Applying Checklist and Design Patterns for Evaluating and Redesigning a Dashboard Interface of a Decision Support Information System

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Abstract: Well-designed dashboards synthesize complex data, allowing users to quickly identify trends and patterns. To achieve their goals, these dashboards should be easy to use, improving the users' ability to understand, interact with, and derive insights from the presented data. This paper highlights the importance of dashboards in supporting decision-making, emphasizing the crucial role of UX and usability in the effectiveness of these systems. The main goal of the paper is to propose quality attributes related to usability and user experience that can be incorporated during the development process of dashboards. Following a literature review on the quality attributes of dashboards, a checklist was developed to evaluate the usability aspects of these systems. The checklist facilitates the structured and easy identification of usability issues, even by inexperienced users, while being a robust evaluation tool built on validated quality attributes from prior literature. Also, an aggregated set of Design Patterns was identified and paired with the verification items of the checklist. Both the inspection checklist and the design patterns were applied for the evaluation and redesign of Dashboards proposed within an information system for Decision Making purposes at the Equatorial Energia Multinational Power Company. The results from this experience suggests the feasibility of considering these quality attributes for improving the ease of use of Dashboards.

1 INTRODUCTION

Dashboards are visual representations of data, typically in the form of graphs, tables, gauges, and other graphical elements, that provide summarized, real-time information about the performance of a system, process, project, or organization (Cahyadi and Prananto, 2015). The importance of dashboards lies in the fact that they simplify the interpretation and communication of complex data, allowing people to easily understand essential information and identify relevant trends, patterns, or anomalies (Costa, 2018).

The use of dashboards has grown significantly in recent years (Praharaj et al., 2022), as companies, colleges, and government agencies recognize the importance of data and visual information for decision-making and tracking the performance of their operations (Vázquez-Ingelmo et al., 2019). However, it is equally important to establish ease of use, or usability, of these dashboards (Richter Lagha et al., 2020). According to (Enache, 2021), usability is a crucial factor in the use of dashboards, as it directly affects

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users' ability to understand, interact with, and derive insights from the presented data. Therefore, dashboards should be clear, simple, and present information concisely (Bach et al., 2022). Usability is considered an indicator of a system's efficiency and effectiveness, assessing its ease of use and the user's ability to successfully complete tasks (Best and Smyth, 2011). User experience, on the other hand, encompasses all aspects related to people's interaction with a product, including the user's perception of how they feel when using it, their understanding of how the system works, and the product's suitability for the context in which it is used (Maia et al., 2020).

Although there are related works on the development of dashboards and User Experience (UX), the number of methods specifically focused on evaluating user experience (Almasi et al., 2023) and usability is still low (Silva et al., 2018). Both usability and UX are considered key factors for the success of a system (Hassan and Galal-Edeen, 2017). However, it is noticeable that there is still a lack of technologies that support dashboard design, integrating the concepts of usability and UX, and that have been applied for validation and evaluation.

This paper aims to contribute to the process evaluating and redesigning dashboards, proposing a more appropriate interface that can help improve the quality of these tools from the perspective of end users. The idea is to offer a set of artifacts that contribute to the development of dashboard interfaces. Initially, we propose the creation of a checklist, which will support and guide developers in evaluating dashboards, ensuring that usability and user experience guidelines are being met. Then, we suggest applying design patterns to help meet the quality attributes regarding usability and UX, by providing solutions and examples. Doing so, we intend to reduce rework and avoiding potential ambiguities in identifying system errors and solutions.

The remainder of the paper is organized as follows. Section 2 presents a review of related works in this area. Section 3 identifies attributes from a literature review and proposes a checklist for evaluating dashboards. Section 4 presents the project context in which the checklist was applied, while also presenting suggestions for correcting the identified problems. Section 5 concludes the paper and outlines future perspectives for this research.

2 RELATED WORK

There is a growing concern in designing high-quality systems that present information effectively and objectively to users (Praharaj et al., 2022). In this context, several studies have highlighted the development of information systems and dashboards aimed at supporting decision-making processes, while focusing on their ease of use (Almasi et al., 2023) (Maceli and Yu, 2020) (Smuts et al., 2015). Below, we present some of these studies and their contribution to the field.

In their research, Almasi et al. (2023) reviewed existing questionnaires used to assess the usability of dashboards and suggested some criteria for this evaluation. The criteria include utility, operability, ease of learning, customized questionnaire, improved situational awareness, user satisfaction, user interface, content, and system capabilities. The authors emphasize that when selecting criteria to evaluate the usability of dashboards, it is essential to consider the study's objectives, the characteristics and capabilities of the panels, and the context of use.

The research by Enache (2021) involved the design and analysis of a dashboard for runners, with the goal of preventing injuries. The evaluation of users of the interactive running dashboard was conducted using the SUS (System Usability Scale) to measure the score and develop a dashboard.

In another study by Maceli et al. (2020), the authors aimed at exploring the design and evaluation of the dashboard through usability testing and heuristic evaluation of an open-source data dashboard interface for archivists. An heuristic evaluation of the environmental monitoring dashboard was conducted, evaluating the interface against Nielsen's ten usability heuristics.

Similarly, Smuts et al. (2015) aimed to investigate the usability of Business Intelligence (BI) tools that support the development of dashboards, with a specific focus on novice users. The main research problem addressed in this paper is the complexity in the development process of dashboards in traditional BI tools.

Sarikaya et al. (2018) aimed at discovering and identifying different types of dashboard designs. To achieve this, they conducted a multidisciplinary literature review to understand practices surrounding the use of dashboards. The review allowed them to build a characterization of the uses and domains of dashboards and identify issues that the literature considers urgent. Later, Bach et al. (2022) described the process of creating design patterns for dashboards, which involved a systematic literature review on dashboards and data visualization. A total of 144 dashboards were collected considering an initial selection of 83 dashboards gathered by (Sarikaya et al., 2018). The authors provided insights into the design of dashboards, offering applicable design knowledge

that could inform and inspire the creation of future dashboards and creation tools.

The analysis of related works on dashboard evaluation, reviews, and design patterns reveals gaps in terms of the robustness and comprehensiveness of the approaches employed. Although these studies often address aspects of usability and user experience, most works rely predominantly on Nielsen's Heuristics, and the System Usability Scale (SUS). While these approaches are widely used, they may overlook specific and relevant quality attributes.

Regarding works that deal with design patterns, in general, these studies do not present a structure that encompasses necessary elements for defining interface design patterns, as highlighted by (Vora, 2009): the identified problem, the proposed solution, and the detailed explanation of how to implement the problem. Instead, such approaches tend to describe only recurring aspects observed in the analyzed dashboards, restricting themselves to the solution dimension.

In response to this gaps, this paper proposes to gather and integrate various quality attributes, organizing them into a consolidated list and transforming them into items for a checklist. This checklist has been applied to evaluate a system from an energy company, focusing on decision-making related to irregularities among its customers. Also, regarding design patterns for dashboards' user interfaces, this paper does not aim to propose new design patterns, but employ the design patterns already available in the literature, integrating them with the identified quality attributes. This integration will ensure that certain items of the checklist are associated with existing patterns, providing a solid foundation for the suggested improvements. Therefore, in this paper we intend to not only enhance the evaluation of dashboards but also to provide guidance for implementing more effective and consistent solutions, to the identified problems.

In the next sections, we present how we developed the checklist that encompasses both usability and user experience in the evaluation of dashboards. Furthermore, we show how we integrated this checklist with design patterns found in the literature.

3 RESEARCH METHODOLOGY

3.1 Developing Evaluation and Design Artifacts

To develop and artifact that provides verification items and also suggestions for the correction of the identified problems, we followed the following research methodology:

1. **Identification of quality attributes for dashboards**, carried out through an informal exploratory review of the literature;
2. **Systematic mapping of the literature**, aimed at identifying design patterns related to usability and user experience (UX) in dashboards;
3. **Analysis of attributes and development of the inspection checklist**, culminating in the presentation of the integrated artifact; and
4. **Application of the artifact** in the development of dashboards from an information system.

The three following subsections describe the stages for proposing the artifacts in detail, while the application of the artifact will be described in Section 4.2.

3.2 Exploratory Analysis of Usability Attributes in Dashboards

The development process of the proposed checklist began with a literature review aimed at identifying relevant studies addressing important quality in the development and creation of a dashboard. To conduct this review, search criteria were defined, such as searching for papers published in the last 10 years in English. Papers that did not meet these criteria, as well as duplicated ones or those unavailable for paid access, were excluded, using an automated search strategy in digital libraries.

The search terms used included keywords such as "Control Panel" or "Dashboard", "Design Patterns", "Quality Attributes", "User Experience", "User Interface", "Usability". Several libraries and search tools were used, including IEEE, Scopus, ACM Digital Library, SpringerLink, and Google Scholar. After the initial selection of papers, the inclusion of each was assessed based on the title and abstract. When it was not possible to make a decision based on this information, the paper was included for full reading. In this second selection process, the paper was considered if it described quality attributes related to usability or user experience in dashboards, and if it met the previously established criteria. A total of 10 papers were selected, which reported relevant quality attributes for dashboard development: A001 - (Maceli and Yu, 2020); A002 - (Almasi et al., 2023); A003 - (Smuts et al., 2015); A004 - (Enache, 2021); A005 - (Raza et al., 2019); A006 - (Shakeel et al., 2022); A007 - (Rahman et al., 2016); A008 - (Bera, 2016); A009 - (Silva-Rodríguez et al., 2022); and A010 - (Peters et al., 2019).

Initially, 165 attributes were identified. These attributes were listed into a document. If an attribute was similar among others, these were grouped and then transformed into a single attribute, in the form of a requirement that should be evaluated in the dashboard (e.g. a verification item). These requirements would then form the checklist when aggregated. For example, the verification item FU_I17 ("The dashboard should include data dimension selection and visualization, offering flexibility to users with options for drilling down, searching, and customizing layouts.") was formed by three quality attributes found in papers from the review:

1. (A005_A17) It is easy to find the necessary information on the dashboard;
2. (A004_A6) Recognition rather than recall: Information, options, and actions should be visible or easily retrievable, reducing the user's need to memorize or recall specific details;
3. (A008_A16) The dashboard has intuitive interfaces and menus for easy use. Does the dashboard have intuitive interfaces and menus, making it easy to find the necessary information?.

During the grouping process, we ensured that the most comprehensive attribute was selected and/or complemented with details from the other attributes. After grouping the similar identified attributes, we identified 54 distinct ones. These attributes were organized into several categories, covering crucial aspects for dashboards evaluation. The categories include Task Adequacy (TA), Learning (LE), System Capabilities (SC), Content (CT), Error Control and Utility (EC), Aesthetic and Minimalist Design (AM), Ease of Use (EU), Flexibility (FL), User Interface (UI), Improvement of Situational Awareness (IS), Operability (OP), Goal Orientation GO, Satisfaction (SA), Page Navigation (PN), Utility (UT), Visibility (VI) and Notes and Highlights (NH). This categorization was drawn from the identified papers, providing a comprehensive view of the essential requirements identified in the context of the analysis.

Table 1 presents a selection of the first 5 (five) requirements extracted from the papers. The complete Table 1, with the 54 requirements from the first review, can be consulted in another Report[1], which also shows the relationship between the requirements and the papers in which they were found.

[1]To access the full Table 1, click here.

3.3 Design Patterns for Usability and UX in Dashboards

Based on the first literature review, the presence of design patterns that offer practical enhancement was identified. These patterns demonstrate how specific elements can be implemented, presenting contextualized examples for implementing usability and UX requirements. Thus, a Systematic Mapping Study was conducted with the aim of identifying works that presented design patterns capable of enhancing usability, and user experience in dashboards. We carried out this literature review using the suggestions by Kitchenham (2004). In this section, the planning and execution of the review, providing all the necessary information to understand the subsequent results.

In accordance with the guidelines by Kitchenham (2004), the protocol will describe the main research question and its secondary questions, the search terms used to uncover the state of the art, the sources for searching papers, and the applied selection criteria. The goal of this review is to examine the current state of the art in dashboard development, focusing on improving usability and UX. As a result, this review aimed at answering the following research question:

- **RQ** - *"What are the existing design patterns that consider user experience and usability in the development of dashboards?"*

After formulating the central research question, we developed a search string that allowed the identification of relevant scientific publications to answer these questions. The search string would be applied to identifying studies that address attributes

Table 1: Requirements and Base Papers of Origin.

ID	Requirements
UT_I01	The dashboard should identify goals that provide specific information, making task execution more effective.
TA_I02	The dashboard should help achieve goals and complete tasks.
UT_I03	The dashboard should improve performance by providing greater control over activities.
UT_I04	The dashboard should allow tasks that would normally take more time to be completed faster when used.
UT_I05	The dashboard should provide more sophisticated metrics and representations to express the nuances of solving complex problems.

related to usability and user experience in dashboards. To achieve this goal, synonyms and key terms were extracted from the analyses conducted by (de Cássio Lemes et al., 2023), (Gomes et al., 2021), (Guerino and Valentim, 2020), and (Cabrejos et al., 2018). Additionally, tests were conducted to validate the String in relation to the main research question, ensuring its effectiveness in retrieving the greatest possible number of relevant publications for this literature review. As a result, Table 3 presents the selected keywords along with their respective synonyms.

Table 2: Terms applied to the construction of the Search String.

Keywords	**Synonyms**
Design Patterns	”Design Patterns” OR ”Design Templates”
Dashboard	”Data Panel” OR ”Indicators Panel”
Usability; User Experience and User Interface	”UX” OR ”UI”

Based on the search terms, the resulting search string was: ((”Dashboard” OR ”Data Panel” OR ”Indicators Panel”) AND (”Design Patterns” OR ”Design Templates”) AND (”User eXperience” OR ”User Interface” OR ”Usability” OR ”UX” OR ”UI”)). This String was executed in the Scopus Digital Library database.

The publications analyzed were extracted from the *Scopus Digital Library*, chosen for being a broad and reliable scientific database, recognized as one of the largest sources of abstracts and citations of peer-reviewed literature in the fields of technology and science, as highlighted by (Codina, 2005). *Scopus* also stands out for indexing publications from other major libraries such as *ACM Digital Library*, *Springer Link Digital Library*, *Science Direct Digital Library*, and *IEEE Xplore Digital Library*.

The analyzed studies in this literature review correspond to publications submitted to peer review and published in scientific journals or events. To ensure the selection of the most relevant publications to answer the research question of this review, specific inclusion and exclusion criteria were established. It is important to highlight that for a publication to be accepted, all inclusion criteria must be met. On the other hand, if any of the exclusion criteria were met, the publication was automatically discarded.

Therefore, the Inclusion Criteria (IC) defined were:

- **IC1**: The publication describes design patterns for usability and UX in dashboards;

The Exclusion Criteria (EC) were:

- **EC1** - The publication does not address design patterns for usability and UX in dashboards;
- **EC2** - The publication is not written in English;
- **EC3** - The publication is not available for reading, downloading, and data collection;
- **EC4** - The publication is not a scientific paper, but rather an abstract, or incomplete text, or not a peer reviewed paper;
- **EC5** - The publication is duplicated.

In order to optimize the execution of the review, a data extraction form was created, as presented in Table 3, which assisted in conducting and organizing the selection of relevant papers for the research. The form fields and their respective descriptions were defined based on the guidelines recommended by Kitchenham and Charters (2007). This form allowed for a structured analysis of the information extracted from the publications, which was considered in the final results of the review[1].

Table 3: Attribute Extraction Form.

Publication ID:	A001
Full Reference of the Publication:	
What are the design patterns?	The design patterns identified in the publication were
Design patterns in their respective categories:	Detail the categories mentioned in the publication
What is the theoretical foundation of the proposed design patterns?	Explain the theoretical or conceptual basis used in the publication to propose the standards

The research was conducted using the string that was defined in the search mechanisms of the Scopus digital library, from August to December 2024. The execution of the String resulted in 209 publications. In the first filter, titles and abstracts were analyzed to discard publications that were not related to the research question of the review. This process resulted in 69 publications that passed to the second filter, where they were read in full and evaluated according to the established inclusion and exclusion criteria. As a result, 3 publications were considered suitable for extracting the necessary information. Table 4 summarizes the results after each applied filter.

[1]Data Extraction Form:(click here)

Table 4: Summary of the number of analyzed papers.

Library	Total	Filter 1	Filter 2
Scopus	209	69	3

The papers that presented design patterns in this review were: A001 - (Bach et al., 2022), A002 - (Rossi and Lenzini, 2020), and A003 - (Sarikaya et al., 2018). However, only the study by (Rossi and Lenzini, 2020) structured its design suggestions based on the work of (Haapio and Passera, 2017). To develop the documentation of the patterns, basic elements were used with the same items suggested by (Vora, 2009), resulting in patterns that include the following components: (a) Code: Identification code of the pattern, categorized according to its application; (b) Pattern Name: A short title that describes the main objective of the pattern; (c) Problem: A brief definition of the problem that the pattern aims to solve; (d) Solution: A proposal based on the identified quality attributes; (e) How: Detailed instructions for best practices and possible variations; (f) Example: An image or representation illustrating the application of the pattern in real interfaces.

By analyzing the selected papers, we identified that the study by Bach et al. (2022) highlighted how certain design items appeared more frequently in analyzed dashboards, providing a complementary website with suggestions organized by categories to assist in dashboard development. On the other hand, the study by Sarikaya et al. (2018) conducted a multi-domain review, analyzing 83 dashboards, and offered insights into how certain elements are implemented, contributing to the improvement of patterns. For instance, Figure 1 presents a pattern described by Bach et al. (2022). The author provides an explanation and examples of how this pattern is implemented in practice, highlighting its application in dashboard design.

In Figure 2, we provide an example of the design pattern proposed by Rossi et al. (2020). In this pattern, the authors discuss that Effective FAQs provide clear, concise answers tailored to the audience, addressing common questions logically and accessibly. They complement, but do not replace, direct contact or detailed documents. FAQs are ideal for explaining processes (e.g., data protection) and offering simple instructions (e.g., account deletion).

Finally, Figure 3 illustrates a pattern identified in the study by Sarikaya et al. (2018). In this pattern, the authors indicate that Dashboards use benchmarks, like gauges, arrows, status lights, or labels, to show when thresholds are met or exceeded. These visual cues help users quickly assess data against performance targets. The attributes that were extracted from the three selected papers can be found in the Footnote[2].

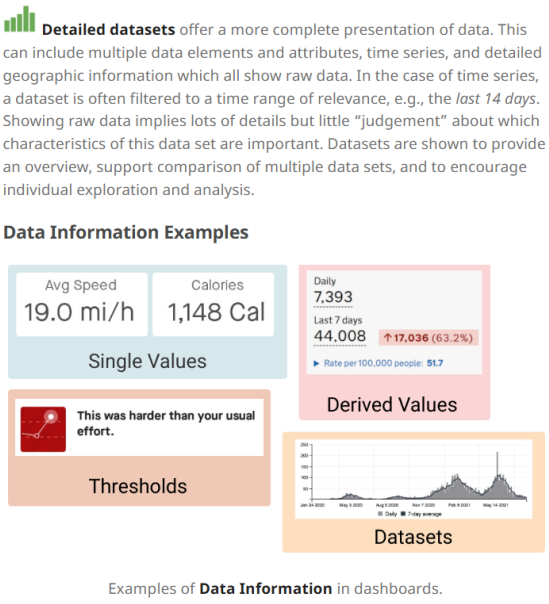

Figure 1: Design Pattern presented by (Bach et al., 2022).

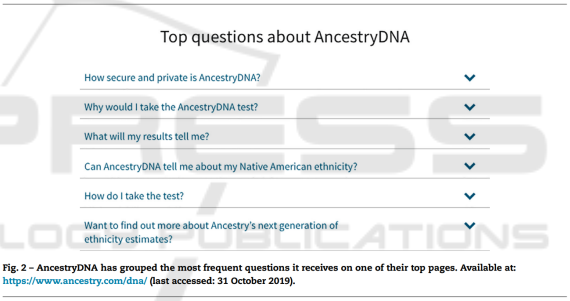

Figure 2: Design Pattern presented by (Rossi and Lenzini, 2020).

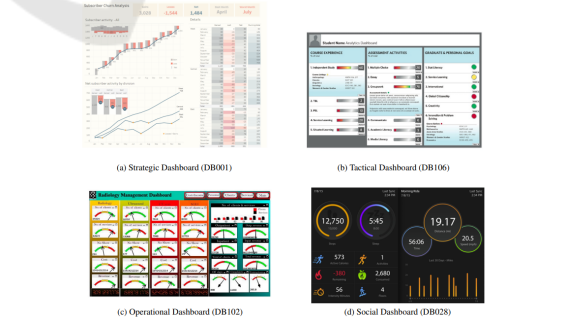

Figure 3: Design Pattern presented by (Sarikaya et al., 2018).

[2]Design Patterns extracted from the selected papers. (click here)

Each selected publication presented a different study, with its own set of design patterns and different types of methodologies to support the work. Table 5 shows the theoretical foundation used by each paper for creating its patterns.

Table 5: Data Extraction Form.

ID	Theoretical Foundation
A001	The paper was based on a systematic analysis of examples and documentation on the use of dashboards. Additionally, it utilized a literature review on the use of dashboards to construct a design space, identify the main types of dashboards, and characterize their design goals, levels of interaction, and associated practices.
A002	The theoretical foundation was based on the work of (Haapio and Passera, 2017), which explores fundamental changes in the world of contracts, including the impact of technology.
A003	This paper presents a multi-domain literature review on dashboard practices, analyzing examples and related documentation. It defines a design space characterizing dashboards by design goals, interaction levels, and associated practices.

Regarding the categorization of the patterns, only one study described categories for the proposed design patterns (Bach et al., 2022). Bach et al. (2022) presented the following categories for its patterns: Data Information Patterns, Meta Information Patterns, Visual Representation Patterns, Page Layout Patterns, Screenspace Patterns, Structure Patterns, Interaction Patterns, and Color Patterns. These categories will be used as the basis for proposing the checklist in Section 3.4

3.4 Analysis of Attributes and Development of the Inspection Checklist

Based on the literature reviews, which addressed both the attributes and design standards, the development of an inspection *checklist* was proposed to assess and identify defects in dashboards in decision-support information systems. To this end, the following steps were considered:

1. Identification of quality attributes for dashboards related to Usability and User Experience (*User Experience*), based on scientific literature, as described in Section 3.2. In this step, we decided to integrate the design standards found in the literature into the attributes, allowing each checklist item to present not only an inspection criterion but also examples of improvements and practical implementation guidelines.
2. Conducting a detailed analysis of the quality attributes, grouping similar attributes, transforming them into system requirements, and organizing all identified items into an inspection *checklist*.

The steps for the development of the *checklist* were based on the methodology used by Frazão et al. (2021)(Frazão et al., 2021), who also developed a checklist based on a literature review. Table 6 contains the items of the inspection checklist. The table also indicates the origin of each item, as follows: (R1) an attribute that was described in Subsection 3.2; and (R2) An attribute that was described in a Design Pattern and may also contain an example of how to implement it if this was described within the design pattern.

4 APLICATION

4.1 Project Context

The irregular consumption of electricity, often associated with areas without formal contracts with distributors, represents a significant challenge for the energy sector. These areas, although connected to the electrical grid, operate unofficially, resulting in considerable financial losses for companies, as well as potential health and safety risks for users. These installations, often outside the required technical standards, are more susceptible to failures and accidents, creating negative operational and social impacts.

The electric sector, essential for the operation of public and private services, faces the urgent need to address problems that affect the quality and sustainability of energy supply. Identifying and regularizing unmapped areas represents one of the greatest challenges, as these practices compromise operational efficiency, increase costs, and elevate risks associated with supply. To address these challenges, a prioritization system is being developed to support companies in regularizing areas with non-formalized access to the electrical grid. The solution combines technical and financial data analysis to generate a prioritized list of areas to be regularized, using criteria such as cost, financial return potential, and strategic factors. The main goal of the information system is to provide decision-making support, allowing a structured

Table 6: Proposed Checklist for Evaluating the Usability and UX of Dashboards Design.

ID	Questions	R1	R2	Yes	No	Does Not Apply
AD_I01	Does the dashboard allow users to highlight and annotate specific visualizations, with persistent changes?	X	X		X	
AP_I01	Is the dashboard easy to learn?	X		X		
AP_I02	Do users learn how to use the dashboard quickly?	X		X		
AP_I03	Does the dashboard provide clear and accessible help documentation, but is intuitive enough to be used without much dependence on it?	X	X	X		
AP_I04	Is the dashboard understandable and does it use language, concepts, and conventions familiar to the users?	X	X		X	
AT_I01	Does the dashboard help achieve goals and complete tasks?	X		X		
AT_I02	Does the dashboard support the daily activities of users?	X		X		
AT_I03	Does the dashboard content fit perfectly on the screen, without the need for unnecessary scrolling or tooltips?	X	X		X	
AT_I04	Are the dashboard functions displayed in an organized and clean manner?	X		X		
AT_I05	Does the dashboard allow configuration of report output display according to user tasks?	X		X		
CE_I01	Does the dashboard recommend graphs that are most useful for visualizing specific data?	X			X	
CE_I02	Does the dashboard provide explanations about the types of graphs?	X			X	
CE_I03	Does the dashboard offer effective assistance to connect to data sources, including support for SQLview, facilitating integration?	X			X	
CS_I01	Does the dashboard undergo regular updates, resulting in automatic data updates?	X	X			X
CS_I02	Does the dashboard have all the functions and features expected by users?	X			X	
CS_I03	Does the dashboard respond to requests at an adequate speed?	X		X		
CS_I04	Does the dashboard integrate its functions in a cohesive and effective manner?	X		X		
CS_I05	Does the dashboard have its functions well-integrated?	X		X		
CT_I01	Does the dashboard limit the amount of information provided to avoid overload?	X		X		
CT_I02	Does the dashboard present an appropriate amount of information, focusing on meaningful data and clear metrics?	X	X	X		
CT_I03	Does the dashboard ensure the quality of the information, including metadata and accountability?	X	X	X		
DM_I01	Does the dashboard avoid unnecessary elements or information that could confuse or overwhelm users?	X		X		
FL_I01	Does the dashboard adequately represent variability?	X			X	
FL_I02	Does the dashboard allow users to reset and reconfigure displayed information based on their preferences and task needs?	X	X		X	
FL_I03	Is the dashboard easy to customize and manipulate its appearance?	X			X	
FU_I01	Is the dashboard easy to use for task execution, with helpful explanations of its features?	X	X	X		
FU_I02	Is the dashboard so easy to use that it doesn't require external help or guidance?	X			X	
FU_I03	Does the dashboard have intuitive interfaces and menus, making it easy to find the necessary information?	X		X		
FU_I04	Does the dashboard adequately represent complexity?	X			X	
IU_I01	Does the dashboard use pre-attentive attributes like shape, color, spatial position, and movement appropriately?	X	X	X		
IU_I02	Does the dashboard support different types of data visualization, such as histograms, pie charts, bar graphs, maps, etc.?	X	X		X	
IU_I03	Does the dashboard provide interaction with visualizations, such as zoom, filters, details on demand, drill-up, and drill-down?	X	X		X	
MC_I01	Does the dashboard support excitement?	X			X	
MC_I02	Does the dashboard support concentration?	X			X	
MC_I03	Does the dashboard support available mental capacity?	X			X	
MC_I04	Does the dashboard support attention division?	X			X	
NP_I01	Does the multi-tab dashboard allow users to switch between pages related to different aspects of decision-making or providing necessary context?	X	X		X	
OO_I01	Does the dashboard help users understand the relationships between parts of the data, providing benchmarks for when limits are exceeded?	X	X		X	
OP_I01	Does the dashboard display data details according to a hierarchical structure, allowing access to different levels of granularity as needed?	X	X		X	
OP_I02	Does the dashboard include selection and visualization of data dimensions, offering options for drilling down, searching, and customizing the layout?	X	X		X	
OP_I03	Does the dashboard present data accessible at different levels of aggregation, with filters and a hierarchical map for granularity?	X	X		X	
OP_I04	When errors occur, does the dashboard provide clear and constructive error messages with guidance for recovery?	X			X	
OP_I05	Does the dashboard allow users to undo actions or exit undesirable states simply, providing continuous control?	X		X		
OP_I06	Does the dashboard follow consistent conventions and standards?	X		X		
OP_I07	Does the dashboard allow writing back to the underlying database or control external elements in the real world?		X		X	
OP_I08	Does the dashboard identify anomalies and call attention to them with alert features?		X		X	
SA_I01	Is the dashboard satisfying to use?	X		X		
SA_I02	Is the dashboard comfortable to use?	X		X		
SA_I03	Is the dashboard interface satisfying?	X		X		
SA_I04	Are the dashboard features and capabilities satisfactory?	X		X		
UT_I01	Does the dashboard identify goals that present specific information, making task execution more effective?	X	X		X	
UT_I02	Does the dashboard improve work performance by providing greater control over activities?	X		X		
UT_I03	Does the dashboard allow tasks that would take longer to be executed more quickly and easily when used?	X		X		
UT_I04	Does the dashboard provide sophisticated metrics and representations to express the nuances of solving complex problems?	X			X	
UT_I05	Does the dashboard adequately represent instability?	X			X	
VI_I01	Does the dashboard provide adequate feedback on actions within a reasonable time?	X		X		

and efficient approach to address the issue.

The system also integrates advanced features for visualization and management reporting, allowing operational teams to quickly identify high-impact areas and plan corrective actions based on concrete data. Figure 4 shows the version of the system in which the inspection checklist was applied. Details of the application and the results obtained will be discussed in Section 4.2.

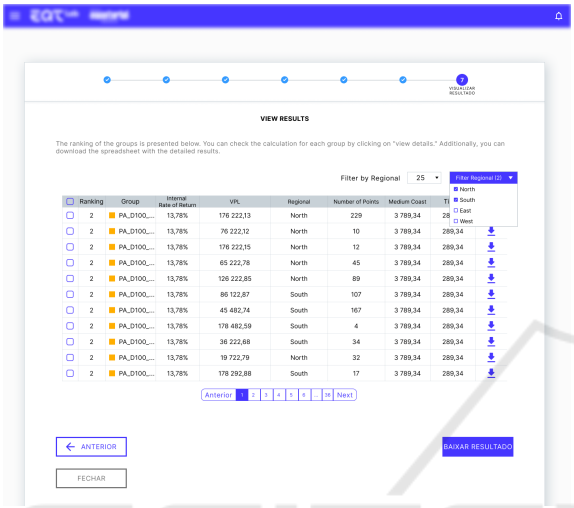

Figure 4: Prioritization system for decision-making support.

4.2 Checklist Application

To evaluate the prioritization system for decision-making support, an analysis was conducted using the proposed checklist composed of 56 items. The evaluation was carried out by two software engineering specialists, each with more than 5 years of experience in the field. After the individual analysis, the results were discussed jointly to reach a consensus on the evaluation. The process consisted of verifying whether each verification item was fully met by the system, with the results recorded in Table 6 (columns Yes, No, Does not Apply), presented above.

The dashboard achieved a total of 47.27% completeness of the evaluated standards, with 26 items met, 29 items not met, and 1 item classified as ”Does Not Apply.” Despite having some implemented features, there are critical gaps that directly impact the user experience and satisfaction. For example, the item OP_I03 (”Does the dashboard present data accessible at different levels of aggregation, with filters and a hierarchical map for granularity?”) was not met, which hinders detailed analysis of information and limits the users’ ability to explore data in depth. Additionally, the item OP_I04 (”When errors occur, does the dashboard provide clear and constructive error messages with guidance for recovery?”) was also not implemented, which compromises usability and increases user frustration when dealing with system failures. Finally, the item IU_I02 (”Does the dashboard support different types of data visualization, such as histograms, pie charts, bar graphs, maps, etc.?”) was another unmet aspect, reducing the flexibility and effectiveness of the dashboard in presenting information intuitively. The absence of these essential attributes negatively impacts the usability and efficiency of the dashboard, highlighting the need for improvements to meet user expectations.

However, several items presented associated design standards that were not met, including: AD_I01, AP_I04, AT_I03, CE_I01, CE_I02, CE_I03, CS_I01, CS_I02, FL_I01, FL_I02, FL_I03, FU_I02, FU_I04, IU_I02, IU_I03, MC_I01, MC_I02, MC_I03, MC_I04, NP_I01, OO_I01, OP_I01, OP_I02, OP_I03, UT_I01, UT_I04, UT_I05. To improve the dashboard, a refinement process was carried out, including specific improvement suggestions for each unmet item, based on the related design standards. The goal of this process is to provide a more efficient, intuitive, and satisfying experience for users. A detailed description of the actions taken, as well as the results achieved, will be presented in the next subsection.

4.3 Interface Refinement

After identifying the unmet checklist items, the inspectors proposed a new interface that would incorporate the implementation of these items. This process was guided by the design patterns found during the second literature review, which included design suggestions and examples that directed the proposed improvements. The proposed new interface was designed considering attributes such as granularity, information hierarchy, visual representations of tabular data, data manipulation, and data customization. One example of this is item ”UT_01 - Does the dashboard identify targets that present specific information, making task execution more effective?”, which highlights the absence of specific metrics to achieve the system’s overall goal, which aims to identify the areas most likely to require intervention by the electric utility company. In response to this problem, several changes were proposed, such as adding targets related to the average ticket, the average cost of works in the identified areas, and the desired return rate, in order to provide greater clarity on which objectives should be achieved, as shown in Figure 5.

Figure 5 illustrates a structure that effectively meets the requirements of item OP_I07, providing ef-

ficient search and filtering functionality. Item AP_I04 is addressed by using clear and accessible language, complemented by the strategic use of icons that facilitate the identification of actions to be taken. Regarding item AT_I03, the structure is appropriately sized, allowing all necessary content for visualization to be displayed in an organized manner on the screen without the need for scrolling. Additionally, the presence of multiple tabs and flexibility in presenting data in different forms and charts robustly addresses item NP_I01.

Figure 6 demonstrates compliance with several items, starting with OP_I01, which ensures detailed data display. According to OP_I03, data is accessible at different levels of aggregation, supported by filters and a hierarchical map that allows adjustment of the granularity of the visualization. This level of interactivity is complemented by compliance with item IU_I02, as the dashboard offers different types of visualizations, including pie charts, bar graphs, and maps, providing a comprehensive data analysis. Regarding item IU_I03, the dashboard allows interaction with visualizations, enabling filtering and on-demand display of details when clicking on specific parts of the chart. Furthermore, the ability to edit goals, as required by item AD_I01, is incorporated into the interface, allowing the user to adjust parameters as needed. The dashboard also offers a compact data view, presenting rankings and comparisons with defined goals, in accordance with item OO_I01. The goal editing functionality, in turn, addresses item FL_I02. However, OP_I07 is only partially met, as, although it allows the user to change goals and objectives, exposing

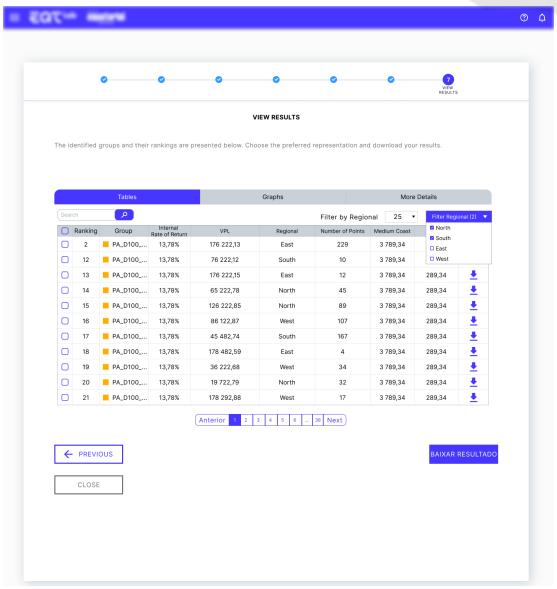

Figure 5: Improvements in the Design of the Information System - Screen 1.

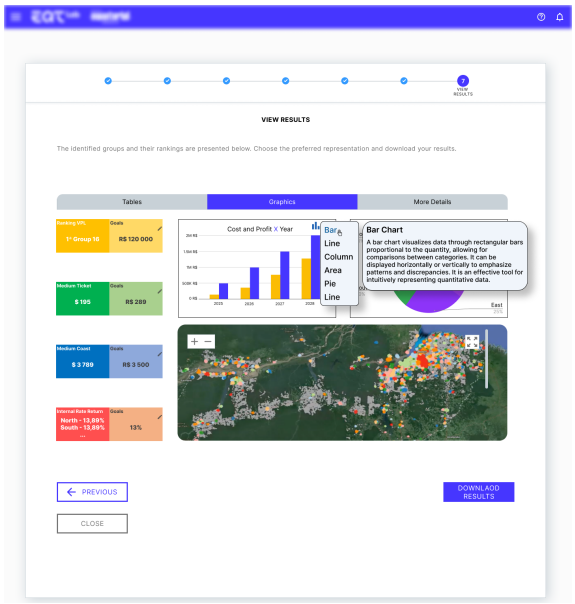

Figure 6: Improvements in the Design of the Information System - Screen 2.

this sensitive data to be edited by any user could compromise the integrity of the information. This vulnerability prevents full compliance with this requirement.

Figure 7 reflects compliance with item OP_I08, which refers to anomaly identification and the use of alert resources. As shown in the figure, the dashboard incorporates an alert system through notifications, drawing the user's attention to any inconsistencies or irregularities detected in the data.

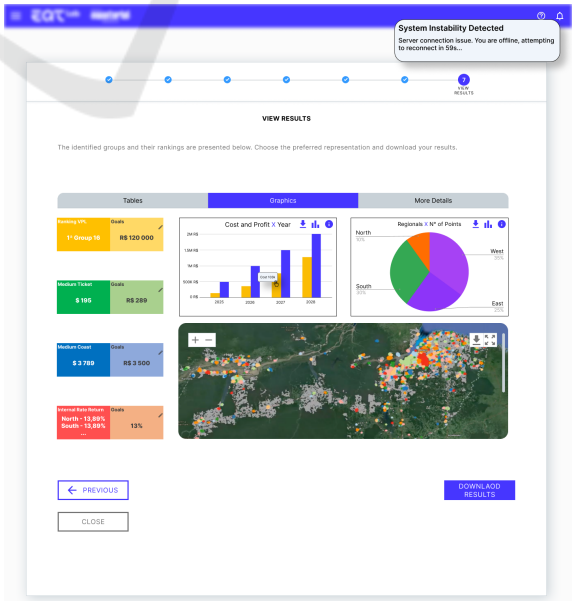

Figure 7: Improvements in the Design of the Information System - Screen 3.

5 CONCLUSIONS AND FUTURE PERSPECTIVES

Developing interfaces for dashboards is a significant challenge for software professionals, especially when it comes to educational monitoring. This work presented a checklist for presenting inspection items but also providing examples of how these items can be implemented, especially in cases where a design pattern is associated. The artifact was derived from a thorough analysis of quality attributes extracted from research that highlights the relevance of usability and user experience in this context.

This effort resulted in a comprehensive guide, with examples that offer valuable insights into common challenges, recommended solutions, and best practices to be followed in the development process of decision-support dashboards. The implementation of well-structured standards, guided by the users' needs, plays a crucial role in ensuring the dashboard's quality, improving the user experience, and increasing its market acceptance. Furthermore, we showed how to apply this standards in the evaluation and redesign of the dashboards of a real decision making information system for a multinational power company. We were able to make improvement suggestions in the design of the system, which will be ultimately evaluated by the clients of the information system.

As future work, we intend to evaluate to what extent the redesign version improved the usability and user experience of the evaluated information system. Also, we intend to apply this new interface to the system under development, assisting developers in building more robust versions of data visualization, aligned with UX and usability principles. Additionally, a more in-depth literature review on decision-support dashboards will be conducted to strengthen the list of standards and meet a broader range of requirements. New standards will also be proposed, based on users' perspectives in real-world use scenarios, complementing the existing examples.

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