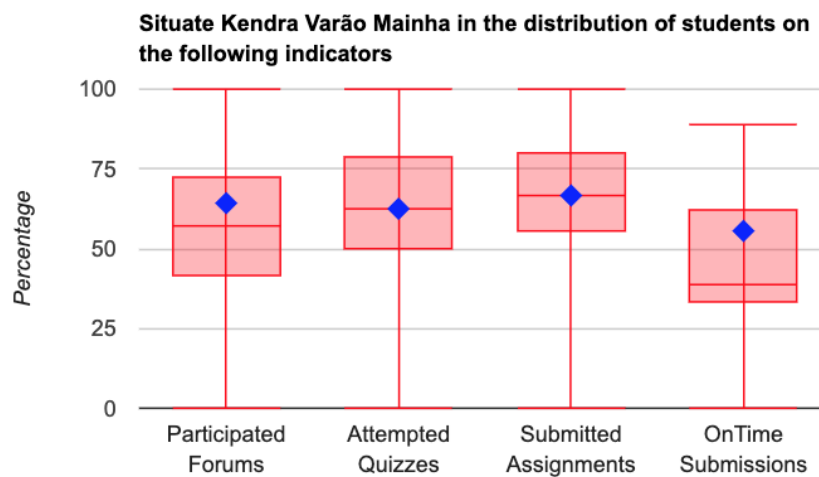


Figure A.12: Close-up of the distribution of the percentages of participation in each activity.

Course ▲	Evaluation	Grade	Percentile
22116	Actividade Forum 0	76.2	0.88
22116	Relatório 1	75.372	0.75
22116	Relatório 2	83.352	1
22119	Actividade Forum 0	100	1
22119	Teste 1	72.009	0.67
22119	Actividade Forum 2	86.321	1
22119	Relatório 3	99.527	1

Figure A.13: Close-up of the grades of each evaluation.

Appendix B

Revised Prototype Close-ups of modified graphs

B.1 Program View

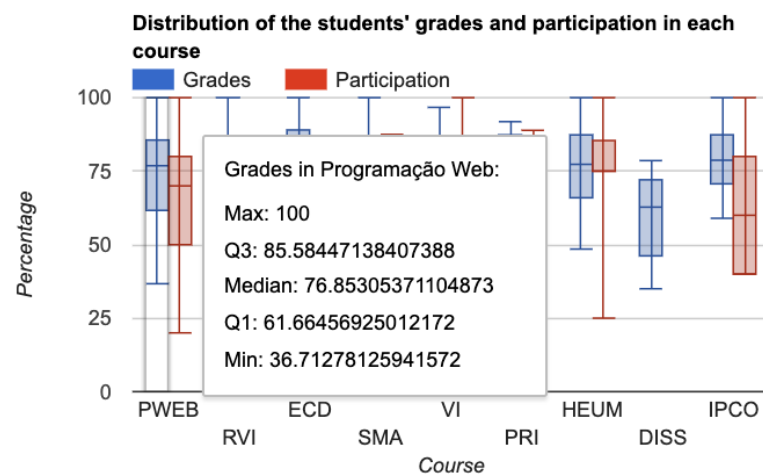


Figure B.1: Close-up of the distribution of students' participation and grades in each course.

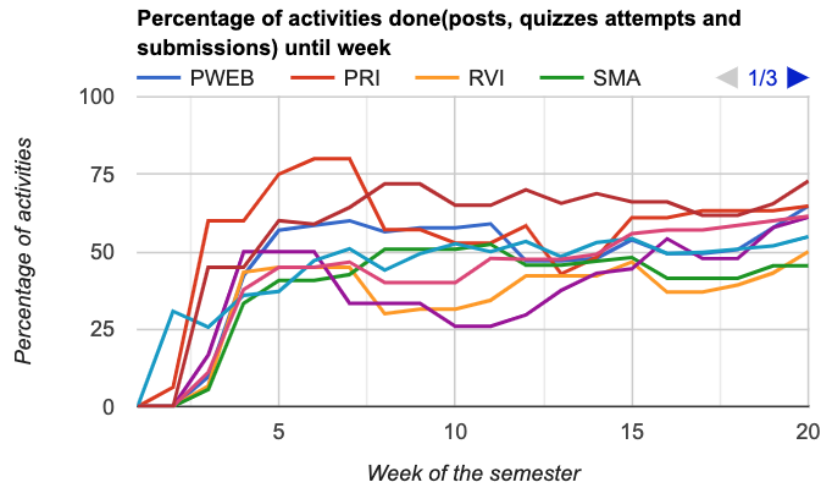


Figure B.2: Close-up of the change in the percentage of participation in each course throughout the weeks of the semester.

B.2 Course View

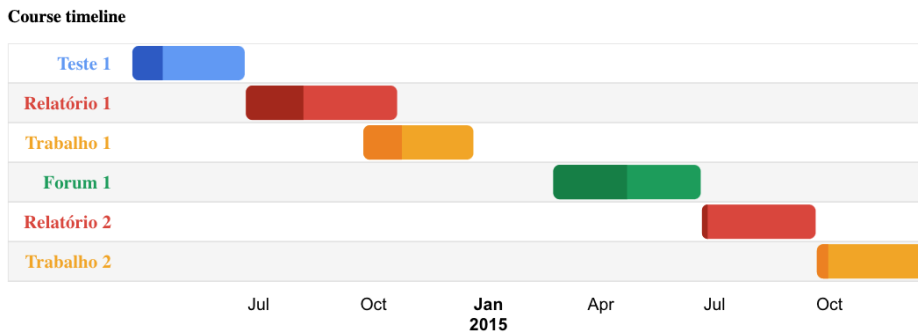


Figure B.3: Close-up timeline activities.

B.3 Student View

activities timeline

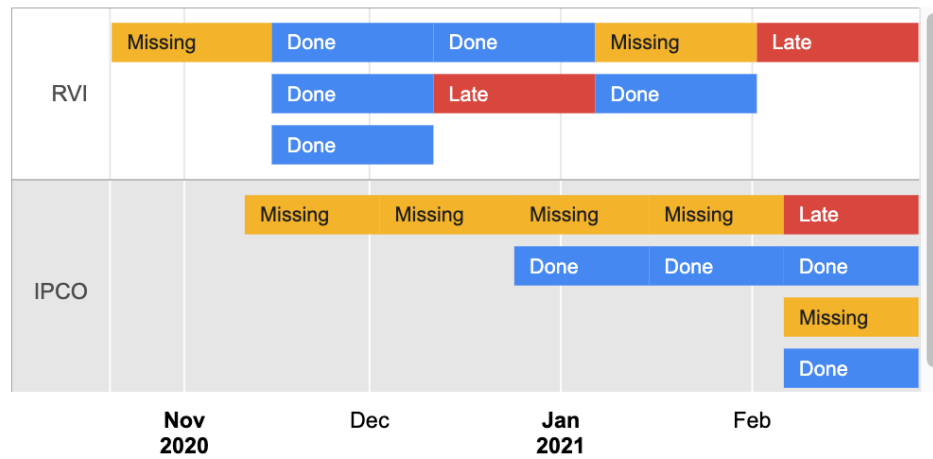


Figure B.4: Close-up timeline activities in each course enrolled.

Course ▲	Evaluation	Grade	Percentile
HEUM	Entrega 0	76.246	0.43
HEUM	Teste 1	63.452	0.14
HEUM	Actividade Forum 2	100	1
HEUM	Teste 3	78.41	0.43
IPCO	Entrega 0	70.131	0.13
IPCO	Entrega 1	98.436	1
IPCO	Actividade Forum 2	89.13	0.88
IPCO	Teste 3	88.625	0.88

Figure B.5: Close-up of the grades of each evaluation.

Appendix C

Masters programs chairs from UAb and UTAD

Master Program	Coordinator	E-mail	University	CV
MEIW	Hugo Paredes	hparedes@utad.pt	UTAD	Appendix D
MEIW	Nuno Sousa	Nuno.Sousa@uab.pt	UAb	Appendix E
MEIW	Leonel Morgado	leonel.morgado@uab.pt	UAb	Appendix F
MEIW	Luís Filipe Barbosa	lfb@utad.pt	UTAD	Appendix G

Appendix D

Master programs chairs Curriculum Vitae - Hugo Paredes

Hugo Paredes é licenciado em Engenharia de Sistemas e Informática (2000), doutorado em Informática (2008) pela Universidade do Minho e possui o título de Agregado pela Universidade de Trás-os-Montes e Alto Douro (2016). Entre 2000 e 2003, desempenhou funções de Engenheiro de Software na SiBS, S.A. e de Consultor de Software na Novabase Outsourcing, S.A.. Desde 2003 colabora com a Universidade de Trás-os-Montes e Alto Douro (UTAD), onde é Professor Associado com Agregação. Em 2017 foi um dos fundadores da empresa Robocode Generation Lda, uma spin-off da UTAD, da qual é consultor científico. Foi Visiting Faculty no Human Computer Interaction Institute da Carnegie Mellon University (2017). É o Diretor do Mestrado em Engenharia Informática e Tecnologia Web desde Dezembro de 2020 e durante 4 anos (de 2017 a 2021) foi também diretor do Mestrado em Engenharia Informática da UTAD e membro da direção do Doutoramento em Informática da UTAD e do Doutoramento em Ciência e Tecnologia Web em associação entre a UTAD e a Universidade Aberta. Desde Maio de 2021 é Pró-Reitor para a área da Transição Digital e Modernização Administrativa na UTAD [18].

Appendix E

Master programs chairs Curriculum Vitae - Nuno Sousa

Nuno Sousa é licenciado em Física (1998) e doutorado em Física, Matemática e Informática (2003) pela Universidade de Coimbra. É investigador do Departamento de Engenharia Civil da Universidade de Coimbra desde 2012 e Professor Auxiliar no departamento de Ciências e Tecnologia da Universidade Aberta. Desde 2015 é analista de sistemas na Spero - Smart Decision Tools, Lda. É Coordenador do Mestrado em Tecnologias e Sistemas Informáticos Web na Universidade Aberta, vogal da coordenação do Mestrado em Engenharia Informática e Tecnologia Web na Universidade Aberta e Universidade de Trás-os-Montes e Alto Douro e ainda vogal da coordenação do Doutoramento em Ciência e Tecnologia Web na Universidade Aberta e Universidade de Trás-os-Montes e Alto Douro [19].

Appendix F

Master programs chairs Curriculum Vitae - Leonel Morgado

Leonel Morgado é licenciado em Engenharia Eletrotécnica - Ramo de Informática (1994) pela Universidade de Coimbra e Doutorado em Informática Aplicada (2006) pela Universidade de Trás-os-Montes e Alto Douro. É Investigador no Instituto de Engenharia de Sistemas e Computadores Tecnologia e Ciência e Professor Associado na Universidade Aberta. De 2016 a 2018 foi Vice-Coordenador do Doutoramento em Ciência e Tecnologia Web na Universidade Aberta, em 2018 foi Vice-Coordenador do Mestrado em Computação Gráfica na Universidade Aberta, de 2016 a 2019 foi Coordenador do Mestrado em Tecnologias e Sistemas Informáticos Web na Universidade Aberta, de 2018 a 2019 foi Diretor do Doutoramento em Ciência e Tecnologia Web na Universidade Aberta e desde 2020 é Vice-Coordenador do Mestrado em Engenharia Informática e Tecnologia Web também na Universidade Aberta [31].

Appendix G

Master programs chairs Curriculum Vitae - Luís Barbosa

Luís Barbosa é licenciado em Engenharia Electrotécnica - ramo Electrónica, Instrumentação e Computação pela Universidade de Trás-os-Montes e Alto Douro e doutorado em Informática também pela Universidade de Trás-os-Montes e Alto Douro. É Professor Auxiliar na Universidade de Trás-os-Montes e Alto Douro e é Vice-Coordenador do Mestrado em Engenharia Informática e Tecnologia Web na Universidade Aberta [14].

Appendix H

Interview protocol (in Portuguese)

Boa tarde!

Em primeiro lugar gostaria de agradecer a sua disponibilidade para conversar comigo e responder a estas questões. Gostaria de saber se me dá autorização para gravar esta conversa para facilitar a recolha de dados?

[SIM / NÃO]

O meu trabalho de dissertação chama-se “Drill-down Dashboard for Coordination of Master Programmes in Engineering” e consiste na elaboração de um painel de instrumentos, para ajudar os coordenadores de mestrado a ter noção de como as atividades do curso decorrem ao longo do semestre.

Se estiver pronto, gostaria de começar por umas questões um pouco mais gerais.

1. Que atividades é que faz enquanto coordenador de curso?
2. Que atividades são realizadas repetidamente ao longo do semestre?
3. Que tipos de problemas acontecem ou podem acontecer ao longo do ano letivo?
 - (a) Pode dar alguns exemplos mais concretos?
4. Como é que estes problemas são resolvidos? Para fazer uma decisão final, em que informação é que se baseia?
5. Existe algum problema que poderia ser evitado se fosse descoberto mais cedo?
6. Existe alguma informação que usaria se esta estivesse disponível? (Que pode ser difícil de encontrar ou que não é de fácil acesso).

Passando agora para a segunda parte da entrevista, teve oportunidade de ver o protótipo que lhe enviei no email? Se o puder abrir e partilhar o ecrã seria melhor sendo que as próximas perguntas vão ser para avaliar o protótipo e queria visualizar também como interage com ele.

Numa dissertação anterior já foi desenvolvido um protótipo, e nesta fase da entrevista gostaria de perceber como é que este se enquadra em relação às atividades no mestrado que coordena.

Para relembrar, neste protótipo existem três vistas, a de curso que é logo a primeira que vê, a vista de disciplina e a vista de aluno.

1. Vista de curso (Primeiro ecrã)

- (a) Qual é a sua impressão geral desta vista?
- (b) Para cada secção:
 - i. Na sua opinião, qual é o objetivo desta secção?
 - ii. Consegue descobrir alguma ação a tomar nesta secção?
 - iii. Quais são os seus comentários sobre esta secção?
- (c) Consegue descobrir mais alguma ação a tomar nesta vista?
- (d) Tem mais algum comentário a fazer sobre esta vista?

2. Vista de disciplina (indicar como mudar de página se necessário)

- (a) Qual é a sua impressão geral desta vista?
- (b) Para cada secção:
 - i. Na sua opinião, qual é o objetivo desta secção?
 - ii. Consegue descobrir alguma ação a tomar nesta secção?
 - iii. Quais são os seus comentários sobre esta secção?
- (c) Consegue descobrir mais alguma ação a tomar nesta vista?
- (d) Tem mais algum comentário a fazer sobre esta vista?

3. Vista de estudante (indicar como mudar de página se necessário)

- (a) Qual é a sua impressão geral desta vista?
- (b) Para cada secção:
 - i. Na sua opinião, qual é o objetivo desta secção?
 - ii. Consegue descobrir alguma ação a tomar nesta secção?
 - iii. Quais são os seus comentários sobre esta secção?
- (c) Consegue descobrir mais alguma ação a tomar nesta vista?
- (d) Tem mais algum comentário a fazer sobre esta vista?

4. Final

- (a) Considerando o protótipo como um todo, o que acha do protótipo e como o avalia?
- (b) Lembra-se de alguma coisa ou de algum problema que não ficaria resolvido com a ajuda do protótipo?
- (c) Tem alguma sugestão geral para melhorias?
- (d) Algum comentário final?

Por fim queria fazer mais umas questões sobre elementos que não foram tidos em consideração no desenvolvimento do protótipo.

1. Acha que faria sentido ter em conta o impacto dos estatutos dos alunos? Ou seja, trabalhadores-estudantes, militares, doença, etc? Se sim, em que sentido?
2. E ter em conta os regimes de matrícula? ou seja tempo parcial versus tempo integral. Se sim, em que sentido?
3. Acha que faria sentido haver um acompanhamento longitudinal dos alunos? Ou seja, ter a perceção da edição do curso em que está matriculado cada aluno? Se sim, em que sentido?
4. Por fim, existem outras variáveis que devem ser tomadas em conta? Se sim, em que sentido?

Muito obrigada pela sua participação!

Appendix I

Translated Interview protocol

Good afternoon!

First of all, I would like to thank you for your availability to talk to me and answer these questions.

I would like to know if you would give me permission to record this conversation to make it easier to keep track of data?

[YES / NO]

My dissertation is called “Drill-down Dashboard for Coordination of Master Programs in Engineering” and it consists on the elaboration of a dashboard, to help master’s coordinators to have an idea of how the course activities take place throughout the semester.

If you’re ready, I’d like to start with some more general questions.

1. What activities do you do ad a master program coordinator?
2. What activities are repeated throughout the semester?
3. What types of problems can happen throughout the year?
 - (a) Can you give some examples?
4. How are these problems solved? To make that decision what information do you use?
5. Is there a problem that you think would be possible to avoid if discovered earlier?
6. Is there any information you would use if available? (maybe because it is difficult to find, or of not so easy access).

Moving on to the second part of the interview, did you have the opportunity to see the prototype I sent you by email? If you’d open it and share the screen, it would be better since the next questions will be to evaluate the prototype and I wanted to also visualize how you interact with it.

A prototype was already developed in a previous dissertation, and at this stage of the interview I would like to understand how it fits in with the activities of the master’s degree that you coordinate.

In this prototype there are three views, the Program view, which is the first view, the Course view and the Student view.

1. Program view

- (a) What was your impression of this view?
- (b) For each display:
 - i. In your opinion, what is the purpose of this display?
 - ii. Can you see any actions to be taken in this display?
 - iii. What are your comments about this display?
- (c) Can you see any actions to be taken in this view?
- (d) Any further comment on this view?

2. Course view

- (a) What was your impression of this view?
- (b) For each display:
 - i. In your opinion, what is the purpose of this display?
 - ii. Can you see any actions to be taken in this display?
 - iii. What are your comments about this display?
- (c) Can you see any actions to be taken in this view?
- (d) Any further comment on this view?

3. Student view

- (a) What was your impression of this view?
- (b) For each display:
 - i. In your opinion, what is the purpose of this display?
 - ii. Can you see any actions to be taken in this display?
 - iii. What are your comments about this display?
- (c) Can you see any actions to be taken in this view?
- (d) Any further comment on this view?

4. Final

- (a) Considering the whole dashboard, what are your thoughts on this prototype and how do you evaluate it?
- (b) Is there anything or any problem that would not be resolved with the help of the dashboard?
- (c) Any feedback for improvement?

(d) Any further comments?

Finally, I wanted to ask a few more questions about elements that were not taken into account when developing the prototype.

1. Do you think it would make sense to take into account the impact of student statuses? E.g. working students, military, illnesses? If so, in what sense?
2. Do you think it would make sense to take into account the enrollment regimes? E.g. part-time versus full-time. If so, in what sense?
3. Do you think it would make sense to have a longitudinal follow-up of students? In other words, have the perception of the edition of the course in which each student is enrolled? If so, in what sense?
4. Finally, are there any other variables that should be taken into account? If so, in what sense?

Thank you for your participation!

Appendix J

Results of the first interviews - Master program chairs activities

Table J.1: Analysis of the activities related questions with program chair Luís Barbosa

Program Chair	Luís Barbosa
Activities	Preparing the beginning of each semester, preparing timetables and coordinate the course, enrollment of students, associate professors to each course, accreditation of students' skills, selecting candidates
Repeated Activities	Not many activities
Problems	Professors with medical certificates, students or professors testing positive for COVID-19
Solutions	Decisions are taken based on the attendance and evaluation results
Avoidable problems	Masters' annual report: analysis of approval and drop-out rates
Useful Information	-

Table J.2: Analysis of the activities related questions with program chair Nuno Sousa

Program Chair	Nuno Sousa
Activities	Evaluation of candidates, preparation of the academic year and course guides, handle interfaces with university heads, to supervise courses: intervening only when necessary
Repeated Activities	Courses follow-ups, most activities are occasional and non-systematic
Problems	Students who do not adapt to the pedagogical model, personal problems that imply needing longer deadlines, incompatibilities with professors
Solutions	Most of the decisions are standard or need individual attention

Avoidable problems	Drop-outs: synchronous meeting at the beginning of the semester where chairs present a recommendation for part-time enrollment for those who have a very intense professional and family life
Useful Information	Analysis of linguistic content from forum posts

Table J.3: Analysis of the activities related questions with program chair Hugo Paredes

Program Chair	Hugo Paredes
Activities	Ensure the quality of the course, monitor the progress of the academic activities and dissertations: student enrollment and the process of choosing, developing and submission of the final course plan, and interact with the orienteering team throughout the year to understand how everything is unfolding
Repeated Activities	Formally, having meetings several times a year with the professors
Problems	Assessments or classes that are not going well, student/teacher relationship does not exist, students complaints about the course going wrong, lack of communication
Solutions	Establish communication channels and understanding both sides to find consensus between both parts
Avoidable problems	If there was individual monitoring of students it could prevent poor results and students dropping out mid-term
Useful Information	Simple-to-read indicators that alert to potential risky situations

Table J.4: Analysis of the activities related questions with program chair Leonel Morgado

Program Chair	Leonel Morgado
Activities	Serialization of candidates throughout various phases (access candidate's information to find out who are foreigners, nationals, contacts, payment problems), monitoring the enrollment process (choosing options, etc), monitoring if students are not dropping out the courses, monitoring teachers' duties (if grades are being released, analyze the general panorama of approval and drop-out rates)
Repeated Activities	Awareness of whether students are dropping out and participating and whether teachers are monitoring online activities and giving students support, feedback and keeping the course active, monitoring dissertations (if proposals are being delivered, etc.)

Problems	Teachers not intervening and being proactive with students or not responding to students in a timely manner, students who do not follow-up with the activities
Solutions	See if there is participation with the coordination Moodle login, Whatsapp group with students where they give feedback, meetings with professors and students twice a year, extraction of Moodle reports and asking professors informally
Avoidable problems	Approaching students who are not participating and inform professors that they are not having the expected behaviour
Useful Information	Possibility to see the students' activity statuses during their dissertation

Appendix K

Results of the first interviews - Evaluation of the prototype

Table K.1: Analysis of the transcripts

ID	Figure	Chair	Full transcript (in Portuguese)	Category
01	6.1	Leonel Morgado	"Os indicadores não aumentam para aproveitar o ecrã disponível, eu ampliei, tenho todo este espaço branco por baixo e depois tenho que fazer scroll nesta janela minúscula e se isto estivesse a descer até baixo teria a hipótese de ser muito fácil clicar em cada aluno, e assim tenho que tentar acertar com o cursor em cada rectângulo de cada aluno."	Layout improvement
02	6.1	Hugo Paredes	"Eu precisava de saber imediatamente quais são as unidades curriculares em que tenho que intervier, se é que existe alguma."	Missing information
03	6.1	Hugo Paredes	"Se há aqui algum aluno com quem eu deva contactar, deveria aparecer quem é o aluno e qual o seu contacto."	Missing information
04	6.1	Leonel Morgado	"Era útil para relatórios e apresentações se isto tivesse um aspeto mais profissional (...) com cabeçalho, logótipos, etc."	Layout improvement

05	6.1	Leonel Morgado	"Se no cabeçalho dissesse vista de curso, vista de disciplina e vista de aluno e a vista de curso estivesse realçada eu sabia que estava na vista de curso e sabia que haviam mais outras duas."	Layout improvement
06	6.1	Leonel Morgado	"Podia clicar na vista de aluno e aparecia uma vista geral com todos os alunos de todas as edições do curso, que é o que mais me falta."	Missing information
07	B.1	Nuno Sousa	"Estes algarismos significativos nos tooltips tornam-se maçadores e não fazem muita diferença na leitura."	Distracting information
08	B.1	Leonel Morgado	"Tem aqui números que nunca mais acabam (...) não preciso de tantos números."	Distracting information
09	B.1	Leonel Morgado	"Aqui eu esperaria, por exemplo, clicando no indicador do próprio gráfico que abrisse, porque é o que movimento que estou habituado de outros ambientes."	Graph improvement
10	B.1	Nuno Sousa	"A navegar pelas páginas não está intuitivo, não dá para perceber onde dá para ir para a página da cadeira ou do aluno."	Layout improvement
11	B.1	Leonel Morgado	"A navegação está muito escondida, não é que eu não pudesse descobrir isto, andava aqui a clicar (...) a legenda não me diz que há um link."	Layout improvement
12	B.1	Hugo Paredes	"Era importante que houvesse algum grau de comparação, ou seja qual seria a distribuição ideal e até que ponto é que isto está aproximado de como os estudantes normalmente se comportam."	Graph improvement
13	B.2	Nuno Sousa	"Aqui também tem demasiados algarismos."	Distracting information
14	B.2	Nuno Sousa	"Isto é só a legenda, parecia que o gráfico continuava."	Graph improvement

15	B.2	Hugo Paredes	"Neste caso a disciplina DISS tem NaN e ele não aparece."	Graph improvement
16	B.2	Nuno Sousa	"No máximo aqui terias 12 cadeiras, se isto aguenta com tantas sem baralhar, não sei."	Graph improvement
17	B.2	Leonel Morgado	"Como no primeiro gráfico dá para ir para cada disciplina neste também devia ser coerente, ou dá num lado ou não dá em lado nenhum."	Lack of coherence
18	A.3	Hugo Paredes	"Eu aqui sei o número de alunos é que estão, mas percentualmente isto era capaz de ser mais interessante (...) pois não sabemos qual o número total de alunos."	Graph improvement
19	A.3	Hugo Paredes	"Existem alunos que não participam nada, que estão no conjunto dos que participam muito pouco."	Graph improvement
20	A.3	Nuno Sousa	"Aqui também tem demasiados algoritmos significativos."	Distracting information
21	A.4	Luís Barbosa	"Os valores estão com uma precisão muito elevada, com muitos dígitos. "	Distracting information
22	A.4	Nuno Sousa	"Aqui demasiados algoritmos significativos outra vez."	Distracting information
23	A.4	Nuno Sousa	"Estas cores são um bocado agressivas de ler."	Distracting information
24	A.4	Leonel Morgado	"Nos alunos, nada me diz que aqui há um link para ir para a página de aluno individual."	Layout improvement
25	A.4	Leonel Morgado	"Existem duas informações importantes que eu não tenho: saber qual situação de inscrição do aluno, ou seja se está inscrito a tempo parcial ou integral, (...) e qual a edição do curso em que o aluno está inscrito."	Missing information
26	6.2	Leonel Morgado	"Este aspeto do nome da disciplina devia estar mais profissional, algo que desse para tirar para o relatório."	Layout improvement

27	6.2	Hugo Paredes	"Eu precisava de olhar logo para isto e em vez de ter que andar para cima e para baixo, ter logo um sumário a dizer o que se passa. Se a disciplina precisa da minha atenção, se não precisa, onde precisa de atenção."	Missing information
28	A.6	Nuno Sousa	"Demasiados algarismos significativos."	Distracting information
29	A.7	Nuno Sousa	"Demasiados algarismos significativos."	Distracting information
30	A.8	Nuno Sousa	"Demasiados algarismos significativos."	Distracting information
31	A.9	Nuno Sousa	"Demasiados algarismos significativos."	Distracting information
32	B.3	Nuno Sousa	"Não é muito claro a diferença entre o que é escuro e é claro ou seja, que o escuro é a percentagem de estudantes que realizou o trabalho."	Colour mislabelling
33	B.3	Leonel Morgado	"Pensei que o escuro foi quem tivesse visto o enunciado (...) eu não percebi que era os que fizeram e não fizeram."	Colour mislabelling
34	B.3	Leonel Morgado	"Aqui dava-me jeito até mais uma coisa (...) dava-me jeito ver quantos alunos viram o enunciado ou seja, quantos viram a actividade, quantos lá clicaram."	Missing information
35	B.3	Hugo Paredes	"As cores fazem confusão pois estava a pensar que pudessem querer dizer o que é que realmente estava a acontecer em cada semana: se havia coisas atrasadas, se não; se estavam a ser entregues a tempo, etc."	Colour mislabelling
36	6.3	Hugo Paredes	"O acompanhamento da parte das dissertações pode não ser tão simples como as unidades curriculares normais."	Extra feature
37	B.4	Nuno Sousa	"esse 'done' não devia estar a verde?"	Colour mislabelling

38	B.4	Hugo Paredes	"Aqui as cores estão ao contrário, ou seja, o missing está a azul e o done a vermelho."	Colour mislabelling
39	B.4	Leonel Morgado	"Não sei o que quer dizer os vermelhos, azuis e amarelos, não faço ideia."	Colour mislabelling
40	B.4	Luís Barbosa	"A minha dúvida é porquê três linhas de informação."	Graph improvement
41	B.4	Nuno Sousa	"Estou um bocado baralhado porque isso tem três linhas, está um pouco confuso."	Graph improvement
42	B.4	Hugo Paredes	"Uns estão em cima, outros estão em baixo (...) não percebo haverem duas linhas para uns e para outros só uma."	Graph improvement
43	B.4	Hugo Paredes	"Não tenho a identificação de qual foi a atividade."	Missing information
44	B.4	Leonel Morgado	"O 'Missing' diz só 'Not Done', da semana de 1 a 5, se tivesse o nome da actividade eu começava a perceber o que se passava ali."	Missing information
45	A.11	Hugo Paredes	"Teoricamente só tem uma tarefa em done nesta semana mas aqui nessa mesma semana ele não tem o 100% de participação, os dados não estão consistentes."	Lack of coherence
46	A.12	Nuno Sousa	"Não sei se o 'OnTime Submissions' não desvia um bocado a atenção do 'Submitted Assignments' que é o mais importante."	Distracting information
47	A.12	Leonel Morgado	" 'They' mas é só um aluno, devia ser 'The student is', pois é só um."	Phrase mislabelling
48	A.12	Leonel Morgado	"Falta uma legenda que me diga que este vermelho é da turma toda e que o azul é a posição do aluno."	Missing information
49	B.5	Nuno Sousa	"Mais uma vez, estas cores são agressivas de ler."	Distracting information

50	B.5	Leonel Morgado	"Aqui o vermelho é que não fez? Ali tenho cores com um significado e aqui tenho as mesmas cores com um significado diferente, fica muito confuso. Pensei que havia alguma ligação das cores para as outras."	Lack of coherence
51	B.5	Leonel Morgado	"Diz 'Evaluation' mas refere-se ao tipo de atividade."	Phrase mislabelling

Appendix L

Results of the first interviews - Other elements to take into consideration

Table L.1: Analysis of the elements to take into consideration

Professor	Student statuses	Enrollment regimes	Longitudinal follow-up	Others
Luís Barbosa	Yes	Yes	Yes	-
Nuno Sousa	No	Yes	No	-
Hugo Paredes	No	Yes	Yes	-
Leonel Morgado	No	Yes	Yes	-

Appendix M

Final Prototype Close-ups

M.1 General

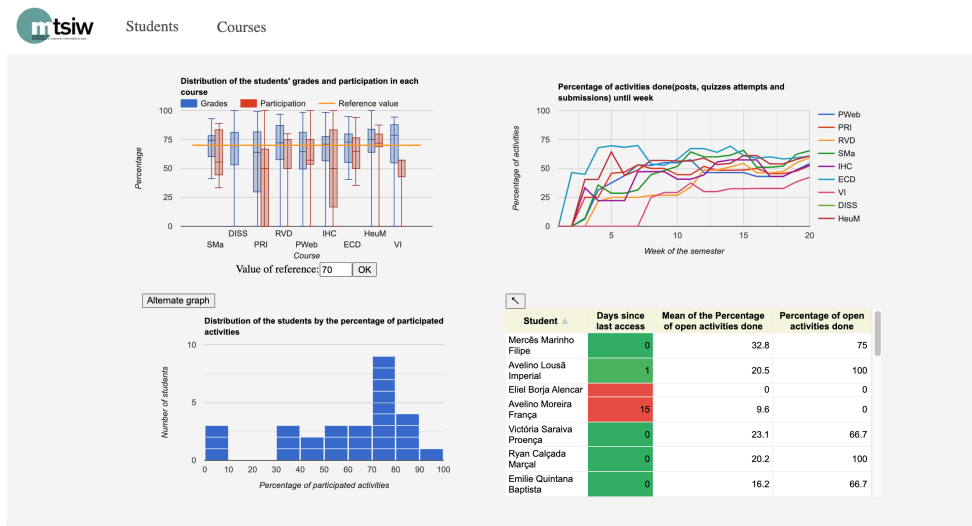


Figure M.1: General view of a smaller screen.



Figure M.2: General view of a bigger screen.

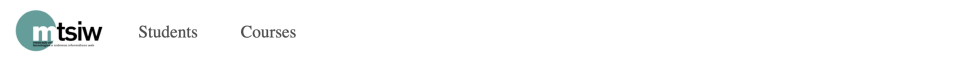


Figure M.3: Close-up of the header.

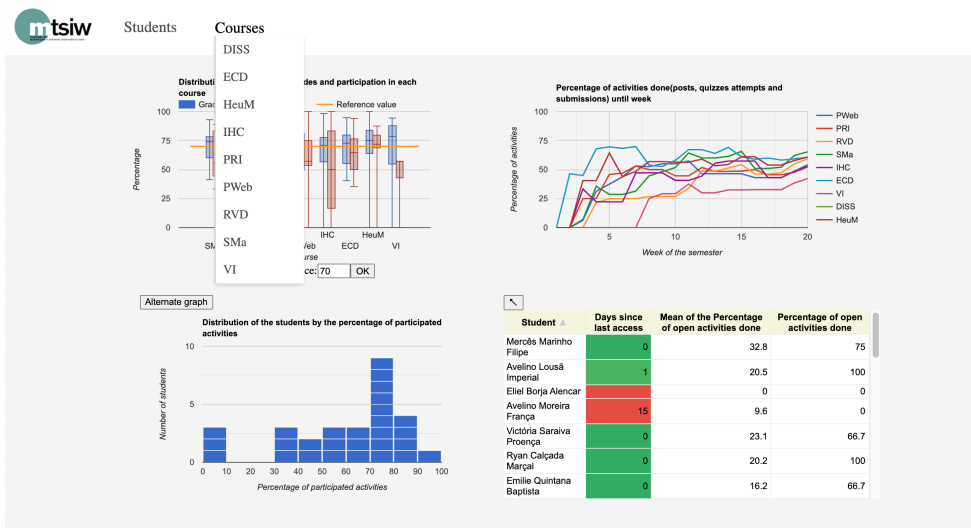


Figure M.4: Close-up of the courses list in header.

M.2 Program View

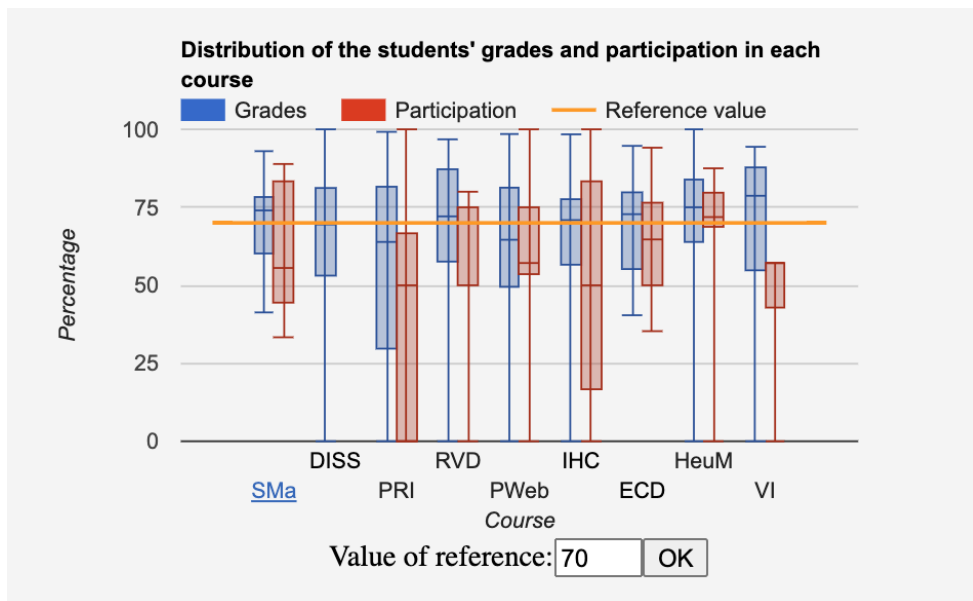


Figure M.5: Close-up of the distributions of the students' grades and participation in each course with the active link in course 'SMa'.

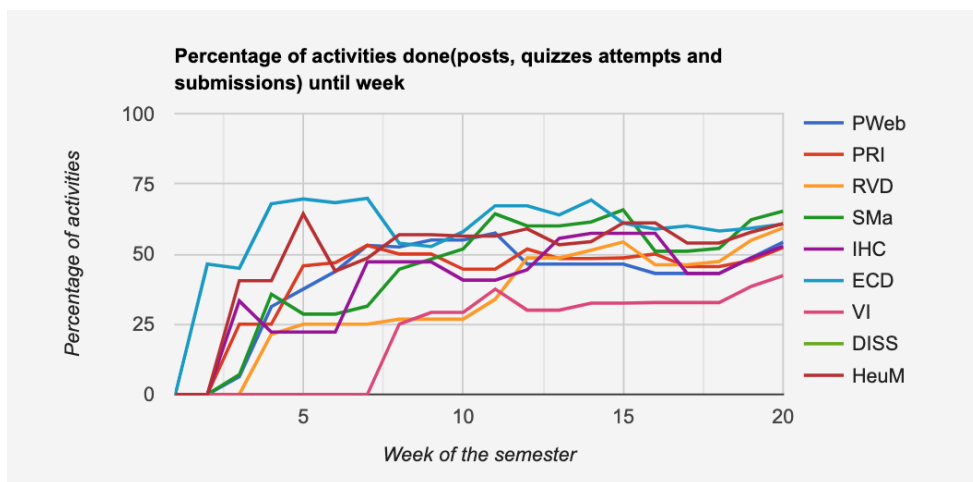


Figure M.6: Close-up of the of the change in the percentage of participation in each course throughout the weeks of the semester.

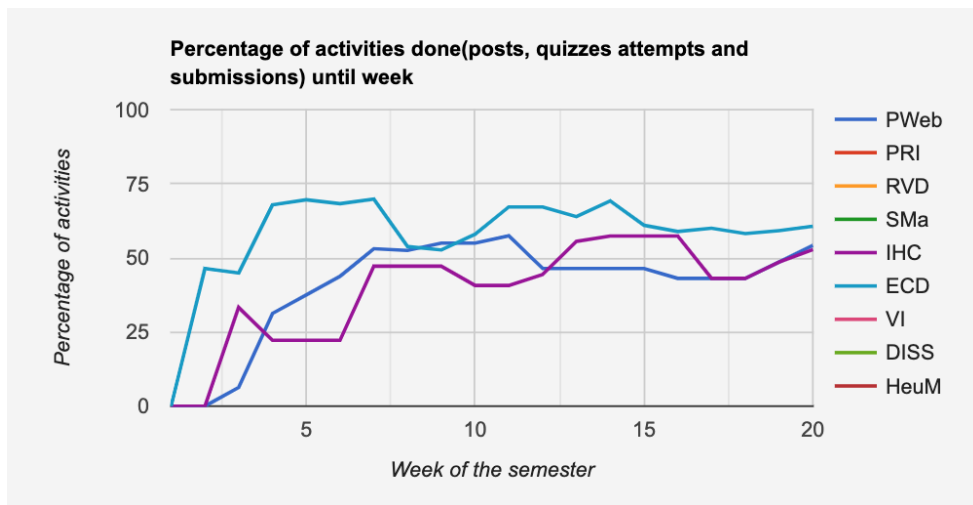


Figure M.7: Close-up of the of the change in the percentage of participation in each course throughout the weeks of the semester with only the courses 'PWeb', 'ECD' and 'IHC' selected.

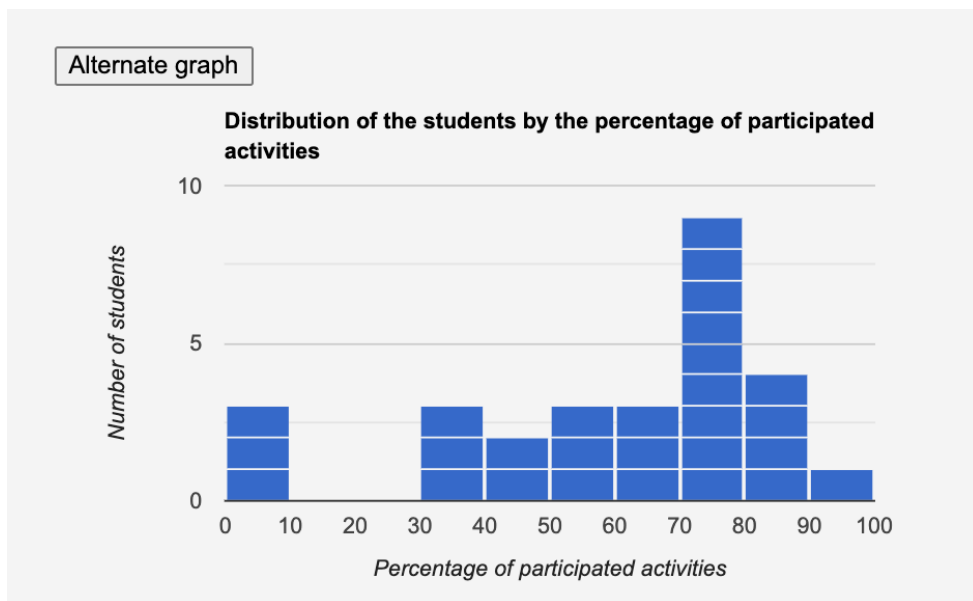


Figure M.8: Histogram close-up of the students' distribution of participation.

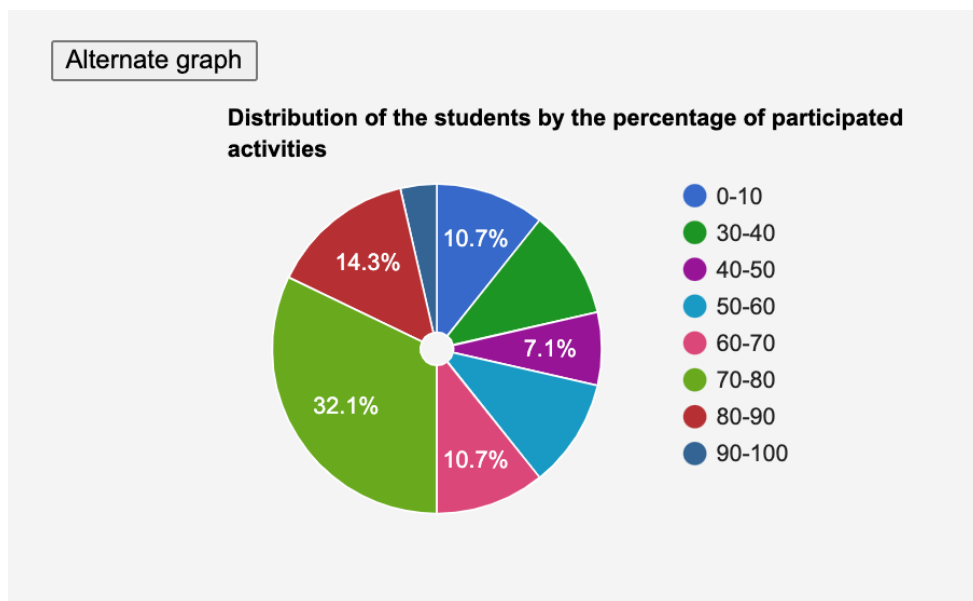


Figure M.9: Pie chart close-up of the students' distribution of participation.

Student ▲	Days since last access	Mean of the Percentage of open activities done	Percentage of open activities done
Mercês Marinho Filipe	0	32.8	75
Avelino Lousã Imperial	1	20.5	100
Elieil Borja Alencar	0	0	0
Avelino Moreira França	15	9.6	0
Victória Saraiva Proença	0	23.1	66.7
Ryan Calçada Marçal	0	20.2	100
Emilie Quintana Baptista	0	16.2	66.7

Figure M.10: Close-up of the overall view of students in the program.

Student	Days since last access	Mean of the Percentage of open activities done	Percentage of open activities done	Course Edition	Enrollment Regime
Mercês Marinho Filipe	0	32.8	75	2ª	tempo parcial
Avelino Lousã Imperial	1	20.5	100	3ª	tempo parcial
Elieíl Borja Alencar	0	0	0	2ª	tempo parcial
Avelino Moreira França	15	9.6	0	5ª	tempo parcial
Victória Saraiva Proença	0	23.1	66.7	6ª	tempo parcial
Ryan Calçada Marçal	0	20.2	100	6ª	tempo parcial
Emílio Quintana Baptista	0	16.2	66.7	6ª	tempo parcial
Raúl Matos Figueiredo	16	6.7	0	6ª	tempo parcial
Andressa Moreira Malheiro	25	4.7	0	6ª	tempo integral
Teresa Cruz Proença	0	22.4	50	6ª	tempo integral
Camilla Espinosa Uíhoa	0	19	100	6ª	tempo parcial
Imran Rosário Caminha	0	34	66.7	6ª	tempo parcial
Telmo Baptista Robalo	0	21	50	6ª	tempo parcial
Mercês Barrico Carvalho	0	17.8	50	6ª	tempo parcial
Jordan Moreira Tabanez	14	16.6	0	6ª	tempo parcial
Mercês Proença Tabanez	0	17.2	50	6ª	tempo integral
Kandra Café Figueira	24	15.4	0	6ª	tempo integral
Luisa Garcez Meireles	1	22.5	75	6ª	tempo integral
Andressa Azambuja Marinho	2	29.6	0	6ª	tempo parcial
Kallany Saraiva Cisneiros	6	7.7	0	6ª	tempo parcial
Alexandro Caminha Carvalho	0	25.6	50	6ª	tempo parcial

Percentage of participated activities: Emílio Quintana Baptista: 0, 16.2, 66.7

Figure M.11: Close-up of the opened modal in the overall view of students in the program.

M.3 Course View

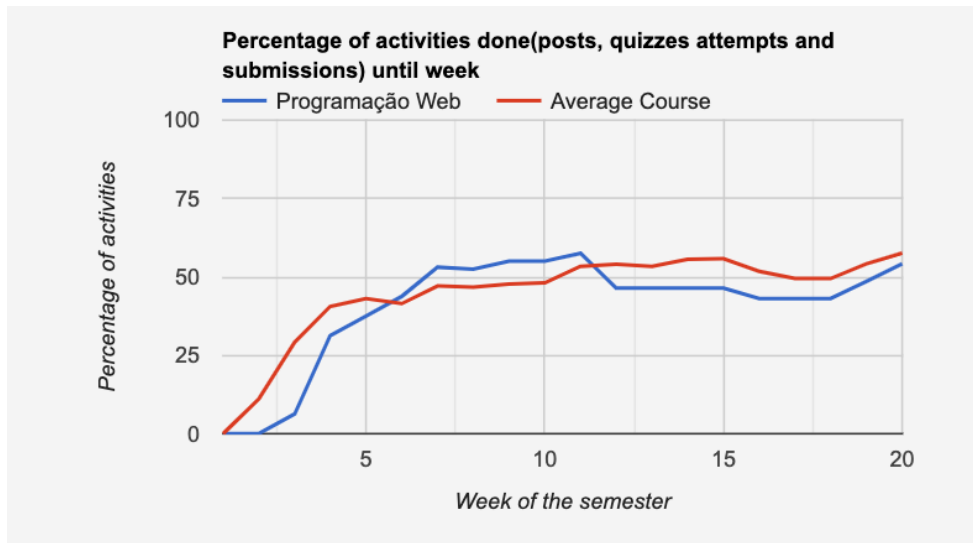


Figure M.12: Close-up of the change in the percentage of participation throughout the weeks of the semester.

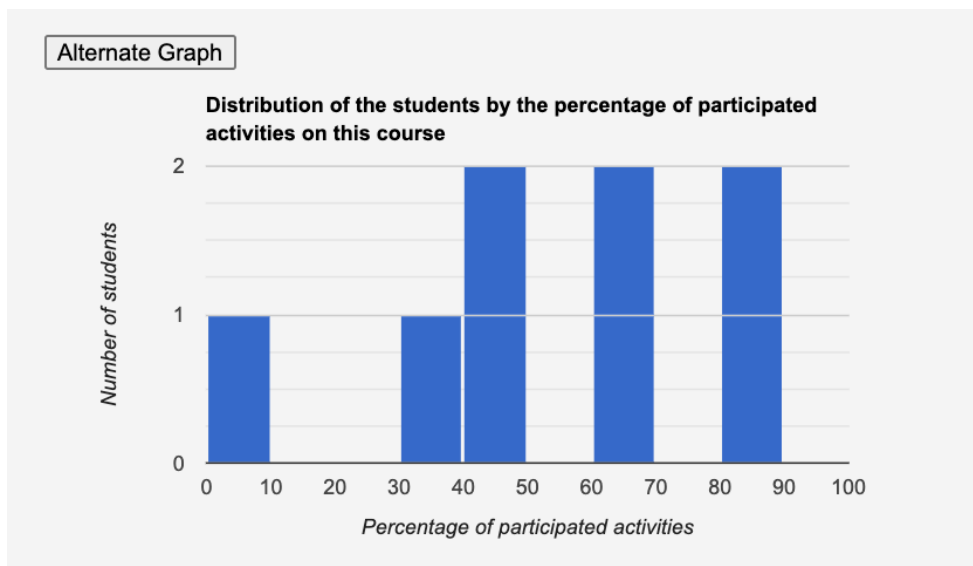


Figure M.13: Histogram close-up of the students' distribution of participation.

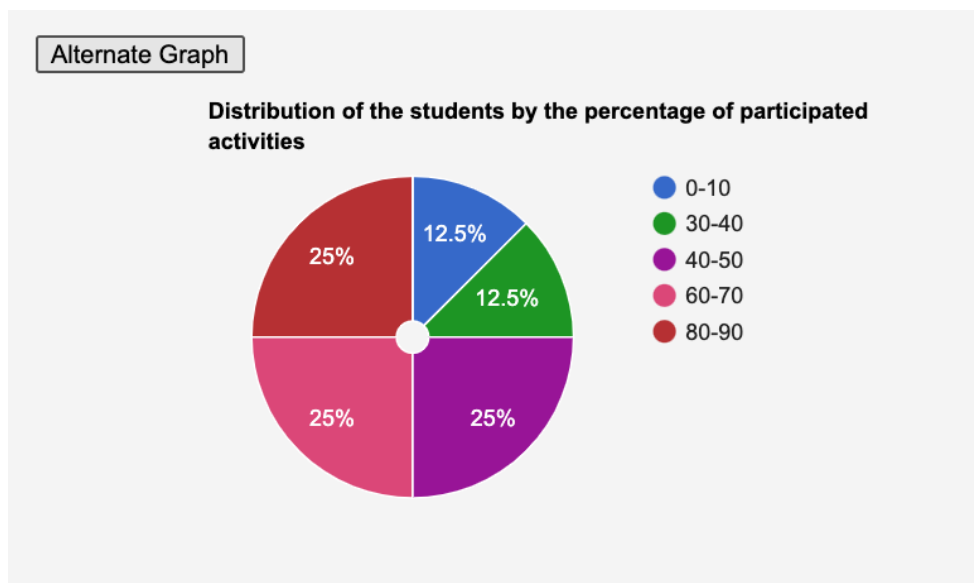


Figure M.14: Pie chart close-up of the students' distribution of participation

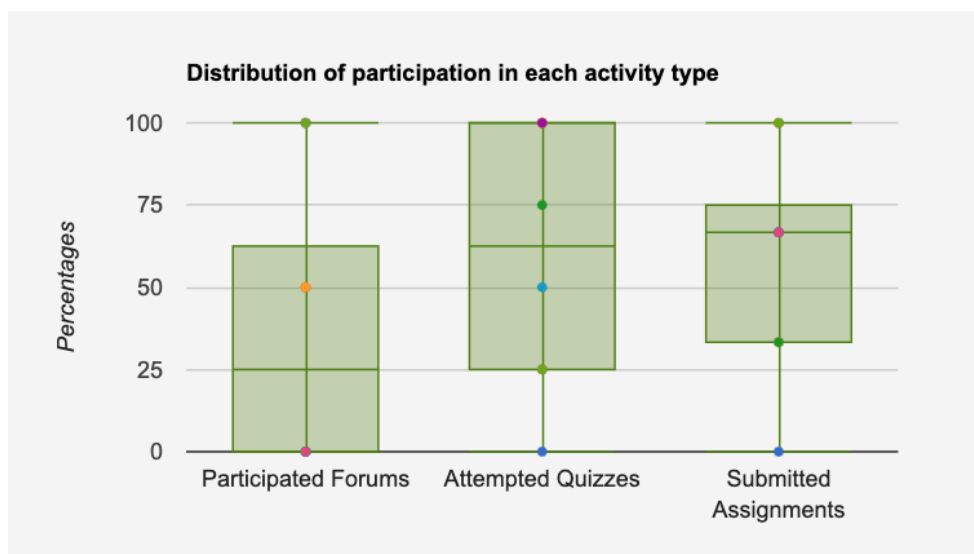


Figure M.15: Close-up of the distribution of the percentages of participation in each activity.

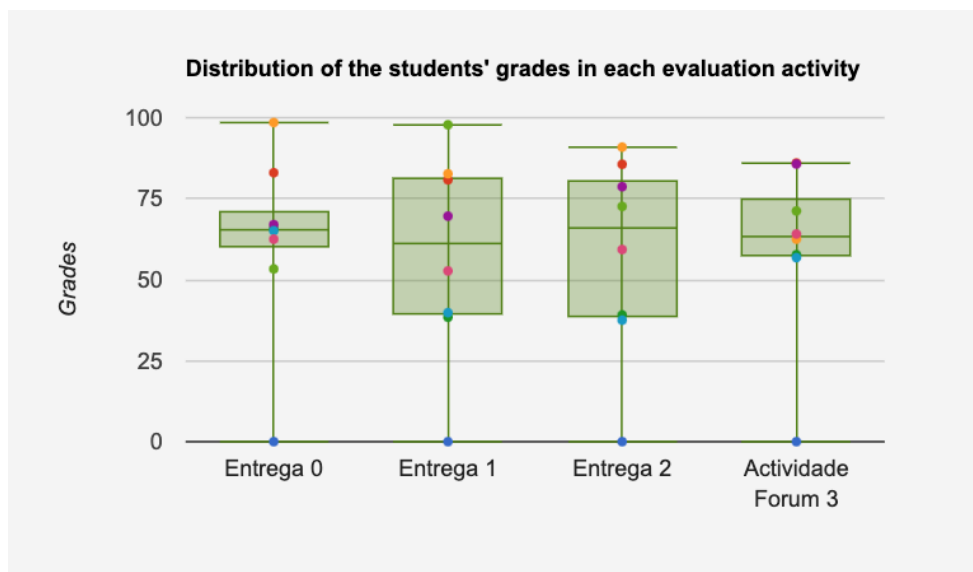


Figure M.16: Close-up of the distribution of the grades in each evaluation.

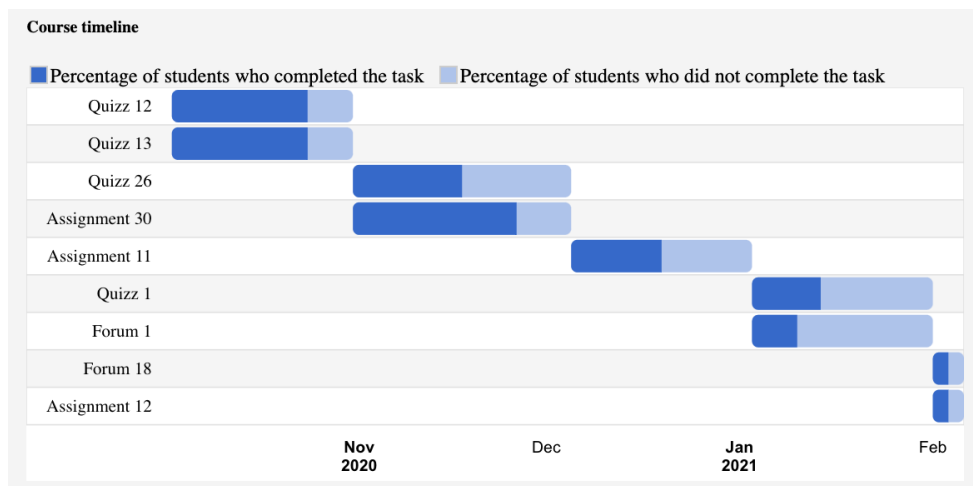


Figure M.17: Close-up timeline activities.

M.4 Student View

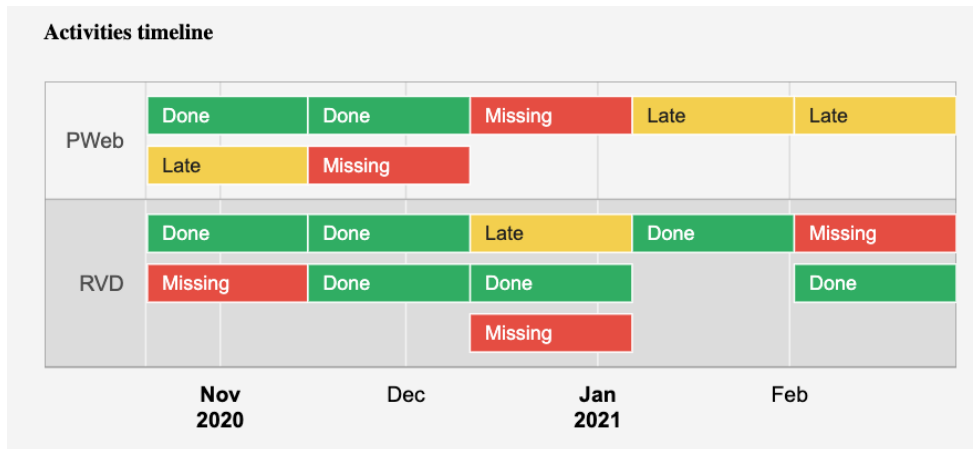


Figure M.18: Close-up timeline activities in each course enrolled.

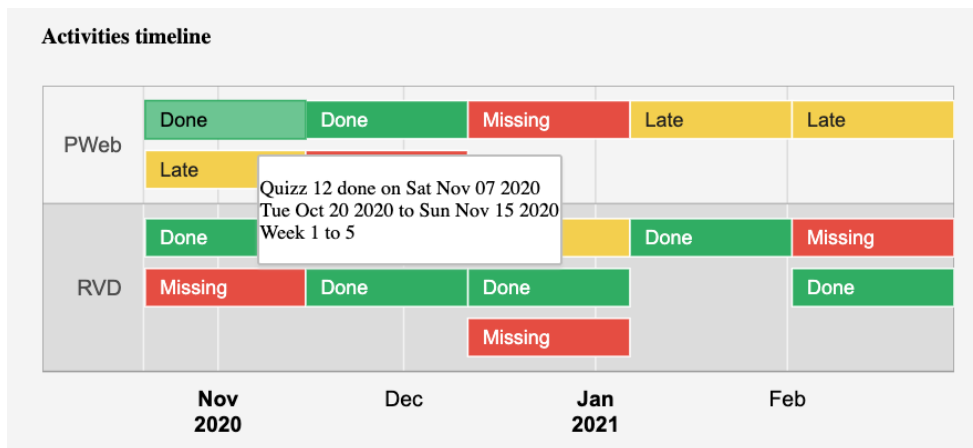


Figure M.19: Close-up timeline activities in each course enrolled showing tooltip

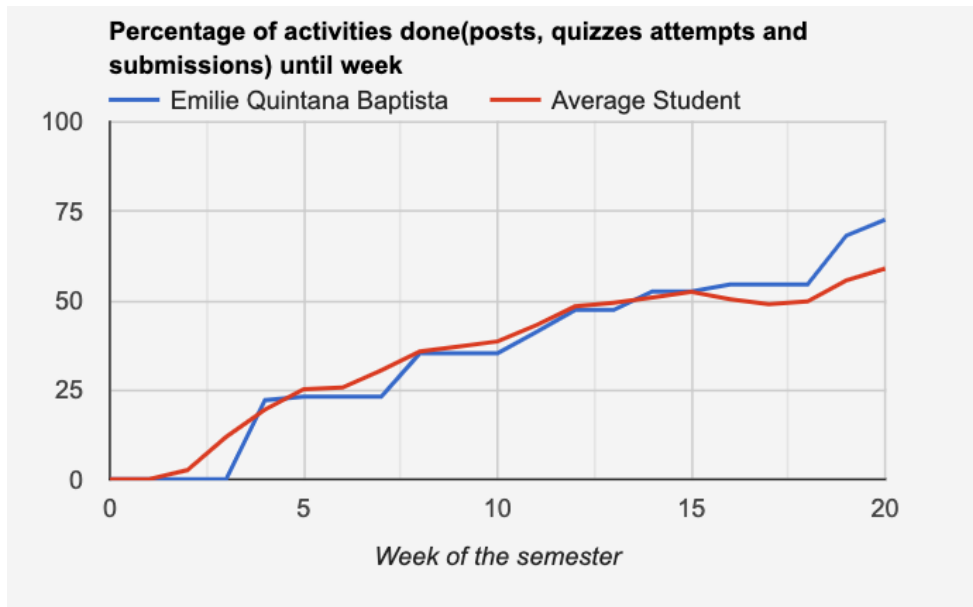


Figure M.20: Close-up of the change in the percentage of participation throughout the weeks of the semester.

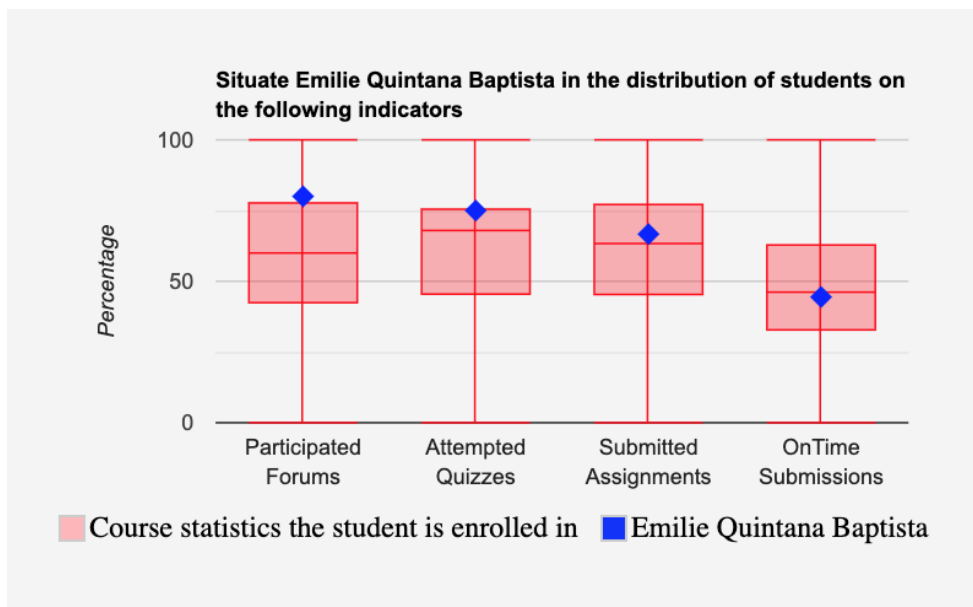


Figure M.21: Close-up of the distribution of the percentages of participation in each activity.

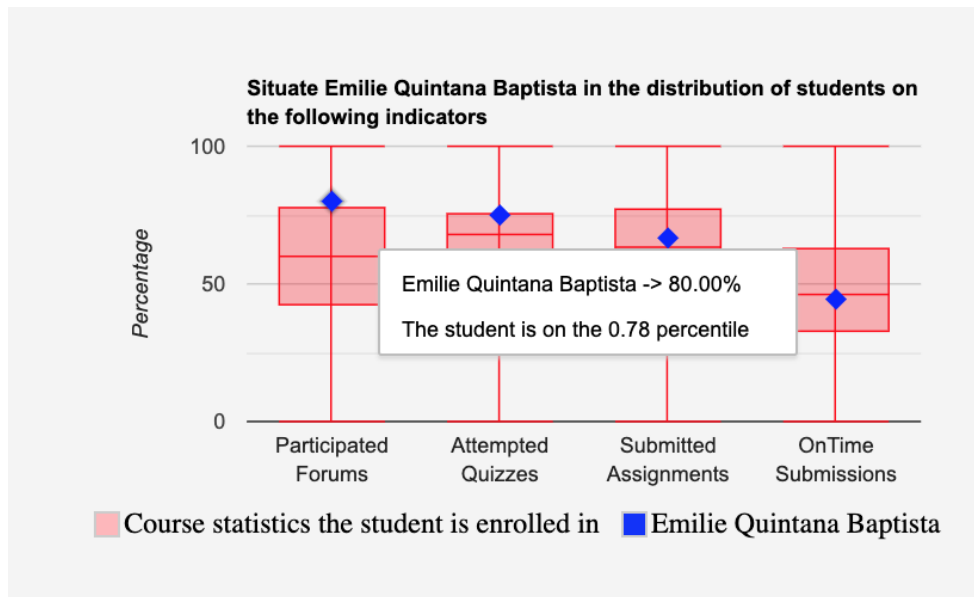


Figure M.22: Close-up of the distribution of the percentages of participation in each activity showing tooltip.

Course ▲	Activity	Grade	Percentile
PWeb	Entrega 0	98.5	1
PWeb	Entrega 1	82.7	0.9
PWeb	Entrega 2	90.9	1
PWeb	Actividade Forum 3	62.5	0.4
RVD	Relatório 0	74.2	0.8
RVD	Relatório 1	81.5	0.7
RVD	Entrega 2	96.8	1

Figure M.23: Close-up of the grades of each evaluation.

Appendix N

Final Prototype Interviewees

Professor	E-mail	University
Hugo Paredes	hparedes@utad.pt	UTAD
Nuno Sousa	Nuno.Sousa@uab.pt	UAb
Leonel Morgado	leonel.morgado@uab.pt	UAb
Luís Filipe Barbosa	lfb@utad.pt	UTAD
Diogo Casa Nova	diogo.casanova@uab.pt	UAb
Vitor Rocio	Vitor.Rocio@uab.pt	UAb

Appendix O

Evaluation interview protocol (in Portuguese)

Boa tarde!

Em primeiro lugar gostaria de agradecer a sua disponibilidade para conversar comigo novamente e fazer esta entrevista. Gostaria de saber se me dá autorização para gravar esta conversa para facilitar a recolha de dados?

[SIM / NÃO]

Para relembrar, o meu trabalho de dissertação chama-se “Drill-down Dashboard for Chairing Online Master Programmes” e consiste na elaboração de um painel de instrumentos, para ajudar os coordenadores de mestrado a ter noção de como as atividades do curso decorrem ao longo do semestre.

Passando então para a avaliação do protótipo, teve oportunidade de ver o link que lhe enviei no email? Se o puder abrir e partilhar o ecrã seria melhor, sendo que as próximas perguntas vão ser para avaliar o protótipo e queria visualizar também como interage com ele.

Para relembrar, neste protótipo existem três vistas, a de curso que é logo a primeira que vê, a vista de disciplina e a vista de aluno.

1. Vista de curso (Primeiro ecrã)
 - (a) Qual é a sua impressão geral desta vista?
 - (b) Para cada secção:
 - i. Na sua opinião, qual é o objetivo desta secção?
 - ii. Consegue descobrir alguma ação a tomar nesta secção?
 - iii. Quais são os seus comentários sobre esta secção?
 - (c) Consegue descobrir mais alguma ação a tomar nesta vista?
 - (d) Tem mais algum comentário a fazer sobre esta vista?
2. Vista de disciplina (indicar como mudar de página se necessário)

- (a) Qual é a sua impressão geral desta vista?
 - (b) Para cada secção:
 - i. Na sua opinião, qual é o objetivo desta secção?
 - ii. Consegue descobrir alguma ação a tomar nesta secção?
 - iii. Quais são os seus comentários sobre esta secção?
 - (c) Consegue descobrir mais alguma ação a tomar nesta vista?
 - (d) Tem mais algum comentário a fazer sobre esta vista?
3. Vista de estudante (indicar como mudar de página se necessário)
- (a) Qual é a sua impressão geral desta vista?
 - (b) Para cada secção:
 - i. Na sua opinião, qual é o objetivo desta secção?
 - ii. Consegue descobrir alguma ação a tomar nesta secção?
 - iii. Quais são os seus comentários sobre esta secção?
 - (c) Consegue descobrir mais alguma ação a tomar nesta vista?
 - (d) Tem mais algum comentário a fazer sobre esta vista?
4. Final
- (a) Considerando o protótipo como um todo, o que acha do protótipo e como o avalia?
 - (b) Lembra-se de alguma coisa ou de algum problema que não ficaria resolvido com a ajuda do protótipo?
 - (c) Tem alguma sugestão geral para melhorias?
 - (d) Algum comentário final?

Muito obrigada pela sua participação!

Appendix P

Translated Interview protocol

Good afternoon!

First of all, I would like to thank you for your availability to talk to me and to do this interview.

I would like to know if you would give me permission to record this conversation to make it easier to keep track of data?

[YES / NO]

My dissertation is called “Drill-down Dashboard for Coordination of Master Programs in Engineering” and it consists on the elaboration of a dashboard, to help master’s coordinators to have an idea of how the course activities take place throughout the semester.

Moving on to the prototype evaluation, did you have the opportunity to see the link I sent you by email? If you’d open it and share the screen, it would be better since the next questions will be to evaluate the prototype and I wanted to also visualize how you interact with it.

In this prototype there are three views, the Program view, which is the first view, the Course view and the Student view.

1. Program view

- (a) What was your impression of this view?
- (b) For each display:
 - i. In your opinion, what is the purpose of this display?
 - ii. Can you see any actions to be taken in this display?
 - iii. What are your comments about this display?
- (c) Can you see any actions to be taken in this view?
- (d) Any further comment on this view?

2. Course view

- (a) What was your impression of this view?
- (b) For each display:
 - i. In your opinion, what is the purpose of this display?

- ii. Can you see any actions to be taken in this display?
- iii. What are your comments about this display?

- (c) Can you see any actions to be taken in this view?
- (d) Any further comment on this view?

3. Student view

- (a) What was your impression of this view?
- (b) For each display:
 - i. In your opinion, what is the purpose of this display?
 - ii. Can you see any actions to be taken in this display?
 - iii. What are your comments about this display?
- (c) Can you see any actions to be taken in this view?
- (d) Any further comment on this view?

4. Final

- (a) Considering the whole dashboard, what are your thoughts on this prototype and how do you evaluate it?
- (b) Is there anything or any problem that would not be resolved with the help of the dashboard?
- (c) Any feedback for improvement?
- (d) Any further comments?

Thank you for your participation!

Appendix Q

Results of the interviews for evaluation of the prototype

Table Q.1: Analysis of the transcripts

ID	Figure	Professor	Full transcript (in Portuguese)	Category
01	N/A	Hugo Paredes	"Como todos os gráficos são do mesmo tamanho nenhum deles tem impacto em termos visuais e não sei para qual deles hei-de olhar (...). O ideal seria ter logo uma visão completa para eu conseguir dirigir logo a minha atenção para aí e não ter de pensar para onde tenho de dirigir a minha atenção. "	Missing information
02	M.5	Leonel Morgado	"A tooltip por vezes tapa a informação do gráfico e isso é muito chato."	Graph improvement
03	M.6	Nuno Sousa	"Se calhar aqui um botão 'activate all' e 'deactivate all' era interessante."	Graph improvement
04	M.6	Diogo Casa Nova	"Permitindo-me navegar em cada uma das disciplinas aqui [no eixo dos x do gráfico representado na figura M.5], estava à espera de um comportamento semelhante neste."	Graph improvement
05	M.6	Vitor Rocio	"Falta conseguir distinguir as linhas que estão ativas das que não estão."	Graph improvement

06	M.6	Hugo Paredes	"Dada a similaridade das cores, para mim é difícil ter a perceção de qual é qual principalmente nos vermelhos e rosas."	Graph improvement
07	M.8	Nuno Sousa	"Será que isto iria funcionar com 100 alunos? Se calhar as barras estão demasiado fininhas."	Non-scalable component
08	M.8	Nuno Sousa	"Não estou a perceber a ordenação disto, se eu quero procurar um aluno como é que eu o faço? Talvez devesse estar ordenado por ordem alfabética de nome do aluno, se eu quiser fazer isso."	Graph improvement
09	M.8	Diogo Casa Nova	"Com muitos mais alunos seria impraticável encontrar um aluno aqui neste gráfico."	Non-scalable component
10	M.9	Leonel Morgado	"Era giro se estas cores fossem progressivas e não apenas diferentes, ou seja, se fosse do vermelho ao verde ou do azul claro ao azul escuro, se houvesse uma evolução lógica eu conseguia rapidamente perceber o que é que tinha que juntar e não ter que estar sempre a ler a legenda."	Graph improvement
11	M.11	Nuno Sousa	"Estes não são números fáceis de ler, ao passo que se tivesse uma cor era capaz de captar um pouco mais à atenção para aquela pessoa que começa a estar em falta."	Graph improvement
12	M.11	Nuno Sousa	"Se estes vazios são os que nunca acederam deve dizer 'Nunca'."	Graph improvement
13	M.11	Leonel Morgado	"Seria bom poder filtrar por edição ou seja, dentro desta edição é que quero ordenar."	Graph improvement

14	M.12	Diogo Casa Nova	"Gostava de ter a possibilidade de não só comparar a percentagem de atividades realizadas mas também com a média das notas da unidade curricular com as restantes unidades curriculares do curso."	Missing information
15	M.12	Leonel Morgado	"Aqui o 'average course' devia ser 'program average' porque 'average course' induz numa expectativa do valor que devia ser, por exemplo nacional, e não o valor verdadeiro da média do curso."	Graph improvement
16	M.13	Nuno Sousa	"Se eu quisesse ver aqui um aluno em particular não é muito fácil de ver onde está."	Non-scalable component
17	M.13	Diogo Casa Nova	"Ao clicar no aluno, em vez de ir para uma página diferente seria interessante abrir uma pop-up do aluno porque assim dava-me oportunidade de conseguir continuar a navegar na página da disciplina sem ter que estar a mudar constantemente de página e porque também quero ver mais informação neste contexto e não num contexto completamente diferente."	Missing information
18	M.13	Leonel Morgado	"Era útil se eu quisesse ver vários alunos eu pudesse vê-los individualmente mas pudesse manter uma espécie de lista dos alunos que eu queria ver."	Graph improvement
19	M.15	Vitor Rocio	"Eu aqui tenho alguma dificuldade em afixar a tooltip para ver os alunos porque os pontos são muito pequeninos."	Graph improvement
20	M.15	Luís Barbosa	"Esta forma de consultar a informação pode não ser muito viável quando a lista de alunos se tornar muito extensa."	Non-scalable component

21	M.15	Leonel Morgado	"Eu gostaria de ver quais eram os trabalhos, as datas... Mostrar uma lista dos trabalhos e eu poder eventualmente clicar nos trabalhos para saber mais coisas."	Missing information
22	M.16	Nuno Sousa	"Isto aqui tem um problema que quando tivermos 20 ou 30 alunos começa a ficar um pouco complicado. Existe um problema de escala, uma janela com 10 tudo bem uma janela com 20 já vai ocupar o ecrã inteiro de alto abaixo"	Non-scalable component
23	M.17	Nuno Sousa	"Existe aqui umas barras onde inverte."	Graph improvement
24	N/A	Diogo Casa Nova	"Gostaria de ter uma tabela como a M.10 para poder ter um sumário dos alunos dentro de cada unidade curricular, pois pode estar ativo numa e não estar nas outras."	Missing information
25	M.17	Luís Barbosa	"Podia haver aqui alguma forma de expandir a vista deste gráfico para permitir que uma informação que saltasse à vista fosse mais pormenorizada."	Missing information
26	M.17	Leonel Morgado	"Se cada barra tivesse um link direto para o moodle para a atividade seria muito útil."	Extra feature
27	M.18	Leonel Morgado	"Era útil poder clicar em cada atividade e ir direto para essa atividade no moodle."	Extra feature
28	M.21	Diogo Casa Nova	"Este gráfico não me é totalmente reconhecido e portanto far-me-ia sentido ter uma legenda que explicasse o que representa aqui a divisão por quartil ou algo que me ajudasse a perceber este gráfico."	Graph improvement
29	M.23	Diogo Casa Nova	"À partida clicando aqui eu estava à espera de ir para a atividade e não para a disciplina."	Graph improvement

30	M.23	Vitor Rocio	"Ao definir um valor de referência no gráfico da figura M.5 talvez fizesse sentido que as cores aqui refletissem isso."	Graph improvement
31	N/A	Diogo Casa Nova	"Gostaria de ter informação demográfica sobre cada aluno para avaliar o aluno e tentar entender como é que o aluno se envolve com a aprendizagem, uma fotografia do aluno se fosse possível, uma apresentação do aluno, homem ou mulher, vem de que país, quais são os objetivos ao fazer o curso, se tem experiência a fazer cursos online, etc."	Extra feature
32	N/A	Diogo Casa Nova	"A partir do momento em que se percebe que o aluno está em risco ter um mecanismo automático ou manual que permite enviar uma mensagem ao aluno para alertar o aluno, para o incentivar, mas tentar criar uma lógica de continuação que permita essa interação com os alunos."	Extra feature