Usability in the Development of a Project Management Software Reinforced with Machine Learning

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Abstract. Software development stages can represent a challenge due to the increase of final user demands since it must comply with standards and metrics that assure the quality of the final product, especially when related to the interface structure, considering that this could lead to the software failure or success. In the case of software oriented to project management, it is important to present them as a simple and practical tool to avoid generating a lack of interest in the final user. Therefore, in this study, we focus on the usability application process for a project management software reinforced with machine learning by analyzing requirements and integrating Nielsen usability guidelines in the design stage of the traditional methodology applied in the software development. The results show that the elements of the graphical interface were easily endorsed enabling a close up to a user-friendly software in the management of PM4r projects.

Keywords: Project management · PM4r · Software development · Design · Nielsen usability guidelines · Usability

1 Introduction

Nowadays, software is used in different branches of human activity and the demands of users to work with them has increased considerably, being necessary to meet certain standards and attributes that meet the needs of the user [9] [10]. The success or failure of software can be largely determined by the quality of its interfaces, so the latter represents one of the essential parts to be developed. Given this, usability is presented not only as the treatment of the appearance of an interface but also considers the interaction of the software with the user. The usability evaluation is in charge of proving that the software allows the user to perform tasks in a practical and intuitive way [2].

In the current competitive environment, there is a large amount of project management software that serves as tools to manage and keep track of projects. However, this kind of software, sometimes, are not presented as an easy tool to use and can generate a loss of interest in the final user. A project software must have as objective and fulfill the maximum amount of visibility and control of the project with the

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minimum effort [4]. This is why the application of usability during software development has become an essential requirement and so, the use of techniques or methodologies with maximum explanatory power for usability problems such as the 10 Usability Heuristics for User Interface Design developed by Jakob Nielsen, which serve more as a general rule of thumb than a set of hard rules [8].

Therefore, in this paper, the analysis and design, under traditional methodology, is studied specifically focusing on the requirements and the usability application by reviewing the Nielsen guidelines for the design of PM4R project management software reinforced with machine learning for the prediction of project time estimate. The research shows the results of the application of the aforementioned to achieve quality criteria in order to generate an appropriate interface for the end user, as well as a view to future work.

2 Background

2.1 Concepts

PM4R: It is a combination of good practices and internationally accepted standards to ensure the achievement of specifics objectives (result, product or service) of the project within the established time [11]. The methodology is based on 7 steps, which are [11]:

- Step 1. WBS: Work breakdown structure in which components, subcomponents, products, deliverables, and work packages are created and edited.
- Step 2. Schedule: Time estimation
- Step 3. S Curve: Resources use curve, called "S curve" because the costs are lower, both in the beginning and at the end.
- Step 4. Acquisitions Matrix: The contracting of goods and services, the type and way of acquisition of the same and the estimated dates are detailed.
- Step 5. Risk Matrix: Presents the risks, probability of occurrence evaluation, its impact and the answers assigned to a responsible.
- Step 6. Communication Matrix: Specifies the quantity and quality of information that must be communicated at the appropriate time to stakeholders.
- Step 7. Responsibilities assignment Matrix: connects the organization chart with the WBS and is based on RAM.

Machine Learning: Kovahi and Provost (1998) define Machine Learning as the discipline that allows the construction of algorithms to learn from data as cited in [7], also known as machine learning algorithms. These algorithms according to Bishop (2006) build models to make predictions or make decisions as cited in [7].

Usability: It is the efficiency, effectiveness and satisfaction by which specific users achieve a set of specific tasks in particular environments [5]. These three components cannot be evaluated independently; while the effectiveness is related to the accuracy and completeness, the efficiency is given by the speed by which users can complete their tasks that may cause or not the satisfaction of the user [1].

Nielsen Usability Guidelines: The 10 principles of Nielsen are considered because they are a set of rules that allow the development of user-friendly systems and are defined as heuristics because they are generalizable to evaluate non-specific designs. These are [8]:

- Visibility of system status: The system should keep users informed about what is happening, through an appropriate comment in a reasonable amount of time.
- Match between system and the real world: The system must speak the language of the users, with words, phrases and familiar concepts for this, instead of terms oriented to the system. It will follow the conventions of the real world, making the information appear in a natural and logical order.
- User control and freedom: Users often choose system functions by mistake and there must be a clearly marked "emergency exit" to exit the unwanted state without extensive dialogue. Support to undo and redo.
- Consistency and standards: Users should not have to ask themselves if different words, situations or actions mean the same thing. Follow the conventions of the platform.
- Error prevention: It must have a design that prevents the occurrence of a problem. A confirmation must be submitted to the user before performing an action.
- Recognition rather than recall: Reduce the user's memory load. This should not have to remember the information from one party to another. Instructions for use or easily recoverable must be visible.
- Flexibility and efficiency of use: Interaction accelerators for the expert user. Allow users to adapt frequent actions.
- Aesthetic and minimalist design: Dialogs should not contain information that is irrelevant or rarely necessary.
- Help users recognize, diagnose, and recover from errors: Error messages should be expressed in simple language (without codes), indicate the problem accurately, and constructively suggest a solution.
- Help and documentation: It may be necessary to provide help and documentation.

2.2 Case of Study

Because of the lack of software for PM4R project management, development projects, which include actors such as public institutions, non-governmental organizations, development agencies, among others, represent an unexplored data source [4].

This problem was addressed as an end-of-career project in [3]. This paper focuses on the analysis of requirements and usability through a review of Nielsen's guidelines at the design stage, the development of a Software for the management of PM4R development projects reinforced with machine learning for estimating the duration of projects.

3 Methodology

As mentioned in the case study, a traditional software development methodology is applied through the cascade model shown in Fig. 1 and is considered a revision of the Nielsen usability guidelines in the Design stage.

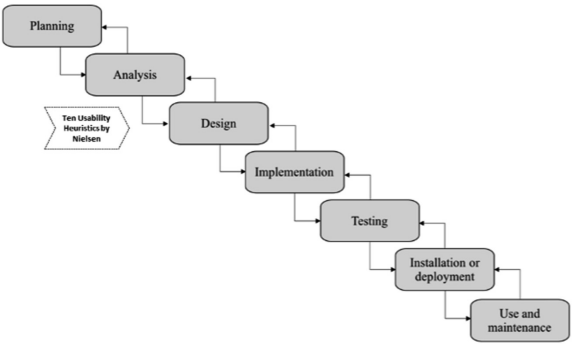


Fig. 1. Software development life cycle - Waterfall model

It is important to mention that in this study we only focus on the first and the second stage of the model previously presented based on [6]:

1. Analysis: Settle what is needed and priorities each requirement.
2. Design: Definition of the general structure, standards and, with the application of the Nielsen guidelines, the base flow software.

4 Results

4.1 Analysis

The objective of this section is to specify the functional (Table 1) and non-functional (Table 2) requirements of PM4R development project management software, as well as their prioritization (Table 3).

Table 1. Catalog of functional requirements.

N[a]	Description	Priority
1.	As a manager, I want to create, edit and delete a project	1
2.	As a manager, I want to add members to the project	1
3.	As a manager, I want to filter the projects based on their characteristics	2
4.	As a manager, I want to visualize the total of projects divided by pages	2
5.	As a manager, I want to have visibility into which phase of the PM4R is a project	1

(*continued*)

Table 1. (*continued*)

N[a]	Description	Priority
6.	As a manager, I want to create components, subcomponents, products, deliverables and work packages per project	1
7.	As a manager I want my selection (component, subcomponent, product, deliverable and work package) to be persistent when reloading a page	1
8.	As a manager, I want my selection of the phase I am working on to be persistent when reloading a page	1
9.	As a manager, I want to create, edit and delete activities and their dependencies	1
10.	As a manager, I want to log, for the months in which the project is in development, the estimated costs and actual costs and visualize if they follow the pattern of a curve S	1
11.	As a manager I want, for each product or deliverable, to create, edit and delete required acquisitions	1
12.	As a manager, I want to create, edit and delete existing risks for components, subcomponents, products or project deliverables	1
13.	As a manager, I want to create, edit and delete communications	1
14.	As a manager, I want to create responsibilities for the project	1
15.	As a manager, I want the system to offer me an estimation report of the project duration by classification	1
16.	As a manager I want the system to offer me the option to configure the classification parameters	1
17.	As a manager, I want the system to offer me an estimate of the project duration by regression	1
18.	As a manager, I want the system to offer me the option to configure the parameters of the regression	1

Table 2. Catalog of non-functional requirements.

N[a]	Description	Priority
1.	The system must generate a report of errors generated during its use	2
2.	The system must be displayed correctly in Chrome browsers	1
3.	The system will maintain the Google Material design standard	1
4.	The system will have a graphic interface in the English language	1
5.	The front-end will be developed using the programming language Typescript and Angular 6 framework	1
6.	The system will use a PostgreSQL database engine	1
7.	The system will use an API Rest server developed in Python, using Django Rest framework	1

Priority: determines the importance of the requirement for software implementation.

Table 3. Priorities of requirements.

Value	Description
1.	High
2.	Medium
3.	Low

4.2 Design

The objective of this section is to define the structure (Table 4) and standards (Tables 5 and 6) of the graphics interfaces to be used during the development of the software, and with the application of the Nielsen usability guidelines, the base flow of the software (Figs. 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16), through mockups related to the requirements.

Table 4. General structure

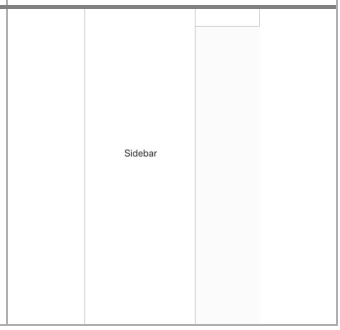
Desktop version	Mobile version
	

Table 5. Font standards

Element	Font	Size	Style
Title	Roboto	18px	Bold
Subtitle		16px	Regular
Text		14px	Regular
Button		14px	Regular

Table 6. Color standards

Colors	Hex	Sample
Primary	3F51B5	
Secondary	EDEDED	
Link Button	E94362	

Software Base Flow: Below is a description of each view, its relationship with the previously presented requirements, the application of the Nielsen principles and the final design obtained. The complete flow between views is available in: https://marvelapp.com/7e164hb/screen/49848726.

1. Home screen

Description: The list of all projects is presented in Fig. 2, with the option to select and delete. In addition, to present the always visible buttons for the creation of projects and the estimating module. On the other hand, it has the paging component.
Requirements: 1, 3, 4
Usability guidelines:

- Principle 2. The presence of the icons to eliminate, filter, more information, paging, search, etc., are consistent in the platform and the Google Material standard is handled.
- Principle 3. Presence of the text 'Projects' represents a fixed emergency exit.
- Principle 4. There is a consistency of color and structure standards.
- Principle 5. When you delete a project, the alert of Fig. 15 is displayed.
- Principle 6. The filtering of projects by many fields allows access to the required information without needing to remember a lot of information.
- Principle 8. The table covers the maximum possible height and width without considering the header or footer and paging.

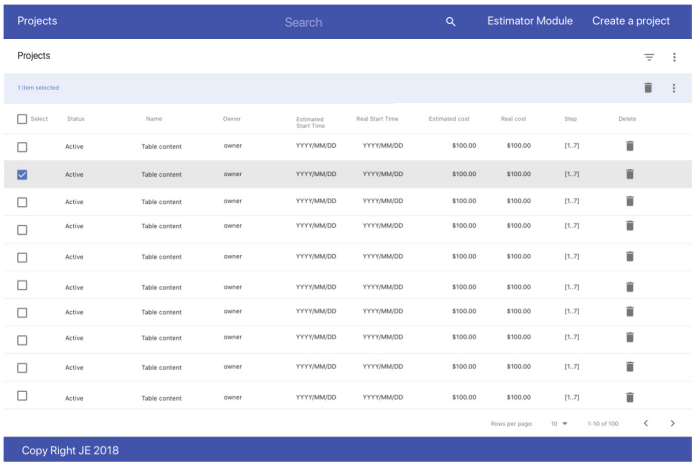


Fig. 2. Home screen

2. Project creation screen

Description: Create or edit projects screen is shown in Fig. 3, in addition to the option to add users from a total list to a selected list.
Requirements: 1,2
Usability guidelines:

- Principle 2. Use of the arrow down icon to display information in the accordion component.
- Principle 3. Presence of the text 'Projects' represents a fixed emergency exit. Additionally, the 'back' button is available if the user does not identify the first option. Ultimately this can use the 'back' icon of the browser itself to return to a previous view.
- Principle 4. There is a consistency of color and structure standards.
- Principle 6. Component of autocomplete when selecting the 'owner' of the project, immediate filtering when selecting the users and also the accordion component of 'Steps' is a permanent instructive.
- Principle 8. The required space to complete the project information is offered, the accordion has a fixed position to accompany the user when it scrolls down in the view.

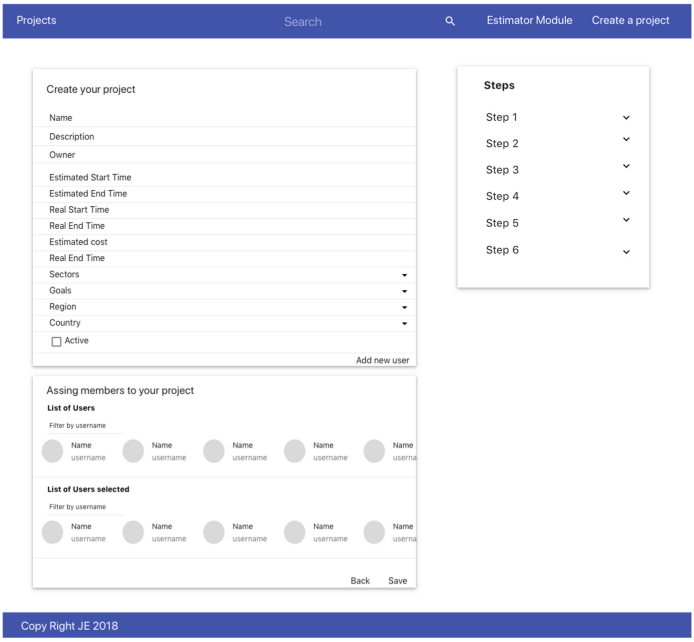


Fig. 3. Project creation screen

3. PM4R screen: Phase 1

Description: EDT screen is shown in Fig. 4, with the option to add components, subcomponents, products, deliverables and work packages.

Requirements: 5,6,7,8
Usability guidelines:

- Principle 1. Presence of the stepper for the user to identify that he is in phase 1.
- Principle 2. The arrow icon to the right and the 'plus' icon to add maintain the Google Material standards that in this case mean continuing to the next phase and adding another element of the EDT respectively.
- Principle 3. Presence of the text 'Projects' represents a fixed emergency exit.
- Principle 4. There is a consistency of color and structure standards.
- Principle 5. When removing an element from the EDT, the alert of Fig. 15 is displayed
- Principle 8. The EDT covers the entire screen and the current box that requires elements has a larger size to represent that it is selected.

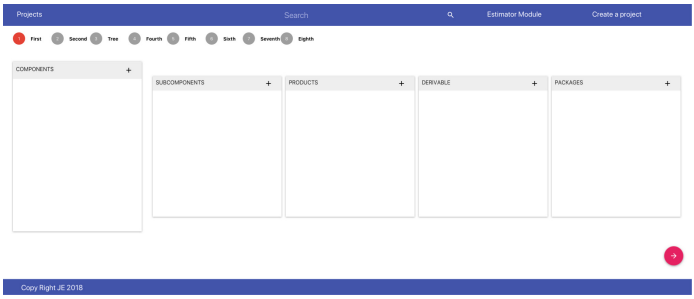


Fig. 4. PM4R screen: Phase 1

4. PM4R screen: Phase 2

Description: Activity creation screen is shown in Fig. 5.
Requirements: 9
Usability guidelines:

- Principle 1. Presence of the stepper for the user to identify that he is in phase 2.
- Principle 2. The arrow icon to the right and to the left maintain the Google Material standards that in this case mean continuing and moving back one phase respectively.
- Principle 3. Presence of the text 'Projects' represents a fixed emergency exit.
- Principle 4. There is a consistency of color and structure standards.
- Principle 5. When you delete activity and when you try to create an activity that is not in the start and end range of the project, the alert in Fig. 15 is displayed.
- Principle 6. The start and end date of the project is presented so that the user can take them as a reference in the creation of tasks.
- Principle 8. The screen is divided into two sections in such a way that the Gantt has greater visibility on the screen and the minimum space required (minimalist) to create new activities.

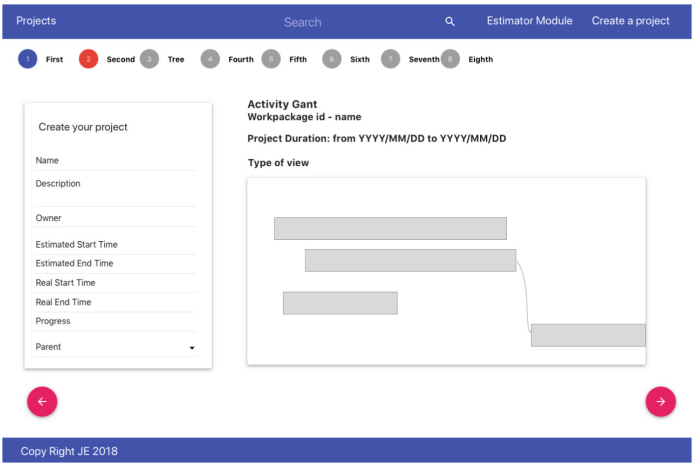


Fig. 5. PM4R screen: Phase 2

5. PM4R screen: Phase 3

Description: Screen of cost estimates and curve S is shown in Fig. 6.
Requirements: 10
Usability guidelines:

- Principle 1. Presence of the stepper for the user to identify that he is in phase 3.
- Principle 2. The arrow icon to the right and to the left maintain the Google Material standards that in this case mean continuing and moving back one phase respectively.
- Principle 3. Presence of the text 'Projects' represents a fixed emergency exit.
- Principle 4. There is a consistency of color and structure standards.
- Principle 8. The screen is divided into two proportional sections in such a way that both the table and the graphic use the minimum space required (minimalist).

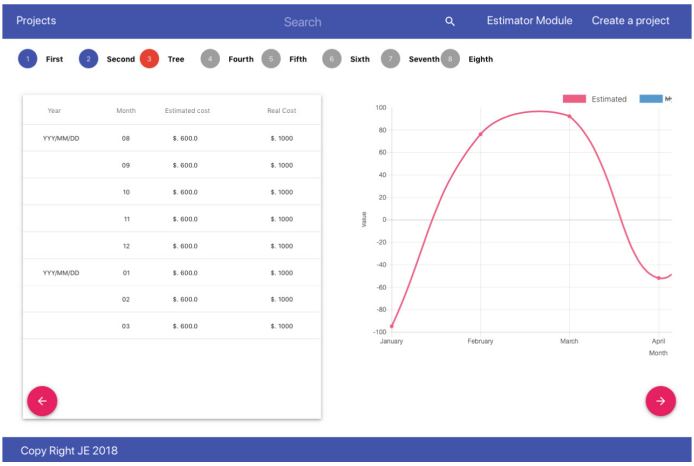


Fig. 6. PM4R screen: Phase 3

6. PM4R screen: Phase 4

Description: Acquisitions screen is shown in Fig. 7.
Requirements: 11
Usability guidelines:

- Principle 1. Presence of the stepper for the user to identify that he is in phase 4.
- Principle 2. The arrow icon to the right and to the left maintain the Google Material standards that in this case mean continuing and moving back one phase respectively.
- Principle 3. Presence of the text 'Projects' represents a fixed emergency exit.
- Principle 4. There is a consistency of color and structure standards.
- Principle 5. When you delete an acquisition, the alert shown in Fig. 15 is displayed
- Principle 7. The tables should not require a button to save the changes because this implies an additional action for the user, consequently, the inputs must automatically save the minimum change, therefore, there will be efficiency of use.

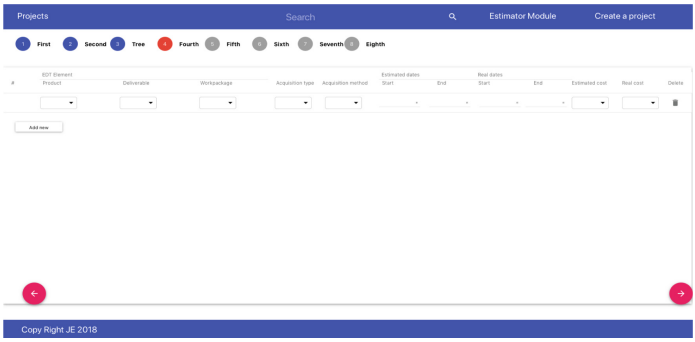


Fig. 7. PM4R screen: Phase 4

7. PM4R screen: Phase 5

Description: Risk screen is shown in Fig. 8.
Requirements: 12
Usability guidelines:

- Principle 1. Presence of the stepper for the user to identify that he is in phase 5.
- Principle 2. The arrow icon to the right and to the left maintain the Google Material standards that in this case mean continuing and moving back one phase respectively.
- Principle 3. Presence of the text 'Projects' represents a fixed emergency exit.
- Principle 4. There is a consistency of color and structure standards.
- Principle 5. When eliminating a risk, the alert of Fig. 15 is displayed
- Principle 7. The tables should not require a button to save the changes because this implies an additional action for the user, consequently, the inputs must automatically save the minimum change, therefore, there will be efficiency of use.

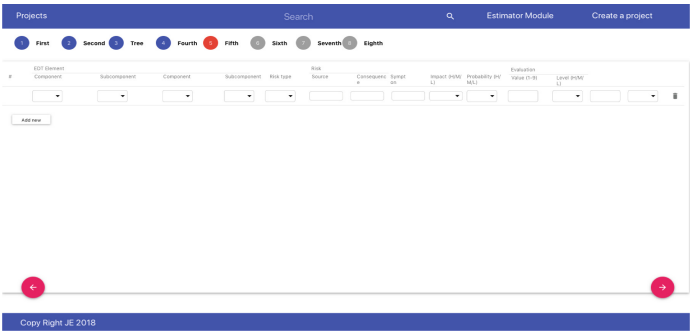


Fig. 8. PM4R screen: Phase 5

8. PM4R screen: Phase 6

Description: Communications screen is shown in Fig. 9.
Requirements: 13
Usability guidelines:

- Principle 1. Presence of the stepper for the user to identify that he is in phase 6.
- Principle 2. The arrow icon to the right and to the left maintain the Google Material standards that in this case mean continuing and moving back one phase respectively.
- Principle 3. Presence of the text 'Projects' represents a fixed emergency exit.
- Principle 4. There is a consistency of color and structure standards.
- Principle 5. When communication is deleted, the alert of Fig. 15 is displayed
- Principle 7. The tables should not require a button to save the changes because this implies an additional action for the user, consequently, the inputs must automatically save the minimum change, therefore, there will be efficiency of use.

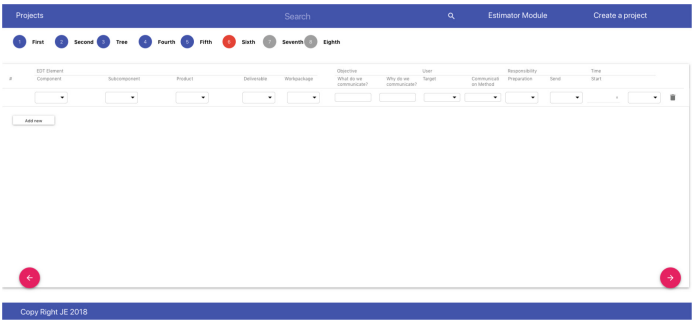


Fig. 9. PM4R screen: Phase 6

9. PM4R screen: Phase 7

Description: Responsibilities screen is shown in Fig. 10.
Requirements: 14
Usability guidelines:

- Principle 1. Presence of the stepper for the user to identify that he is in phase 7.
- Principle 2. The arrow icon to the right and to the left maintain the Google Material standards that in this case mean continuing and moving back one phase respectively.
- Principle 3. Presence of the text 'Projects' represents a fixed emergency exit.
- Principle 4. There is a consistency of color and structure standards.
- Principle 5. When deleting a responsibility, the alert of Fig. 15 is displayed
- Principle 7. The tables should not require a button to save the changes because this implies an additional action for the user, consequently, the inputs must automatically save the minimum change, therefore, there will be efficiency of use.

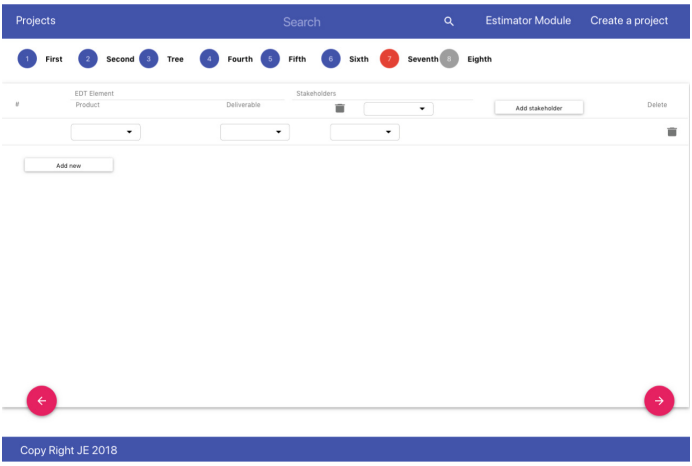


Fig. 10. PM4R screen: Phase 7

10. PM4R screen: Completed

Description: Screen at the end of all phases of the PM4R is shown in Fig. 11.
Requirements: 15
Usability guidelines:

- Principle 1. Presence of the stepper for the user to identify that he is in the final phase.
- Principle 2. The arrow icon to the left maintains the Google Material standards, which in this case means moving back one phase.
- Principle 3. Presence of the text 'Projects' represents a fixed emergency exit.
- Principle 4. There is a consistency of color and structure standards.

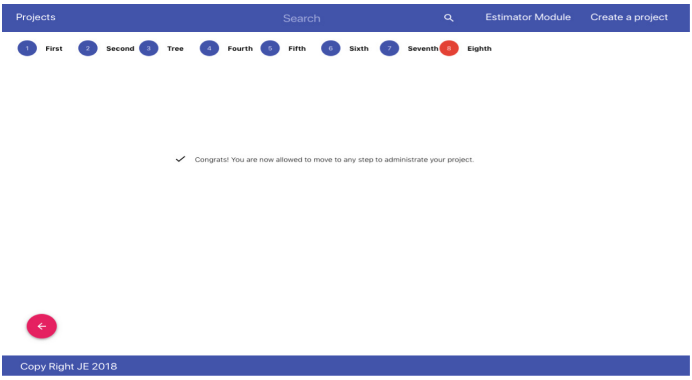


Fig. 11. PM4R screen: Completed

11. Configuration for classification models

Description: Settings screen for classification is shown in Fig. 12.
Requirements: 16
Usability guidelines:

- Principle 2. The presence of the delete and help icons are consistent in the platform and the Google Material standard is handled.
- Principle 3. Presence of the text 'Projects' represents a fixed emergency exit.
- Principle 4. There is a consistency of color and structure standards.
- Principle 5. Deleting a range of project duration displays the alert in Fig. 15
- Principle 10. The use of "help" or "more information" icons allow the user to know what is the function of an element of the screen.

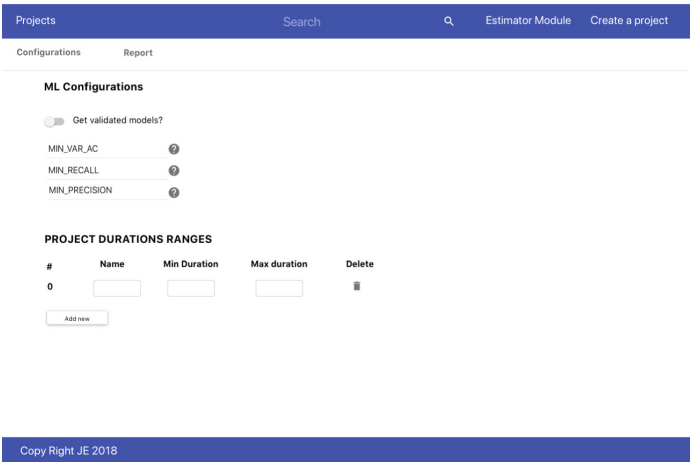


Fig. 12. Configuration for classification models

12. Configuration for regression models

Description: Settings screen for regression is shown in Fig. 13.
Requirements: 18
Usability guidelines:

- Principle 2. The presence of the help icon is consistent in the platform and the Google Material standard is handled.
- Principle 3. Presence of the text 'Projects' represents a fixed emergency exit.
- Principle 4. There is a consistency of color and structure standards.
- Principle 10. The use of "help" or "more information" icons allow the user to know what is the function of an element of the screen.

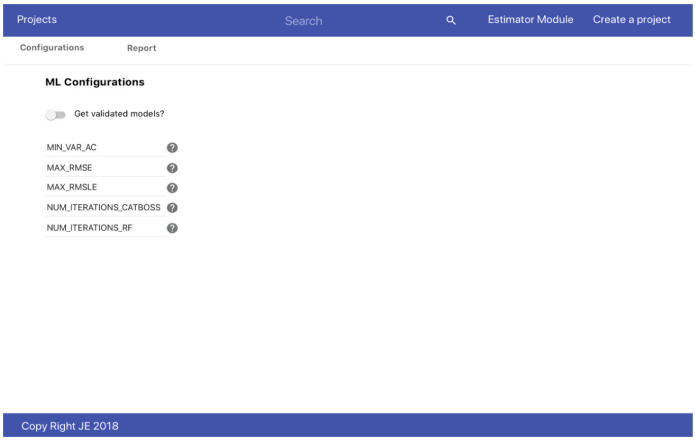


Fig. 13. Configuration for regression models

13. Classification report

Description: Report screen with the list of projects with the duration estimated by classification is shown in Fig. 14.
Requirements: 15
Usability guidelines:

- Principle 3. Presence of the text 'Projects' represents a fixed emergency exit.
- Principle 4. There is a consistency of color and structure standards.
- Principle 8. The screen is divided into two proportional sections in such a way that both the table and the graphics use the minimum space required (minimalist).

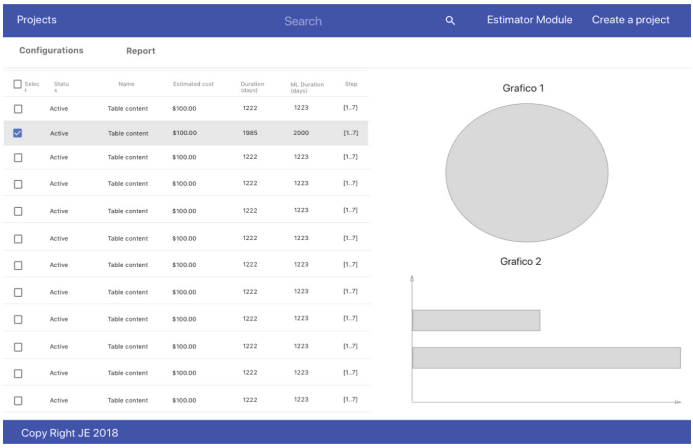


Fig. 14. Classification report

14. Report for regression models

Description: Report screen with the list of projects with estimated duration by regression is shown in Fig. 15.
Requirements: 17
Usability guidelines:

- Principle 3. Presence of the text 'Projects' represents a fixed emergency exit.
- Principle 4. There is consistency of color and structure standards.
- Principle 8. The screen is divided into two proportional sections in such a way that both the table and the graphics use the minimum space required (minimalist).

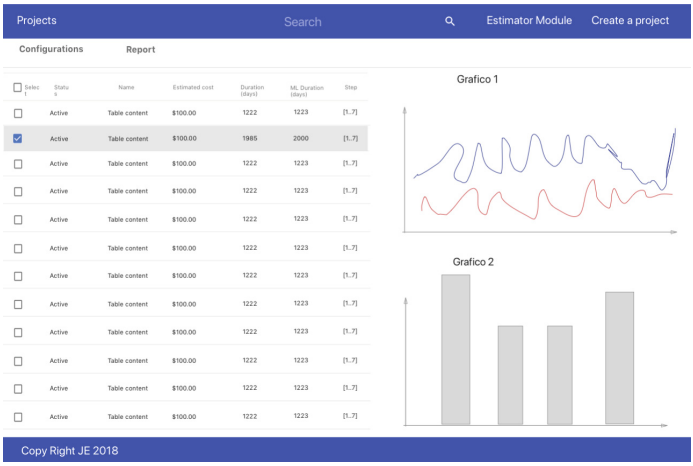


Fig. 15. Report for regression models

15. Dialog of alerts for the platform

Description: Alert dialog when deleting a project is shown in Fig. 16.
Requirements: None
Usability guidelines:

- Principle 4. There is consistency of color and structure standards.
- Principle 5. When you delete a project, the alert is displayed.
- Principle 9. Dialogs should be available to show the reason for an error (diagnosis) through a function that handles exceptions (recognition) and allow the user to take corrective actions.

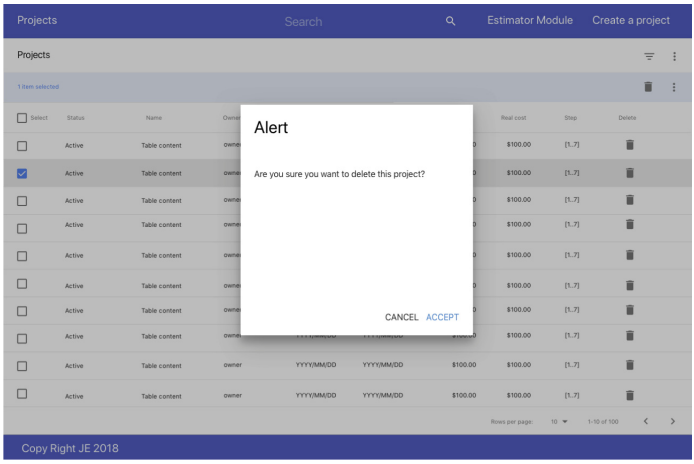


Fig. 16. Dialog of alerts for the platform

5 Conclusions

The first phase 'Analysis' allowed to transform the phases of the PM4R methodology into requirements for its subsequent implementation. In the second phase 'Design', it was possible to obtain the mockups that represent a visualization closer to the final software. Likewise, the design obtained is linked to the requirements established at the beginning to guarantee their consistency, this means that there are no contradictions.

Finally, the first two stages of the traditional methodology with a revision of the Nielsen usability guidelines allowed to establish the elements of the graphical interface easily endorsed in its 10 principles, with which a user-friendly software was obtained in the management of projects.

6 Future Works

Although this paper focuses on the first two stages of Software development and its integration with Nielsen's usability guidelines, it would be appropriate to add, as an additional step, the experts review to the traditional methodology at the end of the development stage, to evaluate possibilities of software improvement.

Additionally, it is possible to deepen in the form in which Machine Learning results are presented, since in this paper we sought to apply generalizable concepts; however, before the imminent impact that this could have, it must have a differentiated analysis.

Finally, and as previously mentioned in the case study, this paper is part of a thesis and as such, future work is related to increasing the range of algorithms, integration of more Machine Learning concepts to strengthen certain project management activities, among others. These can be reviewed in the thesis in question.

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