

MGI

Master Degree Program in
Information Management

Evaluating and Improving Best European Customer Experience Dashboards for Better Decision-Making

João Pedro Lopes Oliveira

Project Work

presented as partial requirement for obtaining a Master's Degree in Information Management

NOVA Information Management School
Instituto Superior de Estatística e Gestão de Informação
Universidade Nova de Lisboa

NOVA Information Management School
Instituto Superior de Estatística e Gestão de Informação
Universidade Nova de Lisboa

Evaluating and Improving Best European Customer Experience Dashboards for Better Decision-Making

by

João Pedro Lopes Oliveira

Project Work presented as partial requirement for obtaining the Master's degree in Information
Management, with a specialization in Business Intelligence

Supervised by

Pedro Simões Coelho, PhD, NOVA Information Management School

July, 2025

Statement of Integrity

I hereby declare having conducted this academic work with integrity. I confirm that I have not used plagiarism, any form of undue use of information or falsification of results along the process leading to its elaboration. I further declare that I have fully acknowledged the Rules of Conduct and Code of Honor from the NOVA Information Management School.

Lisbon, July 15, 2025

João Pedro Lopes Oliveira

Acknowledgements

The completion of this dissertation marks the culmination of a very important stage in my academic and professional journey. Throughout this process, I was fortunate to count on the support of several people, to whom I would like to express my deepest gratitude.

First and foremost, I would like to thank my supervisor, Professor Dr. Pedro Simões Coelho, for the opportunity and guidance throughout the entire process.

To my family — my mother, father, and sister — I am grateful for all the love, patience, and unwavering support.

To my girlfriend, Joana, thank you for being my pillar and source of strength, even in the most challenging moments.

Finally, I would like to thank all those who, directly or indirectly, contributed to the completion of this work. To all of you, my sincere thanks.

Abstract

In an increasingly data-driven world, Business Intelligence (BI) tools play a pivotal role in enhancing organizational decision-making. Among these tools, dashboards are widely adopted for their ability to present complex data in a visual and intuitive format. However, their effectiveness often depends on how well they are designed and aligned with user needs. This dissertation evaluates and optimizes the dashboard used in the Best European Customer Experience (BECX) project, a national initiative that collects customer satisfaction data quarterly to support business decisions. The original dashboard presented several limitations, such as poor visual hierarchy, overloaded information, and limited interactivity, which hindered its usability. Applying Design Science Research Methodology (DSRM), the existing dashboard was critically analyzed, redesigned, and evaluated through expert feedback and a checklist of best visualization practices. The redesigned version incorporates principles of Gestalt, color theory, and UX/UI design to enhance clarity, relevance, and user experience. The results demonstrate a clear improvement in data interpretation, usability, and support for decision-making, fulfilling the goals initially outlined. This work not only contributes to the practical enhancement of the BECX dashboard but also serves as a methodological reference for future BI projects. Future research could explore usability testing with end users, mobile adaptation, and advanced features such as drill-down and visual storytelling to further strengthen the dashboard's strategic value.

Keywords

Dashboard Renovation; Design Science Research Methodology (DSRM); Business Intelligence; Data Visualization; Dashboard Design; User Interaction; Usability; Performance Metrics; Data-Driven Decision Making; Business Analytics; Dashboard Usability Evaluation; Power BI.

Table of Contents

Statement of Integrity	i
Acknowledgements.....	i
Abstract.....	ii
List of Figures	v
List of tables.....	vii
List of Abbreviations and Acronyms	viii
1. Introduction	1
2. Literature review	3
2.1. Best European Customer Experience (BECX)	3
2.2. Business Intelligence	3
2.2.1. Benefits.....	4
2.3. Dashboard.....	4
2.3.1. Types of dashboards.....	5
2.4. Data Visualization and Dashboard Building Tools.....	6
2.4.1. Power BI.....	6
2.4.2. Tableau	6
2.4.3. Google Looker Studio	7
2.4.4. Qlik Sense.....	7
2.5. Impact of Dashboards on Decision-Making	7
2.5.1. Monitoring COVID-19	7
2.5.2. Google Trends.....	8
2.5.3. Business Analysis - Walmart	9
2.6. Data Governance and BI	9
2.7. Trends in the future of dashboards	10
2.8. Effective Dashboard Design.....	11
2.8.1. Understand your audience	11
2.8.2. Tell a Story with Data.....	11
2.8.3. Effective Visualizations	12
2.8.4. Principles of Gestalt.....	14
2.8.5. Usability in Design (UX/UI)	16

2.8.6. Focus on Key Metrics	16
2.8.7. Iteration & Feedback	17
2.9. The role of the client in BI and Dashboarding	17
2.9.1. How to identify business needs	18
2.9.2. Customer Experience	18
2.9.3. Customer Satisfaction	19
3. Methodology	20
3.1. Design Science Research Methodology (DSRM)	20
3.1.1. Problem identification and motivation	21
3.1.1.1. BECX Dashboard Analysis	21
3.1.2. Defining the solution's objectives	29
3.1.2.1. Objectives	30
3.1.3. Design and development	31
3.1.4. Demonstration	33
3.1.4.1. Analysis of the Redesigned Dashboard	33
3.1.5. Evaluation	40
3.1.5.1. Specialists Evaluation	41
3.1.5.2. Quantitative Insights & Limitations	44
3.1.6. Communication	45
4. Empirical Study	46
5. Results and Discussion	47
6. Conclusions and Future Research	48
Bibliographical References	50

List of Figures

Figure 2.1 - Johns Hopkins university – Dashboard Monitoring COVID-19	8
Figure 2.2 - Google trends	8
Figure 2.3 - AI Insights – Power BI	10
Figure 2.4 - Reading Gravity	12
Figure 2.5 - Chart Suggestions – A thought Starter	13
Figure 2.6 - Use of Color in Data Visualization	14
Figure 2.7 - Example of Proximity	14
Figure 2.8 - Example of Similarity	15
Figure 2.9 - Example of Enclosure	15
Figure 2.10 - Example of Closure	15
Figure 2.11 - Example of Continuity	16
Figure 2.12 - Example of Connection	16
Figure 3.1 - Design Science Research Methodology (DSRM) Process	20
Figure 3.2 - 1st BECX Dashboard page	22
Figure 3.3 - 2nd BECX Dashboard page	23
Figure 3.4 - 3rd BECX Dashboard page (1st tab)	24
Figure 3.5 - 3rd BECX Dashboard page (2nd tab)	24
Figure 3.6 - 11th BECX Dashboard page	25
Figure 3.7 - 12th BECX Dashboard page (1st tab)	25
Figure 3.8 - 12th BECX Dashboard page (2nd tab)	26
Figure 3.9 - 13th BECX Dashboard page (2nd tab)	27
Figure 3.10 - 14th BECX Dashboard page	27
Figure 3.11 - 15th BECX Dashboard page	28
Figure 3.12 - 16th BECX Dashboard page	29
Figure 3.13 - Mockup Version	32
Figure 3.14 - 1st BECX Reformulated dashboard page	34
Figure 3.15 - 2nd BECX Reformulated Dashboard page	34
Figure 3.16 - 3rd BECX Reformulated Dashboard page (1st tab - Overall performance)	35
Figure 3.17 - 3rd BECX Reformulated Dashboard page (1st tab - T2B T4B Net Score (NS))	36

Figure 3.18 - 12th BECX Reformulated Dashboard page (1st tab).....	36
Figure 3.19 - 12th BECX Reformulated Dashboard page (2nd tab).....	37
Figure 3.20 - 13th BECX Reformulated Dashboard page (2nd tab).....	38
Figure 3.21 - 14th BECX Reformulated Dashboard page	38
Figure 3.22 - 15th BECX Reformulated Dashboard page	39
Figure 3.23 - 16th BECX Reformulated Dashboard page	40

List of tables

Table 2.1 - Types of Dashboards	5
Table 3.1 - Dashboard Limitations Summary	22
Table 3.2 - Best Practices Checklist for Dashboards	31
Table 3.3 - Best Practices Checklist for Dashboards - Data analyst specialist	42
Table 3.4 - Best Practices Checklist for Dashboards - BI Manager.....	43
Table 3.5 - Best Practices Checklist for Dashboards - Personal Evaluation	44

List of Abbreviations and Acronyms

AI – Artificial Intelligence

BECX - Best European Customer Experience

BI - Business Intelligence

CSAT - Customer Satisfaction Score

DSMR - Design Science Research Methodology

ECSI - European Customer Satisfaction Index

IBM – International Business Machines Corporation

IMS - Information Management School

KPI – Key Performance Indicator

ML – Machine Learning

NPS - Net promote score

NS – Net Score

OLAP - Online Analytical Processing

PLS - Partial Least Squares

SEM - Structural Equation Modeling

T2B – Top Two Box

T4B – Top Four Box

UI – User Interface

UX – User Experience

1. Introduction

In today's data-driven world, organizations increasingly rely on BI tools to support strategic and operational decision-making. With growing volumes of data, relying solely on experience or instinct is no longer enough. Dashboards are one of the most popular BI solutions available, and for good reasons. For people who need to make decisions quickly and intelligently, they assist in converting data and numbers into something more readable and visually appealing.

Despite their widespread adoption, academic literature shows a significant gap in evaluating dashboards from a design and usability perspective, particularly in real-world corporate settings where customer experience is a strategic priority. While many studies focus on the technical development or implementation of dashboards, few critically examine how elements such as layout, interactivity, and visual hierarchy impact decision-making efficiency and user comprehension. Moreover, there is limited research applying structured methodologies such as the Design Science Research Methodology (DSRM) to the iterative redesign and evaluation of dashboards specifically focused on customer experience. This dissertation addresses that gap by combining practical dashboard optimization with a theoretically grounded evaluation approach.

To explore this gap, the study focuses on the dashboard currently used in the Best European Customer Experience (BECX) project, a national initiative that collects quarterly customer feedback from various companies through structured interviews (approximately 250 per company, conducted via online or phone-based surveys). The results are currently displayed on a dashboard that enables users to filter and cross-analyze data. However, several usability limitations have been identified, particularly concerning visual clarity, user interactivity, and alignment with best practices in dashboard design.

The main objective of this study is to redesign the BECX dashboard to increase its usability, effectiveness of data visualization, and conformity to user requirements. More specifically, it aims to assess the limitations of the current dashboard through expert review and feedback, redesign the dashboard following recognized principles of data visualization and user-centered design and evaluate the impact of the redesigned dashboard in terms of user experience and potential support for decision-making.

This dissertation contributes both practically and theoretically. For the BECX project and its participating companies, the redesigned dashboard is expected to improve the interpretation of customer feedback and support faster, more effective decisions. On a broader scale, the project contributes to the BI field by providing practical design guidelines and emphasizing the importance of user-centered dashboard evaluation.

The dissertation is structured into three main chapters. The first chapter presents the literature review, providing a theoretical foundation on BI, dashboard design principles, data visualization, and customer satisfaction metrics. The second chapter details the methodology adopted in the project, following the Design Science Research Methodology (DSRM), and explains each phase of the dashboard redesign process. Finally, the last one presents the main conclusions, discussing the results of the redesign, its practical implications, contributions to the field, and suggestions for future research.

2. Literature review

2.1. Best European Customer Experience (BECX)

In 2021 the BECX project was created (*O ECSI Portugal Agora é BECX - ECSI Portugal*, n.d.) and it is a continuation of the ECSI (European Customer Satisfaction Index) Portugal project created in 1999 and aims to be a national reference in the customer experience evaluation. NOVA IMS (Information Management School) and the Portuguese Association for Quality are the responsible organizations for this project.

BECX builds on the methodological foundation of its predecessor, employing advanced analytical techniques such as Structural Equation Modeling (SEM) and Partial Least Squares (PLS) to evaluate customer satisfaction and experience ((*PDF*) *A Primer on Partial Least Squares Structural Equation Modeling (PLS-SEM)*, n.d.). These methods allow for robust analysis of complex relationships between variables, which is particularly useful in understanding how different factors influence the overall customer experience (“O BECX,” n.d.).

Through data-driven insights, the project enables companies to benchmark their performance against competitors and industry averages. With the support of an interactive dashboard, BECX helps organizations identify the key dimensions that shape customer experience and define strategic priorities for improvement.

The initiative is currently implemented in several sectors, including insurance (Victoria Seguros, Mapfre Seguros Gerais, Liberty Seguros) energy (Lisboagás, Lusitaniagás, Rubis Gás), banking (Banco Santander Totta, Caixa Geral de Depósitos, Banco Crédito Agrícola) or communication (MEO, NOS, Vodafone). Results are shared through regular reports, typically on a quarterly or annual basis, allowing organizations to monitor progress and trends over time (“O BECX,” n.d.).

2.2. Business Intelligence

BI refers to the use of technologies and processes that help organizations turn raw data into meaningful information to support better decisions. In practice, this means collecting, organizing, and analyzing data in a way that reveals trends, patterns, and insights that would otherwise go unnoticed.

Over the years, the definition of BI has changed to keep up with technology. Moss and Atre (2003), for example, described BI as a set of tools focused on data warehousing and reporting to help organizations understand what happened in the past (Moss, 2003). Later, Chaudhuri and Dayal (2011) emphasized how BI moved toward real-time analysis using data mining and OLAP techniques, helping businesses make more proactive decisions (Chaudhuri

et al., 2011). More recently, Tavera Romero et al. (2021) viewed BI as an essential part of decision-making, especially as companies start to see data as one of their most valuable assets (Tavera Romero et al., 2021).

In short, BI has evolved from a reporting tool into something much broader, a way for organizations to become more agile, informed, and competitive.

2.2.1. Benefits

BI brings a range of benefits to companies, depending on how they use it. According to Chen et al., (2012), one of the main advantages is improved decision-making, since BI provides access to accurate and timely information. It also helps businesses become more efficient by highlighting areas where time or resources are being wasted. Another key benefit is the ability to gain a competitive edge for instance, by spotting market trends earlier or understanding customer behavior in more detail.

Finally, many companies now use BI to personalize their services. By better understanding individual preferences and behaviors, they can improve customer satisfaction and build stronger relationships.

2.3. Dashboard

A dashboard offers insights into an organization's operations by visualizing data and KPIs. Dashboards can be anything from straightforward spreadsheets with graphs and charts to interactive interfaces with sophisticated analytical tools and data visualizations. Dashboards can range from simple static spreadsheets to dynamic, real-time platforms powered by BI tools. Few said that "Dashboards should not simply be data-rich; they should be information-rich and actionable" (*Information Dashboard Design*, n.d.).

According to Khatuwal & Puri dashboards are developed using BI tools that allow the collection, integration, analysis, and presentation of data from multiple sources. These tools support various decision-making scenarios, including performance monitoring, operations, trend analysis and data exploration (Khatuwal & Puri, 2022). Microsoft defines a dashboard as "a related group of interactive scorecard and report views that are organized together in a SharePoint or Web-hosted site." (*Getting Started with Dashboards - Microsoft Support*, n.d.).

Dashboards also play a central role in stakeholder communication. According to Sarikaya (2019), they serve not only to inform internal teams but also to align different stakeholders around shared performance objectives, through intuitive visual representation of data. By highlighting trends, patterns, and outliers, dashboards support a more agile and transparent decision-making process (Sarikaya et al., 2019).

2.3.1. Types of dashboards

There are three main types of dashboards that make it possible to monitor an organization's performance according to their purpose as decision support: strategic, tactical and operational dashboards.

Strategic dashboards aim to provide a complete picture of an organization's performance about long term goals. Typically used by executives and strategic leaders, they present key metrics (KPIs) that are presented to support the identification of trends and patterns, and to inform high level decisions. They are generally derived using historical data and less often updated (Pappas & Whitman, 2011).

Tactical dashboards are directed to medium level managers and are intended to help manage and monitor specific initiatives aimed at supporting strategic objectives. They provide a moderate level of detail and are used to monitor projects, evaluate the performance of specific areas and make medium-to-term decisions. Data can be updated on a weekly or daily basis, depending on requirements (Pappas & Whitman, 2011).

Operational dashboards are specifically designed to support day-to-day operations by providing real-time monitoring of business processes. These dashboards enable teams to quickly detect and respond to issues, ensuring operational efficiency (Pappas & Whitman, 2011).

Table 2.1 summarizes the key characteristics of each dashboard type in terms of business objectives, target users, timeframe and data sources.

Table 2.1 - Types of Dashboards

	Strategic BI	Tactical BI	Operational BI
Business objectives	Achieve long-term business goals	Manage tactical initiatives to achieve strategic goals	Monitor & optimize operational business processes
Primary consumers	Executives & business analysts	Business analysts, & LOB managers	LOB managers & operational users Operational processes
Time-frame	Months to years	Days to weeks to months	Intra-day to daily
Data	Historical data	Historical data	Real-time, low-latency, & historical data

2.4. Data Visualization and Dashboard Building Tools

Data must be visualized, ideally with an understandable narrative, for businesses and the public to find it valuable. Tools for data visualization are always changing to provide additional features and increase user accessibility. Wiley define Data visualization as “tools such as Power BI and Tableau are increasingly used in organizations to enhance understanding and communication of key metrics.” (“The Great KPI Misunderstanding,” 2015).

With the constant increase in data year after year, around 27 zettabytes more by 2023, (*Amount of Data Created Daily (2024)*, 2023) the implementation of these visualization tools in companies is imperative, as they facilitate data management and decision-making. Since companies are the main users of these tools, they are the ones who drive them and bring about change. (Sarıkaya et al., 2019)

The main visualization tools work via the cloud and have implemented artificial intelligence features, allowing for the automation of various tasks. Some of the most varied tools are Power BI, Tableau, Google Looker Studio and QlikSense.

2.4.1. Power BI

Power BI was developed by Microsoft and offers various data visualization features. It is a very user-friendly tool and can be used via the cloud (microsoft fabric), giving companies and teams the chance to work together. In addition to the free version, it also offers a corporate version with an associated monthly cost. (dastaffo, n.d.)

This tool is a benchmark in the world of data visualization and dashboard construction and stands out as the tool with the most users worldwide. (*Qlik Sense - Market Share, Competitor Insights in Data Visualization*, n.d.)

2.4.2. Tableau

Tableau belongs to Salesforce and has gained prominence due to its power and flexibility in graphical representation of data, offering various features and functionalities. (*The 9 Best Analytics Tools For Data Visualization Available Today*, n.d.)

Like Power BI, Tableau offers a free version (Tableau Public) and a paid version (Tableau Desktop). In the field of data visualization, Tableau and Power BI are the big competitors, being the tools with the most users worldwide. (*Qlik Sense - Market Share, Competitor Insights in Data Visualization*, n.d.)

2.4.3. Google Looker Studio

It is a data visualization platform developed by Google in 2016, originally under the name Data Studio. Its main advantage lies in its integration into various Google products, such as Analytics, Ads, and BigQuery, making it the ideal tool for anyone using the Google ecosystem. The Looker Studio is a free version. (*The 9 Best Analytics Tools For Data Visualization Available Today*, n.d.)

2.4.4. Qlik Sense

Qlik Sense is a robust BI platform, particularly known for its advanced data visualization capabilities. The ability to integrate data from different sources is one of its strengths, along with a full range of analysis services. The tool does not have a free version, which could be an obstacle for small companies. (*The 9 Best Analytics Tools for Data Visualization Available Today*, n.d.)

These tools, while varied in complexity and purpose, are central to building dashboards that meet organizational needs. Understanding how each one supports data analysis and decision-making is essential to ensure the methodological rigor of dashboard optimization, as explored in the following sections.

2.5. Impact of Dashboards on Decision-Making

In today's digital era, data is generated at an unprecedented pace and volume, estimated at over 328 million terabytes daily by 2023 (*Amount of Data Created Daily (2024)*, 2023). The ability to make quick and informed decisions is essential, making dashboards the ideal tools for this process. They can transform complex data into clear information that is easy to interpret and visualize. They aim to increase efficiency by facilitating access to and analysis of data, enabling rapid responses and at the same time improving effectiveness, contributing to more accurate decision-making. Examples include COVID-19 monitoring, Google Trends and business analysis.

2.5.1. Monitoring COVID-19

Johns Hopkins University has created one of the most widely used dashboards for monitoring COVID-19, with near real-time data and public access. The dashboard allows you to check confirmed cases, deaths, vaccination rates and recoveries, all with a detailed view by country and state.



Figure 2.1 - Johns Hopkins university – Dashboard Monitoring COVID-19

This dashboard has had an impact all over the world because, as well as monitoring the evolution of COVID-19, it has influenced political decisions and public health actions. (COVID-19 Map, n.d.)

2.5.2. Google Trends

It is a free online tool that analyzes searches made on Google and offers insights into trends in people's interests and behavior. The data is presented in interactive, easy-to-interpret dashboards.

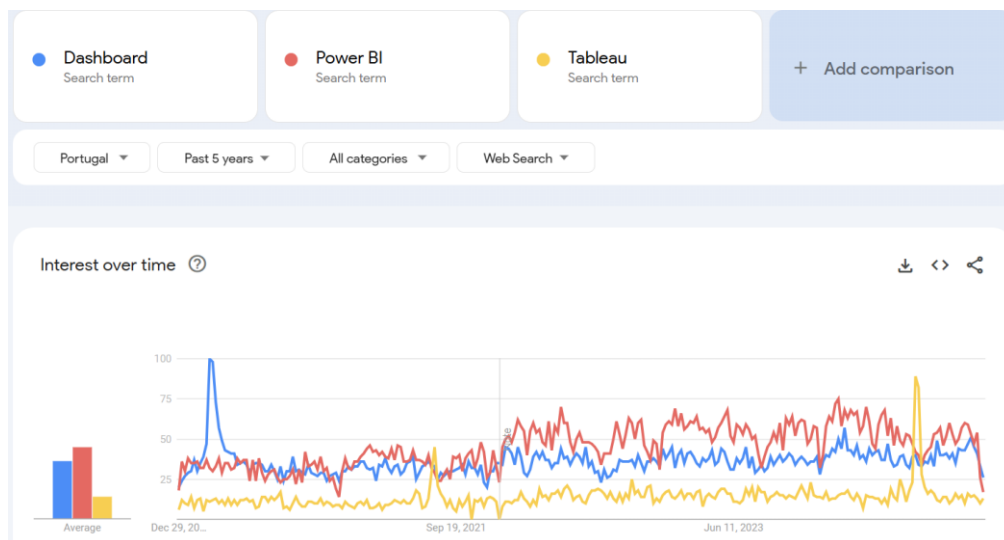


Figure 2.2 - Google trends

Google Trends is used in a wide range of industries, as it provides important information and trends about the market. The tool helps companies adjust their marketing strategies and better understand the needs of their consumers, leading to informed decision-making. (Começar com o Google Trends | Central da Pesquisa Google | Documentação, n.d.)

2.5.3. Business Analysis - Walmart

Walmart is one of the largest retail companies in the world that uses analytical dashboards as a decision-making tool. These allow them to monitor sales in real time, analyze consumer trends and quickly adjust marketing and operations strategies. Through these dashboards, Walmart can manage its resources more efficiently, improving customer experience (Marr, 2017).

These examples illustrate how dashboards, when well designed and aligned with user needs, become indispensable tools for real-time monitoring, behavioral insights, and strategic business decisions across industries and sectors.

2.6. Data Governance and BI

Data governance refers to the set of practices, processes, and policies that ensure the effective and organized management of data within an organization. Its main objective is to guarantee that data is accessible, reliable, consistent, and compliant with internal standards and external regulations.

According to IBM (2024), “Data governance is the data management discipline that focuses on the quality, security and availability of an organization’s data. Data governance helps ensure data integrity and data security by defining and implementing policies, standards and procedures for data collection, ownership, storage, processing and use.” (*What Is Data Governance?*, 2024)

Atlan (2023), said Data Governance in BI, “refers to the overall management of the availability, usability, integrity, and security of the data employed in an enterprise. The goal of data governance is to ensure the data is reliable, consistent, accessible, and secure. This becomes particularly important in BI because relies heavily on the quality and context of the data.” (*Data Governance & Business Intelligence*, n.d.)

To ensure proper data governance in BI tools, four key principles must be considered:

- **Availability** ensures that data is accessible when needed, through the effective management of databases, storage, and server infrastructures.
- **Usability** promotes data organization and clarity by implementing standardized definitions, glossaries, and documentation.
- **Integrity** guarantees the consistency and integrity of data to support effective decision-making.
- **Security** ensures data protection and guarantees compliance with the law and regulations, defining access and implementing data privacy measures. (*Easy*

2.7. Trends in the future of dashboards

The evolution of dashboards is inevitable as organizations embrace digital transformation and manage increasingly large volumes of data. Dashboards, as a core component of BI, continue to evolve to provide more timely, relevant, and actionable insights.

BI platforms have undergone continuous updates to enhance usability and analytical power. A key trend shaping the future of dashboards is the integration of artificial intelligence (AI) and machine learning (ML). These technologies allow dashboards to move beyond descriptive analytics toward predictive and prescriptive analytics, enabling, for example, sales forecasts based on historical performance or customer behavior prediction.

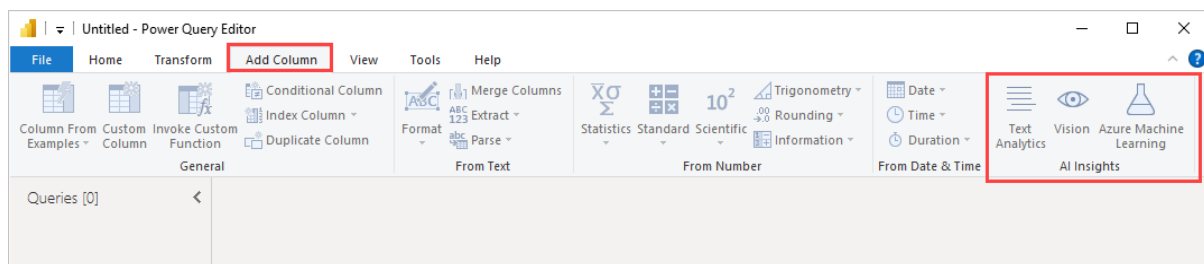


Figure 2.3 - AI Insights – Power BI

Another major trend is the growing adoption of **real-time analytics**. As businesses seek immediate insights, real-time dashboards provide continuous updates on operational performance. A compelling example is the aviation industry: modern airplanes are equipped with approximately 300,000 sensors, generating nearly 20 terabytes of data per hour (Guest, n.d.), demonstrating the scale and speed at which real-time analysis can be applied.

As dashboards become more sophisticated, the need for the data to tell a story has also become a trend. Storytelling presents data in such a way that it's not just numbers and graphs but a visual narrative, with the aim of engaging users and making the dashboard easy to understand. According to SAP, “storytelling transforms dashboards from static visuals into compelling, data-driven journeys” (*What Is Business Intelligence (BI)?*, 2021).

Finally, the widespread use of **cloud-based BI platforms** has significantly impacted dashboard development. These platforms allow companies to scale operations efficiently, integrate with other business applications, and reduce the need for on-premises infrastructure, fostering an adaptable and collaborative analytics ecosystem.

2.8. Effective Dashboard Design

When building dashboards, it is necessary to consider a few essential points to support their planning and construction. The aim is for it to be as functional, accessible and effective as possible.

Some essential pillars for building dashboards are: Understand your audience, tell a story with data, effective visualizations, principles of Gestalt, usability in design (UX/UI), focus on key metrics and interaction & feedback. (*The Big Book of Dashboards Visualizing Your Data Using Real-World Business Scenarios*, n.d.)

2.8.1. Understand your audience

Understanding and identifying the audience is an essential pillar when building a dashboard. It is important that the objectives are clear and relevant, as well as familiarity with the data to adapt the content to the needs of the audience. For example, a financial director will prioritize the analysis of financial KPIs, while a marketing director will prioritize monitoring the performance of marketing campaigns and actions.

In addition to audience perception, it is imperative that the dashboard has a purpose and provides relevant insights, answering the key questions for which it was created.

2.8.2. Tell a Story with Data

Effective dashboards are more than a grouping of graphs and numbers; They are storytelling tools and aim to guide users logically and naturally through the different types of visualizations that make up the dashboard. As mentioned in the previous point, it is essential to understand the audience of the dashboard so that it is built with focus and is objective for its intended audience.

The use of visual elements such as graphics, colors and layouts should be used with intention, emphasizing key insights such as metrics, trends, conclusions or anomalies.

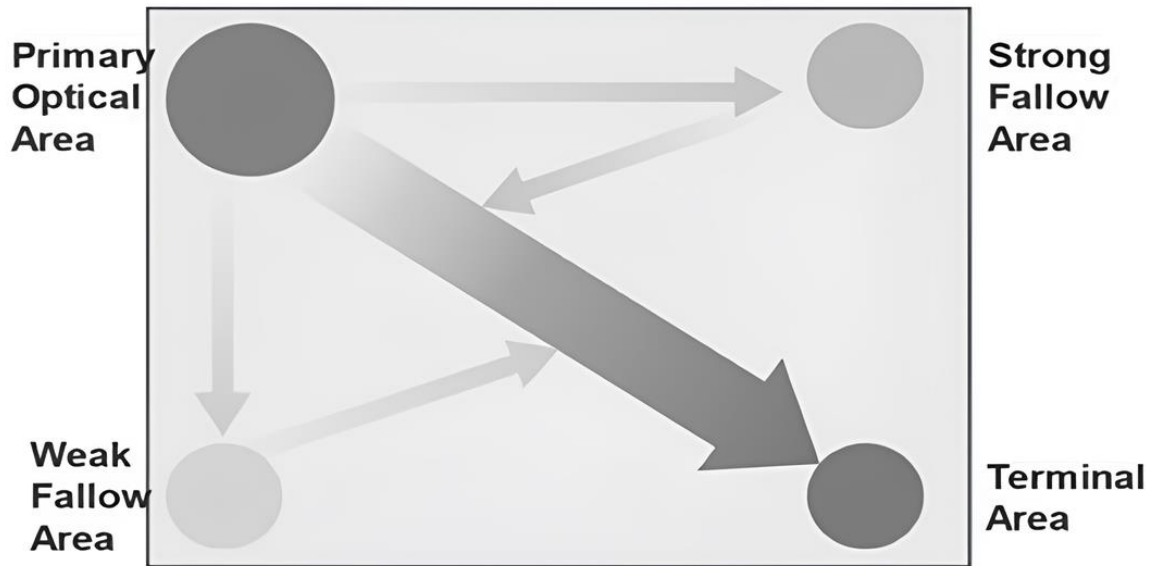


Figure 2.4 - Reading Gravity

An extremely important aspect is the organization of the data and visualizations on the dashboard. It must be organized in a functional and easy-to-read way, as shown in the image above.

2.8.3. Effective Visualizations

Visualizations are the core of any dashboard, as they transform raw data into clear, easy-to-understand visual insights. The first step towards effective visualization is choosing the right chart for a particular type of data.

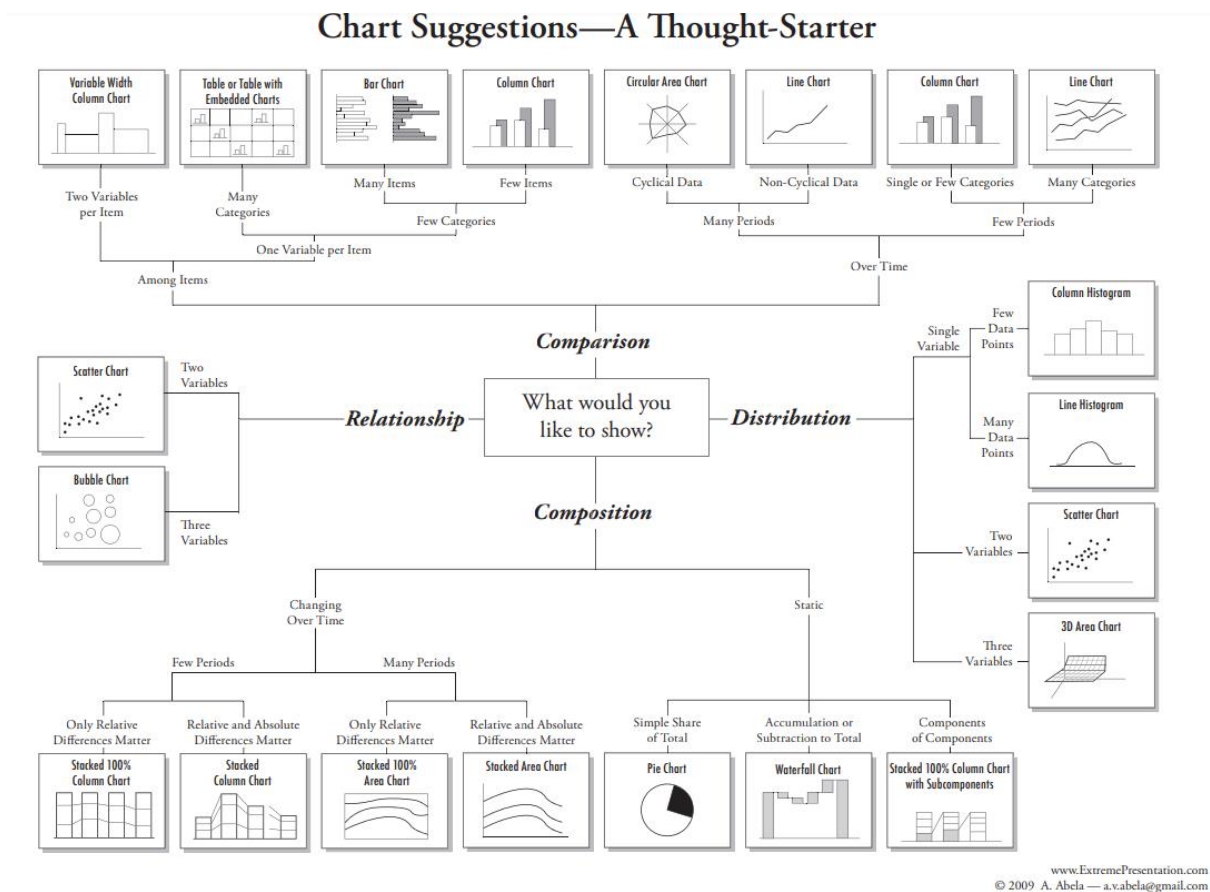


Figure 2.5 - Chart Suggestions – A thought Starter

For example, line graphs are a great ally when the aim is to show trends over time, while bar graphs are more suitable for making comparisons. On the other hand, unsuitable charts, such as pie charts, should be avoided when the aim is to show many variables.

In addition to adapting the data to the ideal chart, it is necessary to maintain a clean layout, remove unnecessary elements and opt for uniform formatting between fonts, colors and chart styles, so that users remain focused on the data presented.

In terms of colors, their choice is undoubtedly the most strategic, as they could capture the user's attention. The color scheme should be limited, always maintaining the same color tone throughout the dashboard. If it is necessary to highlight or alert the user to some information, the ideal is to use colors that are easily highlighted, such as red (an idea of negativity) and green (an idea of positivity).

USE OF COLOR IN DATA VISUALIZATION

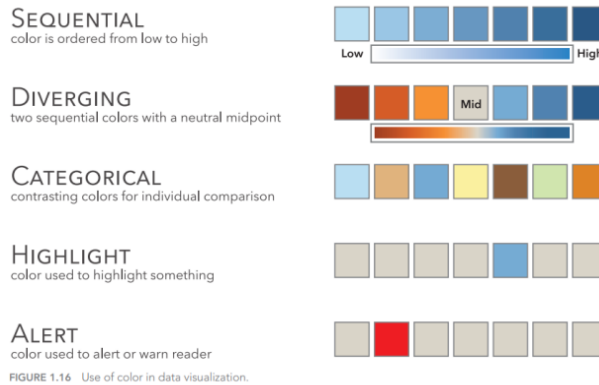


Figure 2.6 - Use of Color in Data Visualization

Another crucial aspect is avoiding overloading information in the dashboard. Ideally, a dashboard should feature between 5 and 7 key views to maintain clarity and balance. This approach helps keep the dashboard visually organized, making it easier for users to digest the information. Including visualizations with excessive detail or those that are unclear can hinder data analysis and negatively impact decision-making.

2.8.4. Principles of Gestalt

Gestalt principles are a theory developed by psychologist Max Wertheimer that describes how the human brain visually captures information. It also provides fundamental instructions for structuring the design of dashboards, helping to direct the user and guide their interpretation of the content. These principles influence the way information is understood by users and their main objective is to create a visual flow that facilitates reading and understanding. The Gestalt principles are 6, proximity, similarity, enclosure, closure, continuity and connection.

Proximity, the closer objects are to each other, the more logical we think that they belong to the same group. It is important to ensure that there is white space between the objects so that the distance between them is perceptible.

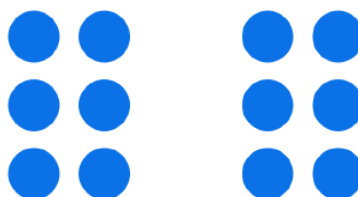


Figure 2.7 - Example of Proximity

Similarity is understood as objects of the same color, size, shape and orientation belonging to the same group. It is common to associate categorical variables with attributes such as red with a loss or green with a profit.



Figure 2.8 - Example of Similarity

Enclosure is defined as a group of objects surrounded by something that forms a visual border around them. This border ensures that, visually, the objects appear to be separated by a region that is distinct from the rest.

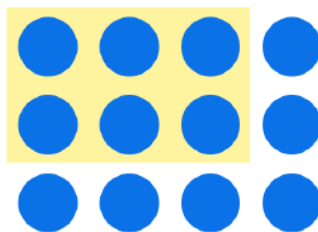


Figure 2.9 - Example of Enclosure

Closure is referred to as the natural human tendency to complete unfinished shapes or to perceive a set of elements as a complete figure.



Figure 2.10 - Example of Closure

Continuity is defined as objects belonging to each other, as part of a single whole, if they are aligned with each other or appear to form a continuation of each other. For example, in a pivot table, it is implied that groups belong to the subgroup when the hierarchy is expanded.



Figure 2.11 - Example of Continuity

Connection is understood as objects that are connected in some way, whether through lines, points or any other possible connection. It is a relevant principle, as it can replace other principles such as proximity and similarity, since it can place a direct connection between objects.

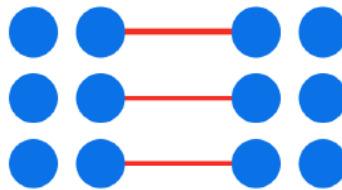


Figure 2.12 - Example of Connection

2.8.5. Usability in Design (UX/UI)

An effective dashboard should prioritize usability by being easy to navigate between all its features. In addition to providing users with a clear view of the data, its main objective is to ensure that it is designed from the outset to provide the user with the best possible experience. This means ensuring that they can access the information on the dashboard quickly and efficiently, and that the main visualizations are highlighted as intended.

The use of interactive elements such as filters, tooltips and drilldowns is essential to ensure usability and user experience. Filters give users the ability to customize the data they want to see, making it easier to view. Tooltips provide additional data when the cursor passes over the data, giving the user more detail. Drill-downs, as the name suggests, allow users to start from a macro point and go down to a more micro layer, with more detail.

A dashboard with effective usability not only makes it easier for users to interpret the data but also conveys confidence in decision-making.

2.8.6. Focus on Key Metrics

The selection of metrics is one of the most important aspects of effective dashboard design. Their choice should reflect the user's main objectives, always ensuring that the

dashboards provide relevant and actionable insights. To deliver value to the user, it is first necessary to understand their objectives, to build a tool that supports decision-making

The metrics should be organized in such a way as to guide the user to what really matters, prioritizing the use of visual hierarchies such as colors, size and position. Metrics that don't add value should be removed, to ensure that the user's focus remains on the insights that really add value.

2.8.7. Iteration & Feedback

The process of building an effective dashboard, it is essential to involve users from the very beginning of the project, to understand their needs and expectations. Feedback is crucial and should be continuous throughout the construction process, with the aim of ensuring that the result meets the user's requirements.

Using interviews, meetings or even forms, it is possible to guarantee user feedback, always focusing on the construction of the dashboard on what the user's objectives are. In addition to user involvement, it is important to validate the integrity of the data to guarantee trust and credibility.

In conclusion, building effective dashboards goes far beyond simply presenting data. It requires a deep understanding of the target audience, the ability to tell compelling data stories, careful selection of visualizations and color schemes, adherence to design and visual perception principles, and a focus on delivering a smooth and intuitive user experience. Well-designed dashboards not only enhance data interpretation but also support faster, more informed, and strategic decision-making. Continuous iteration and active user feedback are ultimately what ensure these tools evolve in line with business goals.

2.9. The role of the client in BI and Dashboarding

The customer is an essential factor for any business strategy to be successful. As such, understanding their needs and behaviors in such a competitive and dynamic world is a priority for all companies.

Lemon and Verhoef (2016) point out that the complexity of customer experience has increased significantly due to the high number of contact points and interaction channels, such as social networks, digital platforms and physical stores. (*Understanding Customer Experience Throughout the Customer Journey* - Katherine N. Lemon, Peter C. Verhoef, 2016, n.d.)

Given the growing demands of the customer, companies must integrate different roles, such as marketing, logistics and operations, to provide outstanding experiences that at the same time create lasting relationships and generate value.

2.9.1. How to identify business needs

Identifying business needs is an essential factor in ensuring effective decision-making support. This process must begin before the dashboard is built, always ensuring that the company's strategic objectives are aligned with the result. To achieve this, it is important to have a thorough understanding of the business challenges, user expectations and the goals to be achieved.

To understand the business and its challenges, it is necessary to involve those involved in the process, whether through meetings, interviews or even forms, who will provide valuable insights that will support the construction of dashboards. In addition to understanding the business, it is essential to choose the KPIs and metrics that best reflect the company's objectives and at the same time help with decision-making.

Once the process of identifying users' business needs has been completed, these may change, for example through changes in strategy or even the company's own vision. Given these changes, it is necessary to implement a continuous monitoring process that allows the dashboard to be adjusted according to new guidelines.

2.9.2. Customer Experience

Customer experience can be defined as the set of perceptions that the consumer has about a particular company throughout their purchasing journey, i.e. from the first contact they have with the company right through to the post-sale period. This whole process is crucial for building healthy and lasting relationships between the company and the customer.

Keyser et al. (2015) describe customer experience as consisting of the cognitive, emotional, physical, sensorial, spiritual, and social elements that mark the customer's direct or indirect interaction with (an)other market actor(s).

Schmitt, Brakus, and Zar Antonello (2015) said that every service exchange leads to a customer experience, regardless of its nature and form. This expansive perspective considers customer experience holistic in nature, incorporating the customer's cognitive, emotional, sensory, social, and spiritual responses to all interactions with a firm.

Customer experience is a complex process that requires constant evaluation and improvement. There are several methods for streamlining this process, the best known of which are the Net Promoter Score (NPS) and journey mapping, which shows the steps the user takes throughout the purchasing process. Other techniques that can be used are A/B testing, emotional response analysis, which measures human emotions, and qualitative feedback like interviews.

2.9.3. Customer Satisfaction

Companies focus on producing value, whether through products or goods, to satisfy their customers' needs, trying their best to provide a good experience. And it is through this experience that customer satisfaction is assessed, which is an essential indicator for measuring a company's success.

Customer satisfaction can be based on the level of happiness after using or buying a good or service. This can vary depending on the experience the customer had during the purchase and can be influenced by the way they are treated by staff, the accessibility of the company or even the personalization of the services provided.

Zeithaml, Bitner e Gremler describe customer satisfaction like the customer's evaluation of a product or service in terms of whether it has met their needs and expectations (Zeithaml et al., 2017).

Kotler & Keller (2017) said that customer satisfaction is a person's feeling of pleasure or disappointment resulting from comparing a product's perceived performance in relation to their expectations (Zeithaml et al., 2017).

According to Oliver (2014), it is the consumer's fulfillment response, a judgment that a product or service feature, or the product or service itself, provides a pleasurable level of consumption-related fulfillment (Oliver, 2014).

It is extremely important for companies to understand whether their customers are satisfied with their services. As such, there are several metrics that can be used to measure this, such as the customer satisfaction score (CSAT), the SERVQUAL model which measures the quality of the service, or post-purchase surveys. Other measures that can be used are the Likert scale analysis that measures customer opinions and behaviors, the retention rate and the repeat purchase rate (Kelley & Turley, 2001).

Placing the customer at the center of BI efforts ensures that dashboards and analytical tools are not only aligned with corporate goals but also with real market demands. Understanding customer needs, behaviors, and satisfaction levels leads to smarter, more human-centric decision-making.

To sum up, the literature review has explored the key concepts surrounding BI, dashboards, data visualization tools, and the importance of aligning these solutions with user needs and customer experience. These theoretical foundations serve as a critical base for the practical component of this research, which focuses on the development and validation of a dashboard solution. The following chapter presents the methodology adopted to apply these principles in a real-world context, describing the design process, tools used, data sources, and the evaluation criteria that guide the dashboard construction and optimization.

3. Methodology

3.1. Design Science Research Methodology (DSRM)

The methodology adopted for the development of this dissertation was DSRM, which is particularly appropriate for addressing complex organizational problems through the creation and evaluation of innovative artifacts. According to Venable and Baskerville, DSRM is “research that invents a new purposeful artefact to address a generalized type of problem and evaluates its utility for solving problems of that type.”

The DSRM process includes six sequential yet iterative activities: identifying the problem and motivation, defining the objectives of a solution, designing and developing the artifact, demonstrating its use, evaluating its performance, and communicating the results. This dissertation applies DSRM to the redesign and evaluation of a real dashboard, aiming to enhance its usability, visual clarity, and effectiveness in decision-making. The process followed is illustrated in Figure 13.

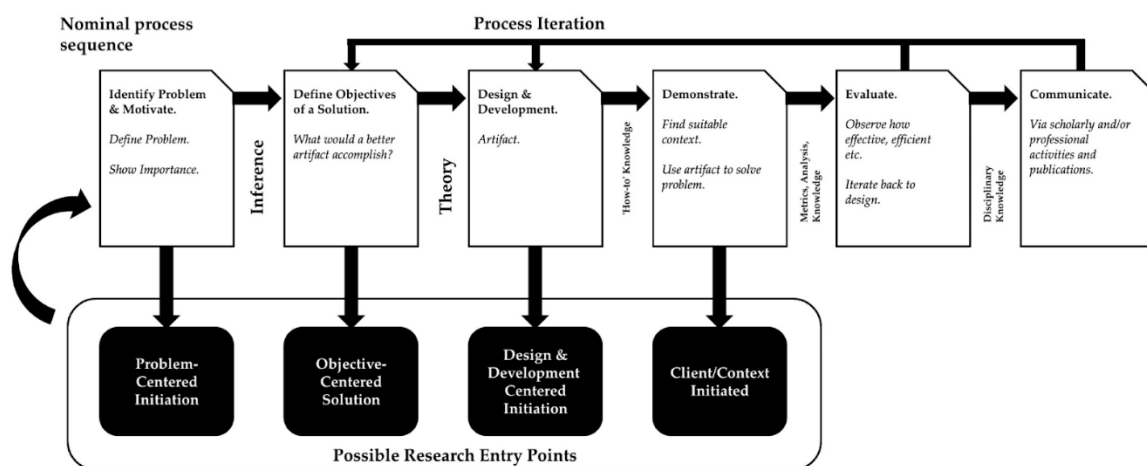


Figure 3.1 - Design Science Research Methodology (DSRM) Process

For the methodology to be best applied, it must follow a process consisting of a series of activities.

The process begins with **identifying the problem and the motivation** behind solving it. This step is essential to ensure that the artifact developed, such as the redesigned dashboard, addresses a real and relevant need.

In the second step, the **objectives of a potential solution are defined**. These objectives can be either quantitative, if measurable through data, or qualitative, when related to user perception or experience.

After identifying the problem and outlining the objectives, the process of **creating the artifact** begins, which can be defined as a solution designed to solve a particular problem. It

can be manifested in models, methods, frameworks or systems and its main objective is to contribute to the advancement of knowledge in each field.

The next step is the **demonstration of the artifact's** usefulness in a real-world scenario. In this dissertation, this was done by applying the redesigned BECX dashboard to the actual business context for validation. The last two steps are **evaluation**, which monitors the performance of the artifact in relation to the proposed solution and **communication**, where the entire design process and its effectiveness in solving the problem is presented to the target audience. The methodology must follow the entire process as rigorously as possible to guarantee the best results, contributing to the advancement of knowledge within the area under analysis.

3.1.1. Problem identification and motivation

Data-driven decision making has become a fundamental pillar for the efficiency and growth of companies, as it allows them to make informed decisions. However, this process is highly influenced by both the quality of the data and the way it is visualized. Dashboards play a fundamental role as they act as a link between the data and its visualization. Despite the widespread use of dashboards, numerous studies and practical cases indicate that many of them fall short in effectively supporting decision-making. This is often due to poor visual design, lack of alignment with user needs, or inadequate data structuring.

Common issues include a lack of visual hierarchy, ineffective use of color, misuse of chart types, and information overload. Combined, these factors can hinder the user's ability to extract meaningful insights and reduce the overall usability of the dashboard.

Given these challenges, this research seeks to critically analyze the current BECX dashboard, identifying its limitations and potential for improvement. The goal is to redesign the dashboard using best practices from the fields of data visualization and UX/UI design, to enhance usability, improve user experience, and better support decision-making.

3.1.1.1. BECX Dashboard Analysis

The Dashboard currently used by BECX consists of 16 pages of information, organized in such a way as to provide a comprehensive view of customer experience, sector benchmarking and company performance. It begins with an introductory page that allows direct access to the different dimensions analyzed. This is followed by a "Global Results" overview, which consolidates the key indicators. Subsequently, the dimensions are explored individually, providing a more detailed analysis of the various factors that influence customer experience. Finally, the dashboard includes an explanation of the methodology used in the BECX project, as well as a navigation guide to facilitate data interpretation and the user experience.

The BECX Dashboard has a well-designed organizational structure. It stands out for its logical distribution of information, which guides the user from the home page (summary of all the information) to more detailed analyses of each indicator. It is also important to highlight the benchmarking modules, which make a positive contribution to supporting decision-making. However, there are opportunities for improvement, which could make the dashboard more effective and efficient. Data visualization could be optimized with graphics that are better suited to the data presented. The excessive use of tables throughout the dashboard makes it difficult for the user to analyze and identify trends.

To better structure the main limitations identified, the following table summarizes the most critical issues found across key dashboard pages, classified by severity and recurrence:

Table 3.1 - Dashboard Limitations Summary

Page	Limitation	Severity	Frequency
Intro Page	Poor use of white space and grey background	Medium	Recurrent
Global Results	Weak visual hierarchy, information overload	High	Recurrent
Emotions – Tab 2	Excessive data table, low readability	High	Recurrent
Recommendations – 1st Tab	Long explanatory text diverts user attention	Medium	Isolated
Recommendations – 2nd Tab	Poor visual link between tables, text too prominent	Medium	Recurrent
Characterization	Inadequate choice of graphs for data	Medium	Recurrent
Methodology Page	Text-heavy, lacks visual/graphic support	Low	Isolated
Final Navigation Page	Overlapping tooltips create visual clutter and distraction	Medium	Isolated

The following section presents a detailed review of each dashboard page, expanding on the limitations summarized in the table above.

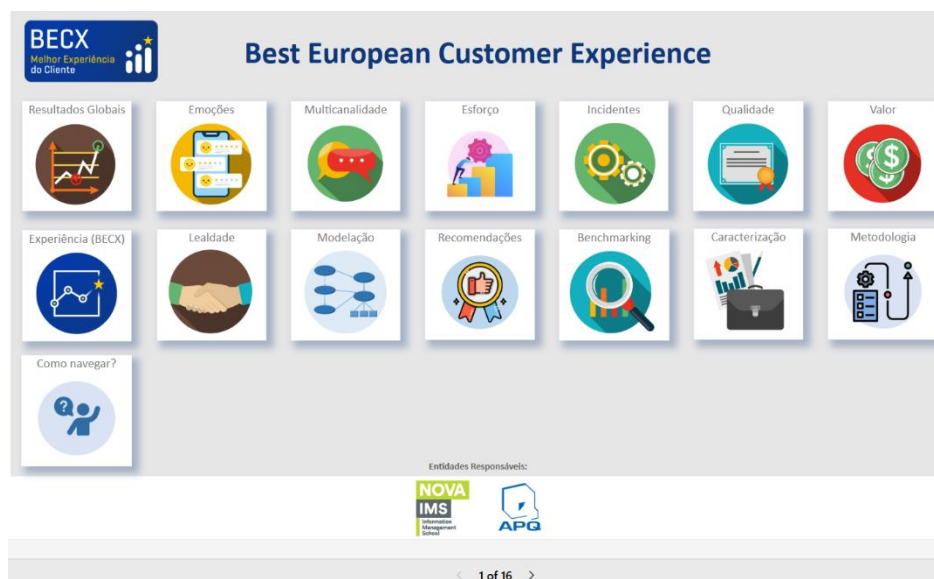


Figure 3.2 - 1st BECX Dashboard page

The introductory page in a dashboard of this size is essential for navigation between the various pages to be as fluid as possible. However, it should be noted that both

aesthetically and organizationally it has some limitations. In terms of aesthetics, the background color should be as clean as possible and the grey used has a significant impact on the user experience. As far as the organization of the page is concerned, the ideal would be to make better use of the white spaces, rearranging the buttons so that they occupy the entire page, making their display clearer and more uniform.



Figure 3.3 - 2nd BECEX Dashboard page

The Overall Results page serves as a consolidation of all the dimensions that have been analyzed throughout the Dashboard. Although it has a well-organized structure, it has some limitations that could be improved to enhance the user experience. The first limitation focuses on the visual hierarchy, which, according to Few (2009), is essential in guiding the user's attention to the most critical insights. A lack of proper emphasis on key KPIs may lead to confusion and misinterpretation of data priorities.

Another important point is the overload of information. Even though it is a consolidation of information, it is necessary to readjust and reduce some indicators so that they are more visually appealing to the user. In addition, the comparison between the Company and the Sector could be more intuitive, making it easier to interpret the differences in performance. Finally, and with the aim of further improving the user experience, it would be essential to make the indicators more interpretable, providing insights and visual highlights that identify patterns and trends.

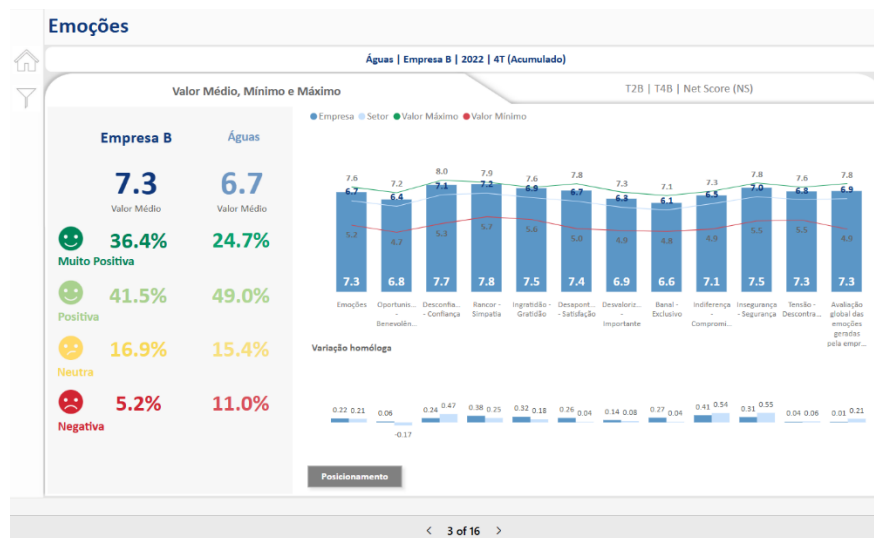


Figure 3.4 - 3rd BECX Dashboard page (1st tab)

The third page of the dashboard presents a detailed analysis of customer sentiment. The structure is like that of the "overall results" page, which is a positive point as it represents consistency. However, there are some limitations that need to be improved. In particular, the highlighting of average values, both for the company and the sector. The bar chart, given the number of variables and indicators being analyzed, is very difficult for the user to read. About the year-on-year change, highlighting the figures is essential, as it is a legend to make the graph easier to interpret.

Emoções

Águas | Empresa B | 2022 | 4T (Acumulado)

Valor Médio, Mínimo e Máximo T2B | T4B | Net Score (NS)

	Empresa B				Águas			
	7.3	18.4%	60.2%	-3.7	6.7	12.1%	49.2%	-14.2
Indicador	Valor Médio	T2B	T4B	NS	Valor Médio	T2B	T4B	NS
Rancor - Simpatia	7.8	40.3%	77.3%	17.6	7.2	32.9%	68.2%	1.1
Desconfiança - Confiança	7.7	35.8%	76.4%	12.2	7.1	31.9%	69.8%	1.7
Insegurança - Segurança	7.5	37.4%	74.7%	12.1	7.0	26.5%	68.0%	-5.5
Ingratidão - Gratidão	7.5	37.5%	72.5%	10.0	6.9	27.6%	65.4%	-7.0
Desapontamento - Satisfação	7.4	35.0%	71.4%	6.4	6.7	25.6%	63.1%	-11.3
Avaliação global das emoções geradas pela empresa	7.3	28.9%	67.6%	-3.5	6.9	22.0%	63.9%	-14.1
Tensão - Descontração	7.3	30.8%	72.5%	3.4	6.8	24.0%	66.0%	-10.0
Indiferença - Compromisso	7.1	29.5%	64.1%	-6.3	6.5	22.4%	57.2%	-20.4
Desvalorizado - Importante	6.9	28.6%	57.8%	-13.6	6.3	16.9%	53.8%	-29.3
Oportunismo - Benevolência	6.8	25.5%	58.4%	-16.1	6.4	19.6%	56.0%	-24.4
Desvalorizado - Excluído	6.6	25.5%	58.4%	-16.1	6.4	19.6%	56.0%	-24.4
Indiferença - Compromisso	6.5	22.4%	57.2%	-20.4	6.5	22.4%	57.2%	-20.4
Desvalorizado - Importante	6.3	16.9%	53.8%	-29.3	6.3	16.9%	53.8%	-29.3
Oportunismo - Benevolência	6.4	19.6%	56.0%	-24.4	6.4	19.6%	56.0%	-24.4
Desvalorizado - Excluído	6.4	19.6%	56.0%	-24.4	6.4	19.6%	56.0%	-24.4
Indiferença - Compromisso	6.5	22.4%	57.2%	-20.4	6.5	22.4%	57.2%	-20.4
Desvalorizado - Importante	6.3	16.9%	53.8%	-29.3	6.3	16.9%	53.8%	-29.3
Oportunismo - Benevolência	6.4	19.6%	56.0%	-24.4	6.4	19.6%	56.0%	-24.4
Desvalorizado - Excluído	6.4	19.6%	56.0%	-24.4	6.4	19.6%	56.0%	-24.4

T2B (TOP TWO BOX) = %9 e 10 | T4B (TOP FOUR BOX) = %6 e 10 | NS (Net Score) = %9 e 10 - %1 a 6

< Pages >

Figure 3.5 - 3rd BECX Dashboard page (2nd tab)

The second tab overwhelms the user with dense tables, which contradicts the principles of cognitive load theory (Sweller, 1988), potentially hindering effective information retention and insight extraction.

Pages 4 to 10 follow a similar structure to that presented on page 3, with a detailed focus on the different dimensions of the customer experience. That said, the observations

made earlier about the need to reorganize the visual hierarchy, improve the comparison between the company and the sector, reduce information overload and improve the usability of the tabs apply equally to these pages.

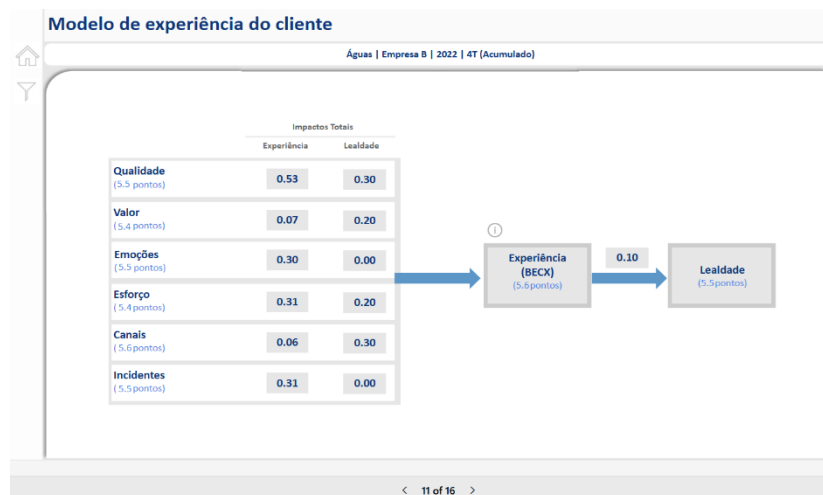


Figure 3.6 - 11th BECX Dashboard page

This page represents the relationship between the different customer experience factors (Quality, Value, Emotions, Effort, Channels and Incidents) and their impact on Experience (BECX) and Loyalty. The use of numerical values provides a precise and data-driven view of each factor's contribution. The structure effectively highlights which elements have a stronger influence on the customer journey, allowing for clear prioritization in improvement efforts. Additionally, the connection between Experience and Loyalty is represented through a straightforward flow, helping to contextualize how customer satisfaction translates into long-term engagement.

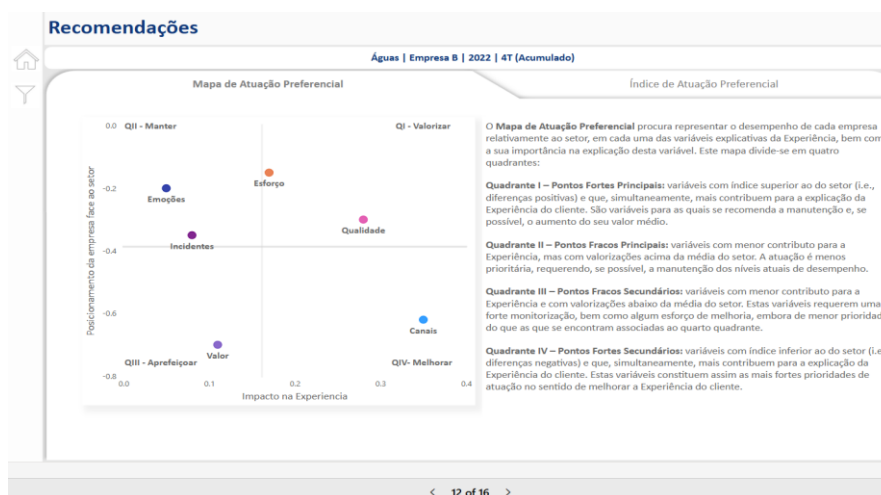
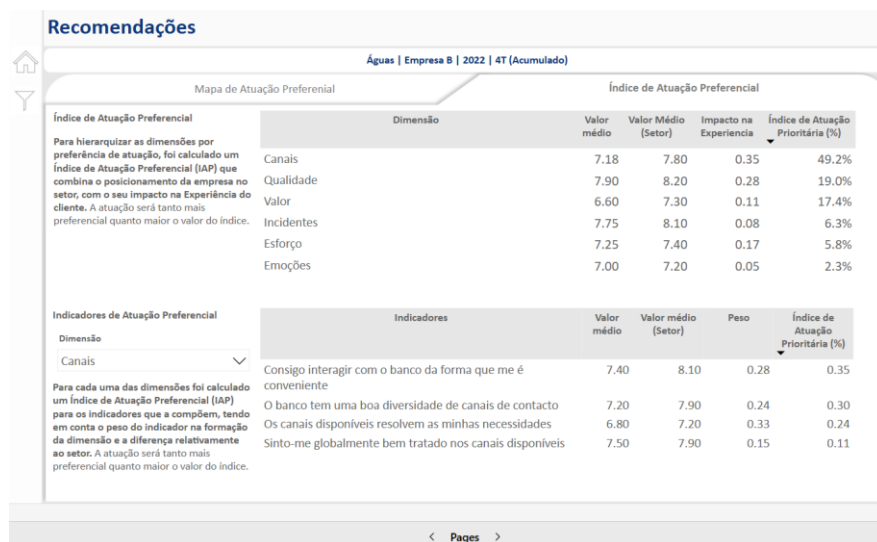


Figure 3.7 - 12th BECX Dashboard page (1st tab)

The "Recommendations" page is represented by a Preferred Performance Map, which makes it possible to analyze the performance of a given company and sector in the different factors analyzed. It is divided into four quadrants: Q1 (Enhance), Q2 (Maintain), Q3 (Improve) and Q4 (Improve). It is useful for companies to have an idea of their strengths and weaknesses and aims to support the design of improvement strategies.

Regarding limitations, it is necessary to highlight the factors that need improvement. The explanatory text is too long and takes the user's focus away from the factors that need the most attention. The explanation needs to be reworded and an alert with automatic insights should be included to summarize the main concerns.



Recomendações

Águas | Empresa B | 2022 | 4T (Acumulado)

Mapa de Atuação Preferencial

Índice de Atuação Preferencial

Para hierarquizar as dimensões por preferência de atuação, foi calculado um Índice de Atuação Preferencial (IAP) que combina o posicionamento da empresa no setor, com o seu impacto na Experiência do cliente. A atuação será tanto mais preferencial quanto maior o valor do índice.

Dimensão	Valor médio	Valor Médio (Setor)	Impacto na Experiência	Índice de Atuação Preferencial (%)
Canais	7.18	7.80	0.35	49.2%
Qualidade	7.90	8.20	0.28	19.0%
Valor	6.60	7.30	0.11	17.4%
Incidentes	7.75	8.10	0.08	6.3%
Esforço	7.25	7.40	0.17	5.8%
Emoções	7.00	7.20	0.05	2.3%

Indicadores de Atuação Preferencial

Para cada uma das dimensões foi calculado um Índice de Atuação Preferencial (IAP) para os indicadores que a compõem, tendo em conta o peso do indicador na formação da dimensão e a diferença relativamente ao setor. A atuação será tanto mais preferencial quanto maior o valor do índice.

Dimensão	Indicadores	Valor médio	Valor médio (Setor)	Peso	Índice de Atuação Preferencial (%)
Canais	Conseguo interagir com o banco da forma que me é conveniente	7.40	8.10	0.28	0.35
	O banco tem uma boa diversidade de canais de contacto	7.20	7.90	0.24	0.30
	Os canais disponíveis resolvem as minhas necessidades	6.80	7.20	0.33	0.24
	Sinto-me globalmente bem tratado nos canais disponíveis	7.50	7.90	0.15	0.11

< Pages >

Figure 3.8 - 12th BECX Dashboard page (2nd tab)

The second tab on the "Recommendations" page represents the Preferred Action Index. The first table shows all the dimensions analyzed throughout the Dashboard and the second table shows the indicators corresponding to a specific dimension.

The explanations on the left-hand side of the tables are very prominent. Although it's important to understand where the data comes from and how it should be interpreted, the focus should be on the numbers and their impact on the company. In addition, it is difficult for the user to understand the connection between the first and second tables. It would be important to improve the visual relationship between the two tables.

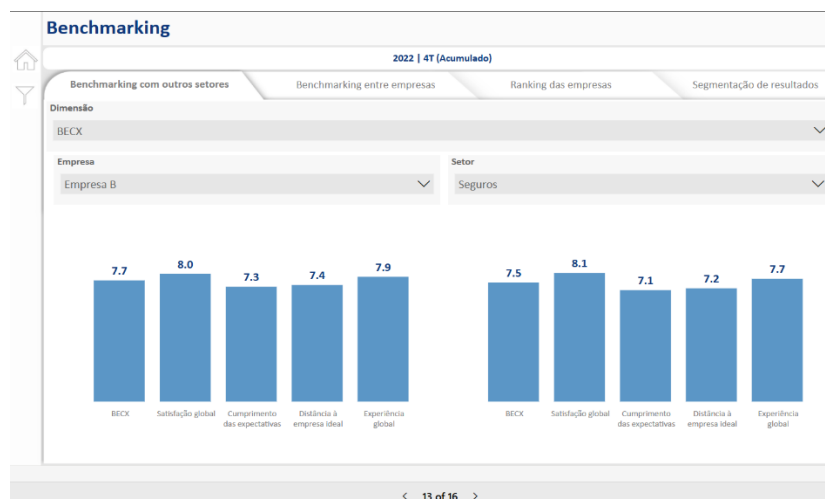


Figure 3.9 - 13th BECX Dashboard page (2nd tab)

The "Benchmarking" page makes it possible to make various comparisons between the company and other sectors, companies and indicators. It's an important topic that gives the company a global view of its competitors, thus enabling it to apply strategies that help it to improve against its competitors.

The page is well designed, with intuitive and clear navigation. The data is presented in a comparative and straightforward manner, allowing for a simple and objective analysis. Comparing only one company and one sector at a time ensures a more detailed focus in the analysis, avoiding information overload and allowing a clear and efficient reading of the data, thus complying with good visualization practices. The following tabs have the same visual structure, which, like the current tab, ensures consistency and makes it easier to interpret the data.

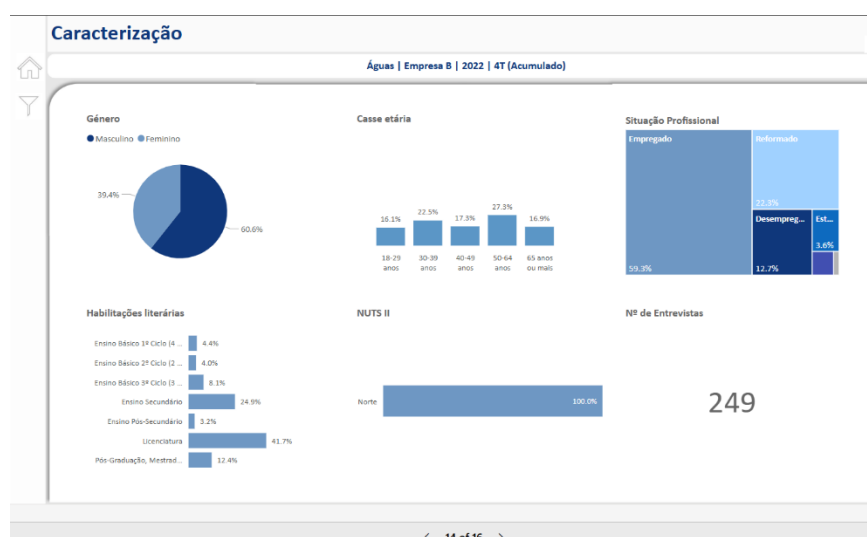


Figure 3.10 - 14th BECX Dashboard page

The "Characterization" page presents demographic and socio-demographic data on the interviewees. The data is presented in various graphs, as shown in the image. However, some improvements could be implemented, making the page clearer and more functional.

The limitations mainly center on the choice of graphics for the data being presented. For example, the circular graph representing gender would be more effective if replaced by a horizontal bar graph, which according to Cleveland & McGill (1985), provides greater precision and ease of comparison in visual perception tasks.

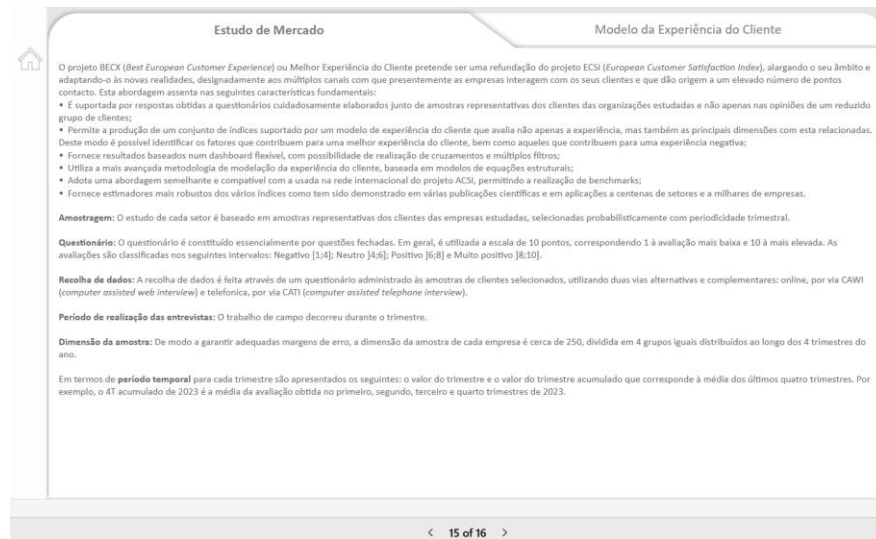


Figure 3.11 - 15th BECX Dashboard page

The 15th page of the dashboard focuses on explaining the methodology used by BECX, which includes its objective, how the data is sampled and how often the structure of the questionnaire and the data collection methods. Although this is essential content for contextualizing users of the data used in the dashboard, it could be improved. The main limitation is that the text is very long, which makes it difficult to read and interpret. As a dashboard associated with visual elements, it would be important to include infographics, such as a flow chart or icons to facilitate the segmentation of information.

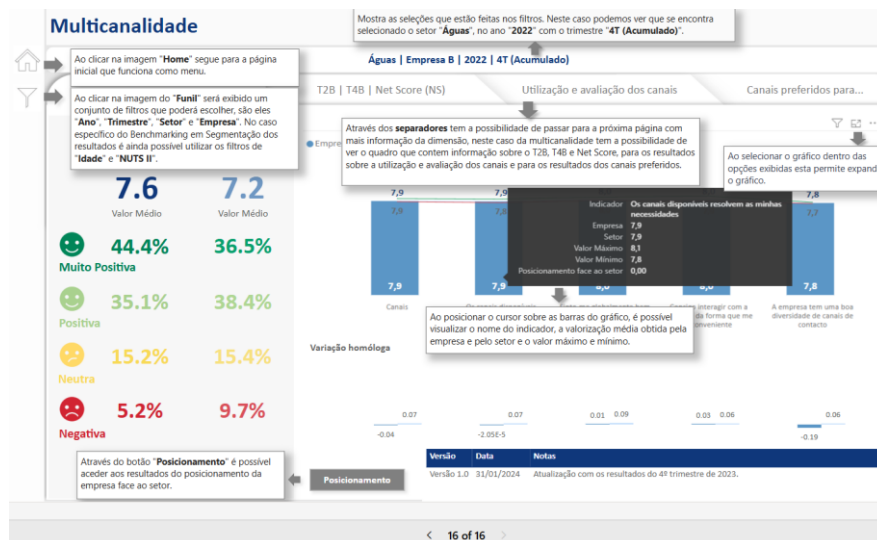


Figure 3.12 - 16th BECX Dashboard page

The last page of the Dashboard acts as a navigation guide, providing instructions on how to use the various features available. This page has a lot of positive points, as it has several informative pop-ups, with clear explanations of its functionalities, reinforces the use of the most varied filters and highlights the interactivity of the tooltips in the visualization of the graphs. However, the addition of dynamic explanations would make this page more functional and easier to interpret.

Through this critical page-by-page analysis, it was possible to identify several opportunities for improvement that impact the effectiveness of data visualization and the user experience. Although the Dashboard is well structured and enables the analysis of various indicators that assess customer experience, the lack of a clear visual hierarchy, the excessive use of tables, the need to adapt the graphics to the type of data and the lack of prominence of some of the most relevant insights are some of the limitations highlighted throughout this analysis.

Additionally, informal feedback collected from end users revealed difficulties in navigating between tabs and identifying the most relevant indicators, further reinforcing the need for visual optimization and simplification.

Since dashboards are essential tools for data-based decision-making, it is essential that their optimization is aligned with the best design and usability practices, to increase their clarity, ensuring that the data is perceptible and easy for users to interpret.

3.1.2. Defining the solution's objectives

In the context of the Design Science Research Methodology (DSRM), these objectives guide the design and development of the artifact proposed to address the identified problem.

In point 3.1.1.1, a detailed analysis was made of the dashboard currently used in the BECX project, based on good design and data visualization practices. This analysis revealed several limitations that impact usability and efficiency in decision-making by users.

In this context, it is essential to define objectives that will serve as a guide for the redesign of the dashboard. These objectives must ensure that they not only mitigate all the limitations identified in point 3.1.1.1 but also offer significant improvements that enhance the user's experience. In addition, they must be aligned with point 2.8 (Effective Dashboard Design) present in the literature review of this document.

3.1.2.1. Objectives

To resolve these limitations and ensure that the dashboard is correctly evaluated and optimized, several objectives were set. The general objective, **the development of an optimized and interactive dashboard**, which applies the principles of effective design to improve clarity, accessibility and efficiency in data analysis, facilitating interpretation and decision-making by users.

The following objectives were defined to overcome the limitations found during the analysis of the dashboard:

Improving the organization and presentation of information is a specific objective based on restructuring the layout in a logical and coherent way, always ensuring a clear visual hierarchy. In addition to the layout, it is essential to prioritize the arrangement of the most important KPIs, ensuring that they have a prominent place on the dashboard and the appropriate use of graphics for the type of data being presented. Finally, it is necessary to eliminate redundant information and ensure that storytelling techniques are used with data that supports the information presented.

Increasing usability through effective design principles can be achieved using Gestalt principles, which group and organize visual elements in an intuitive way. Implementing color theory to highlight relevant information and, in a way, make the data easier to read. And ensuring that the dashboard follows good UX/UI design practices, to provide easy and intuitive navigation.

Increasing interactivity and the ability to explore data. Although the current dashboard already has filters, it is important to revise it to allow users to customize and visualize the data more, applying the filters according to their needs. In addition to filters, the integration of drill-through and drill-down is an added value, as it allows users to carry out more detailed analyses.

The last objective focuses on **validating the new dashboard according to the guidelines for good data visualization practices** set out in the literature review. To ensure

that this objective is met, two validations will be applied. The first is through the creation of a checklist of best practices for dashboards (based on the literature review), as shown in table 3.2. It will serve to evaluate the before and after and has a count at the end that will serve as a method of comparison and evaluation between the two dashboards. The second validation will come from a BI specialist, who will provide feedback by comparing the current version and the redesigned version of the dashboard and then responding to the checklist of good practices.

To assess whether the reformulated dashboard aligns with these objectives and established best practices, the checklist presented in Table 3.2 will be used as an evaluation tool.

Table 3.2 - Best Practices Checklist for Dashboards

Best Practices Checklist for Dashboards		Current dashboard		Reformulated dashboard	
Theme	Question	Yes*	No*	Yes*	No*
Organization and Information Hierarchy	Does the dashboard have a logical and intuitive structure?				
	Are important pieces of information highlighted?				
	Are the data organized in a coherent manner?				
	Does the layout follow a natural reading flow?				
Design and Data Visualization	Does the dashboard follow Gestalt principles?				
	Is there a balance between graphics, tables, and explanatory text?				
	Is the use of colors consistent and does it facilitate data interpretation?				
	Are colors used meaningfully (e.g., green for growth, red for decline)?				
	Does the dashboard avoid excessive use of vibrant colors?				
	Is the page space used appropriately?				
Usability and Interactivity	Are the graphs chosen according to the type of data?				
	Does the dashboard have interactive filters?				
	Are the filters and slicers well positioned and easy to use?				
	Are drill-through and drill-down options available for detailed analysis when needed?				
	Is navigation between different dashboard sections intuitive?				
Clarity and Data Understanding	Is the dashboard loading time fast and optimized?				
	Do all charts and tables have clear or self-explanatory titles?				
	Are legends and labels used when necessary to facilitate reading?				
	Are the metrics and units clearly indicated (e.g., millions, %, units)?				
	Does the dashboard avoid unnecessary technical jargon that may confuse users?				
Accessibility and Responsiveness	Are short explanations available for more complex metrics, if needed?				
	Is the dashboard accessible for different types of users?				
	Is the font size and visual elements appropriate for reading on different devices?				
	Is the design responsive and does it work well on smaller screens (e.g., tablets or laptops)?				
Validation and Feedback	Does the dashboard allow data export for additional analysis?				
	Was the dashboard tested by real users before launch?				
	Were the design and functionalities validated by BI and data visualization specialists?				
	Does the dashboard follow best practices recommended in the literature review?				
TOTAL		0	0	0	0

*Mark with an "X" if applicable.

With the objectives clearly defined, the next step involves designing and developing the new dashboard version, as outlined in the following section.

3.1.3. Design and development

Aligned with the third phase of the Design Science Research Methodology (DSRM), the design and development of the artifact (dashboard) aimed at translating the defined objectives into a functional and user-centered solution. The main goal of this stage was to

ensure that the redesigned dashboard effectively addressed the previously identified limitations, while enhancing usability and user experience.

To begin the development process, mockups were created using Power BI. These mockups function not only as visual prototypes but also as iterative tools to test and refine layout decisions, interactive elements, and graphical options. This experimentation phase was crucial for validating design choices before proceeding to the final version, ensuring a smoother and more optimized user experience.



Figure 3.13 - Mockup Version

Clear design criteria were defined to guide the development process, including clarity in data presentation, interaction efficiency, consistency, and prioritization of relevant content. These criteria were grounded in established best practices from the literature on data visualization and user experience (Few, 2006; Yigitbasioglu & Velcu, 2012). Particular attention was given to maintaining aesthetic consistency, ensuring that visual elements supported the data rather than distracting from it.

The layout was structured to facilitate easy reading and seamless navigation across the entire dashboard. Visual hierarchy was established to ensure that key indicators received appropriate prominence, while colors, typography, and spacing were used consistently to improve comprehension and reduce cognitive overload.

Once the mockups were validated, the next step was to demonstrate the artifact's applicability in a real-world context, as presented in the next section.

Throughout the design and development process of the dashboard, ethical principles were carefully considered to ensure the integrity and responsible use of data. The dataset used was fully anonymized, containing no personal identifiers, thus guaranteeing compliance

with data protection regulations. All improvements made to the dashboard focused on enhancing user experience without manipulating or misrepresenting the underlying information. Additionally, informal feedback from stakeholders was collected voluntarily and anonymously, respecting participants' privacy and autonomy. These precautions helped ensure that the development of the artifact adhered to ethical standards commonly required in BI and user-centered design projects.

3.1.4. Demonstration

The reformulation of the current dashboard is grounded in the implementation of good data visualization practices. It was developed with the objective of providing a clear and dynamic view of a wide range of indicators. Structurally, it was designed with a strong focus on interactivity and fluid, user-friendly navigation.

It is expected that with this new version, end users will benefit from improved data perception and enhanced overall experience.

3.1.4.1. Analysis of the Redesigned Dashboard

A detailed comparison between the original version and the reformulated dashboard highlights the improvements implemented in terms of interactivity, design and the application of best practices.

Although the original BECX dashboard already offered a dynamic layout and some degree of interactivity, it presented substantial visual noise, which negatively affected both data perception and user experience. The reformulated version, in contrast, sought to address these shortcomings by applying good design principles and prioritizing clarity and simplicity.



Figure 3.14 - 1st BECX Reformulated dashboard page

The limitations found focused on the uniform appearance of the buttons, the aesthetic organization and the use of space. The redesigned version has significant changes, which aim to address all the limitations found. By adjusting the colors of the new version, the page has become more harmonious, making it easier for users to read and experience, as well as offering a more visually pleasing interface. When it comes to optimizing space, reorganizing the buttons is a priority, as it eliminates blank spaces, makes the page more accessible and creates visual uniformity.

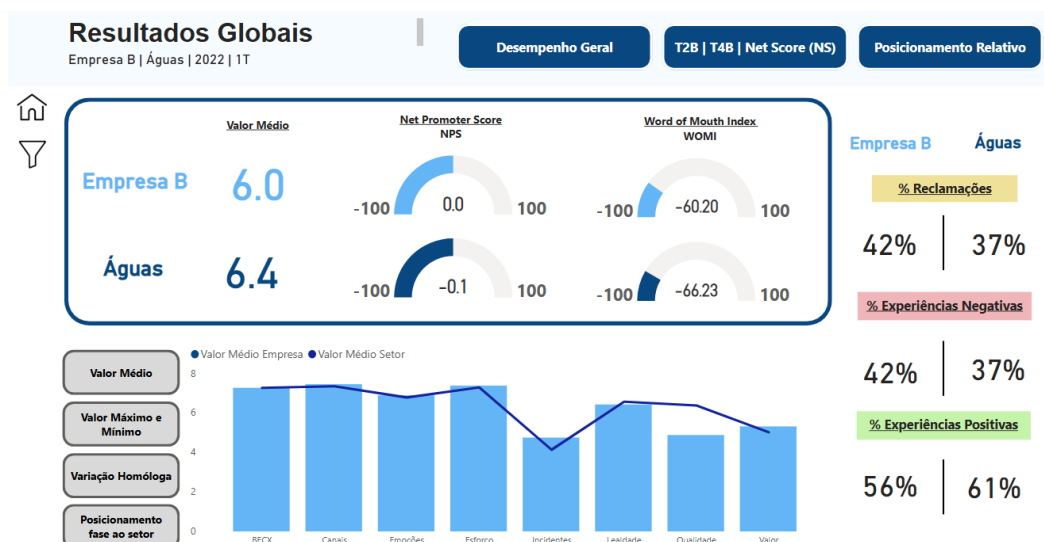


Figure 3.15 - 2nd BECX Reformulated Dashboard page

The global results page, after the cover, is a very important strategic point for the user, because this is where they can get an overview of the information, which helps them to draw up strategies and action plans. So, the easier it is to interpret the data, the better. In the old version, the identification of priorities was not well delineated and this was a point that weighed heavily in choosing the layout of the redesigned dashboard. With this version, it is possible to see visual clarity and a clear highlighting of the most important KPIs.

There has also been a clear change in the colors, which despite remaining blue, have been adjusted to place more emphasis on the comparison between the company and the sector. The excess of information was a limitation that was pointed out, and as can be seen, this has been overcome by giving priority to the most important graphics and information. By using buttons, it has been possible to keep all the KPIs and graphics of the old version, only much more dynamic and intuitive.

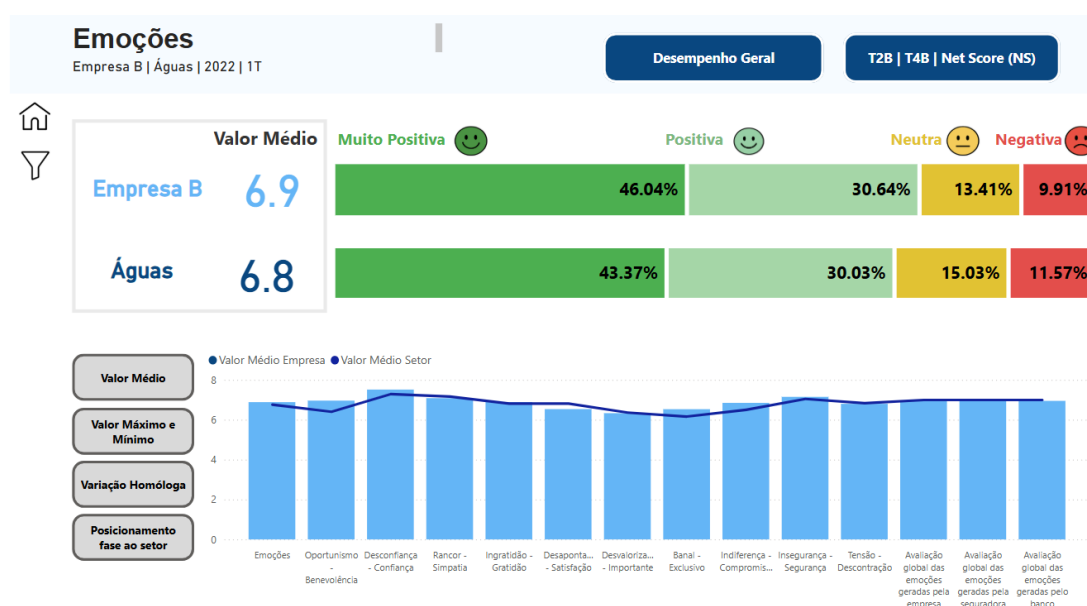


Figure 3.16 - 3rd BECX Reformulated Dashboard page (1st tab - Overall performance)

After a more comprehensive analysis on the global results page, the 3rd page of the dashboard takes a more detailed look at the dimensions relating to consumer experience. From page 3 to page 10 of the dashboard the pages depict the different dimensions, they follow the same layout and information, so only the 3rd page will be analyzed. The first point to make is the clear change in appearance, which makes the dashboard more eye-catching. The consistency of colors and the visual hierarchy are very present, emphasizing the comparison between company and sector in the various KPIs. In the old version, the bar graph was a point of improvement and the way it was solved was by creating buttons that allow you to have the same perception of the graph but with different views. The satisfaction percentages presented in this way are more visually striking, which makes the user pay more attention.

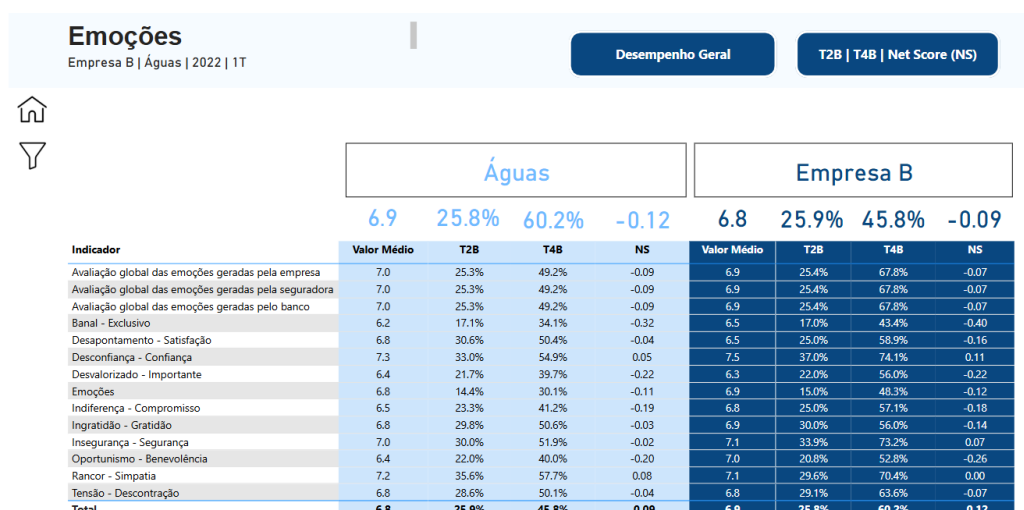


Figure 3.17 - 3rd BECX Reformulated Dashboard page (1st tab - T2B | T4B | Net Score (NS))

About the "T2B | T4B | Net Score (NS)" tab, to maintain the same information, the company and the sector have been given due prominence, differentiating them with the use of specific colors for each one. As for the indicators, we opted for a display with colors ranging from white to grey to make them easier to read.

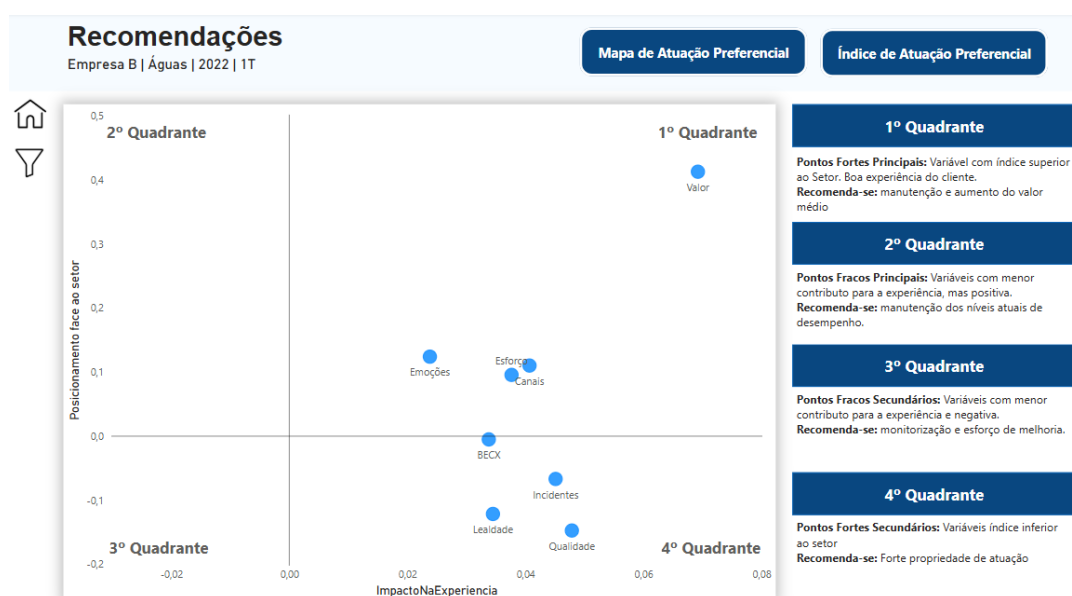


Figure 3.18 - 12th BECX Reformulated Dashboard page (1st tab)

The 12th page of the redesigned dashboard shows the map of preferred action organized into 4 quadrants. This page was designed with the aim of remedying the limitations pointed out, namely the size of the graphic, the excess of text and the way it is presented.

To this end, more space has been allocated to the preferential action map, ensuring a clearer and more accessible view. Next, the explanatory text for each quadrant has been

restructured with user-friendly language, emphasizing recommendations and strengths and weaknesses. With these changes, it is strategically easier to make decisions, as they support the clarity of the information and, above all, support decision-making by users.

Recomendações

Mapa de Atuação PreferencialÍndice de Atuação Preferencial

Índice de Atuação Preferencial

Para hierarquizar as dimensões por preferência de atuação, foi calculado um índice de atuação Preferencial que combina o posicionamento da empresa no setor, com o seu impacto na Experiência do cliente.

Dimensão	Valor médio	Valor Médio (Setor)	Impacto na Experiência	Índice de Atuação Prioritária (%)
Canais	7.18	7.80	0.35	49.2%
Qualidade	7.90	8.20	0.28	19.0%
Valor	6.60	7.30	0.11	17.4%
Incidentes	7.75	8.10	0.08	6.3%
Esforço	7.25	7.40	0.17	5.8%
Emoções	7.00	7.20	0.05	2.3%

Indicadores de Atuação Preferencial

Para cada uma das dimensões foi calculado um Índice de Atuação Preferencial para os indicadores que a compõem, tendo em conta o peso do indicador na formação da dimensão e a diferença relativamente ao setor.

Indicadores	Valor médio	Valor médio (Setor)	Peso	Índice de Atuação Prioritária (%)
Dimensão: Canais				
Consigo interagir com o banco da forma que me é conveniente	7.40	8.10	0.28	0.35
O banco tem uma boa diversidade de canais de contacto	7.20	7.90	0.24	0.30
Os canais disponíveis resolvem as minhas necessidades	6.80	7.20	0.33	0.24
Sinto-me globalmente bem tratado nos canais disponíveis	7.50	7.90	0.15	0.11

Figure 3.19 - 12th BECX Reformulated Dashboard page (2nd tab)

The second tab on the recommendations page shows in detail the dimension and indicators according to their preferred action index. That said, to improve the readability of the page, the explanatory texts were reformulated. The headings were highlighted in blue, giving them their importance. In addition to the design changes, two buttons have been added to switch between the two tabs.

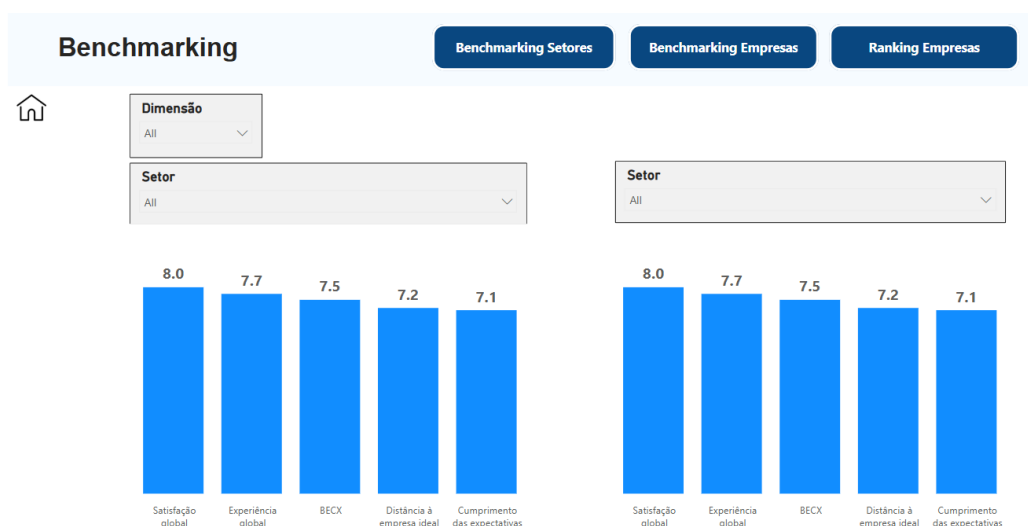


Figure 3.20 - 13th BECX Reformulated Dashboard page (2nd tab)

The Benchmarcking page is extremely important for strategic decisions based on competition, as it allows effective comparisons to be made between companies and different sectors. The visual structure, as mentioned in the evaluation of the dashboard, is well organized and has intuitive and clear navigation. The design has been simplified to make it clearer to interpret. The use of a more striking color draws the user's attention to the most important points to be analyzed.

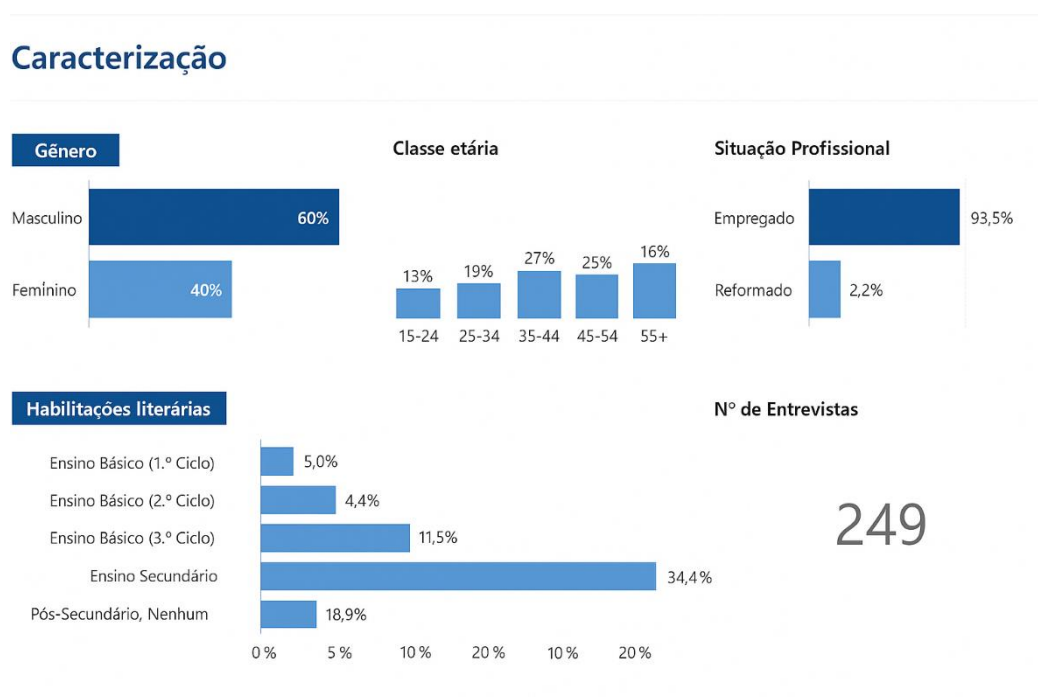


Figure 3.21 - 14th BECX Reformulated Dashboard page

The characterization page was built keeping the initial structure. The criterion for revising the graphics was based on the type of data and the most appropriate graphic to cope with the information to be presented. The main differences are in the design of the graphs in relation to the color chosen, the change from the circular graph to the horizontal bar graph referring to gender and the elimination of the NUTS II graph as it does not add insights to decision-making.



Figure 3.22 - 15th BECX Reformulated Dashboard page

To deal with the limitations mentioned above, namely the excess of text that made it difficult to read and understand, it was revised and restructured. In the reformulated version, we opted for a clearer and more segmented approach, reorganizing the textual content into distinct thematic blocks. Thus, all the information previously presented in a continuous manner has been divided into autonomous topics, namely: BECX Project, Characteristics, Period and Sample and Evaluation Model. The main aim of this new structure is to make it easier for users to read and interpret the data, promoting a more intuitive and efficient experience.

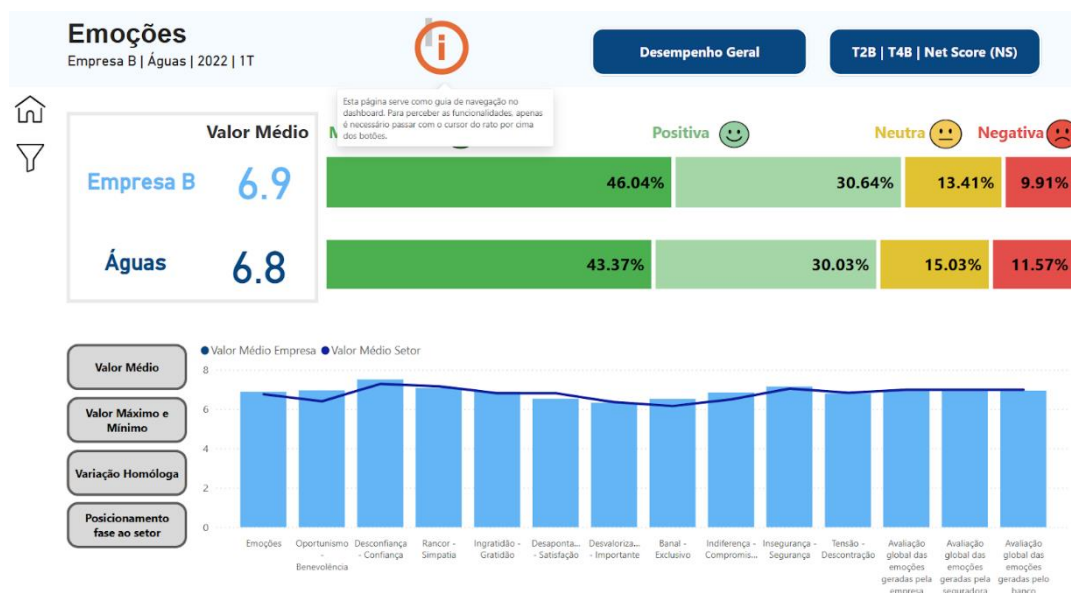


Figure 3.23 - 16th BECX Reformulated Dashboard page

The last page of the dashboard, although it currently has a lot of positive points in terms of the usefulness of the information, has undergone changes aimed at improving the visualization and clarity of the information. One of the main changes was to replace the fixed explanatory text with interactive tooltips. These serve as informative elements that appear automatically when the user positions the cursor over the graphics or buttons, providing indications about them and guidance on how to navigate the dashboard.

3.1.5. Evaluation

After redesigning the dashboard, it was possible to address all the needs identified in point 3.1.1. The new version has resulted in a significantly more effective, intuitive and decision-making-oriented tool. The new version has a clear visual hierarchy, which makes it easier to read and prioritizes the most relevant insights, allowing the user to quickly identify the critical areas of customer experience.

In terms of design, visual noise and excessive information have been reduced and replaced with graphics that are appropriate to the type of data and properly organized to facilitate data interpretation. The visual elements have been organized in a logical and consistent way, using dynamic buttons that allow navigability and promote quick interpretation of the information. In addition to the changes already mentioned, the revision of the filters was essential to guarantee a personalized and detailed analysis according to the user's needs.

Through this reformulation, the dashboard is now in line with good data visualization practices, as it guarantees clear communication and enhances its strategic value in supporting decision-making and customer experience.

3.1.5.1. Specialists Evaluation

To meet the proposed objectives, 2 experts were asked to participate. Both currently work in a medium-sized company whose core business is providing services focused on Management and Marketing. The first analysis was carried out by a Data Analyst who performs various functions, the main one being focused on building Dashboards and Reports in BI Tools. To have a more strategic and business-focused assessment, the second specialist is the BI Manager, whose duties focus on validating the quality of BI solutions and supervising data quality. Both gave their opinion on both the current dashboard and the redesigned one, through a subjective assessment and by filling in the checklist of good data visualization practices (table 2). For confidentiality reasons, none of the experts wanted to reveal their identity.

The Data Analyst said the following, "After analyzing both versions of the dashboard, I believe that the redesign was well done. The previous version had a good structure, which made the redesign much easier, but it lacked the visual clarity and practicality that the new version brings. The old version contained a lot of information, which made it difficult to read. The new version highlights the improved layout, the choice of colors and the impact they have on the navigability of the dashboard. Regarding the use of space, the new version has made up for this, filling the spaces better and emphasizing the most important KPIs. Although the redesigned version has many positive points, there are some improvements that would raise its quality. Better use of tooltips, so that some graphs are more explanatory. In addition, the dashboard doesn't have many drill-through options to analyze the data in more detail. Finally, the dashboard is only adapted to working on a computer and it would be interesting to adapt it to a version for tablets or cell phones.

In conclusion, the redesigned dashboard has brought a clear improvement, both in terms of visualization and the overall user experience. The dashboard is much closer to best practice and is much more functional."

Table 3.3 - Best Practices Checklist for Dashboards - Data analyst specialist

Best Practices Checklist for Dashboards		Current dashboard		Reformulated dashboard	
Theme	Question	Yes*	No*	Yes*	No*
Organization and Information Hierarchy	Does the dashboard have a logical and intuitive structure?		x	x	
	Are important pieces of information highlighted?		x	x	
	Are the data organized in a coherent manner?		x	x	
	Does the layout follow a natural reading flow?		x	x	
Design and Data Visualization	Does the dashboard follow Gestalt principles?		x	x	
	Is there a balance between graphics, tables, and explanatory text?		x	x	
	Is the use of colors consistent and does it facilitate data interpretation?		x	x	
	Are colors used meaningfully (e.g., green for growth, red for decline)?	x		x	
	Does the dashboard avoid excessive use of vibrant colors?		x	x	
	Is the page space used appropriately?		x	x	
Usability and Interactivity	Are the graphs chosen according to the type of data?		x	x	
	Does the dashboard have interactive filters?	x		x	
	Are the filters and slicers well positioned and easy to use?		x	x	
	Are drill-through and drill-down options available for detailed analysis when needed?		x		x
	Is navigation between different dashboard sections intuitive?		x	x	
Clarity and Data Understanding	Is the dashboard loading time fast and optimized?	x		x	
	Do all charts and tables have clear or self-explanatory titles?		x		x
	Are legends and labels used when necessary to facilitate reading?		x	x	
	Are the metrics and units clearly indicated (e.g., millions, %, units)?		x	x	
	Does the dashboard avoid unnecessary technical jargon that may confuse users?	x		x	
Accessibility and Responsiveness	Are short explanations available for more complex metrics, if needed?	x		x	
	Is the dashboard accessible for different types of users?		x	x	
	Is the font size and visual elements appropriate for reading on different devices?		x	x	
	Is the design responsive and does it work well on smaller screens (e.g., tablets or laptops)?		x		x
Validation and Feedback	Does the dashboard allow data export for additional analysis?	x		x	
	Was the dashboard tested by real users before launch?				x
	Were the design and functionalities validated by BI and data visualization specialists?			x	
	Does the dashboard follow best practices recommended in the literature review?		x	x	
TOTAL		6	20	24	4

*Mark with an "X" if applicable.

After completing the checklist of best practices, the data analysts clearly preferred the redesigned version, with 24 positive answers out of 28 questions.

The BI Manager had this to say: "In general terms, the new version of the dashboard represents a very solid qualitative leap. Compared to the previous version, the difference is striking. Not just in terms of design, but mainly in the way the data is presented.

The structure is more in line with what is expected of a decision support dashboard. The hierarchy of information is clearer, the main KPIs are clearly visible at the top, and then we go down to more specific analyses. This helps a lot with quick reading and allows any user, even without a technical background, to see what's going on straight away.

It's noticeable that care has been taken to adapt the type of visualization to the nature of the data, and that's something I really value, because it's not enough to show numbers, they need to tell a story. And here the dashboard already begins to do that. Another strong point is visual uniformity. Consistent colors, good spacing and legible fonts. All this contributes to cleaner and more professional experience.

Of course, there is still room for improvement. For example, I think it still lacks a bit of analytical depth on certain points. It doesn't have *drill-throughs* or more detailed explanations next to the KPIs, which could be useful for those who want to go beyond a macro view. It would also be interesting to ensure that this dashboard had a lighter or more responsive version, especially with users consulting it via mobile devices in mind.

But overall, the evolution of the dashboard is very satisfactory. This version is much more in line with good BI practices. It's definitely been a good overhaul."

Table 3.4 - Best Practices Checklist for Dashboards - BI Manager

Best Practices Checklist for Dashboards		Current dashboard		Reformulated dashboard	
Theme	Question	Yes*	No*	Yes*	No*
Organization and Information Hierarchy	Does the dashboard have a logical and intuitive structure?		x	x	
	Are important pieces of information highlighted?		x	x	
	Are the data organized in a coherent manner?		x	x	
	Does the layout follow a natural reading flow?		x	x	
Design and Data Visualization	Does the dashboard follow Gestalt principles?		x	x	
	Is there a balance between graphics, tables, and explanatory text?		x	x	
	Is the use of colors consistent and does it facilitate data interpretation?		x	x	
	Are colors used meaningfully (e.g., green for growth, red for decline)?		x	x	
	Does the dashboard avoid excessive use of vibrant colors?		x	x	
	Is the page space used appropriately?		x	x	
Usability and Interactivity	Are the graphs chosen according to the type of data?		x	x	
	Does the dashboard have interactive filters?	x		x	
	Are the filters and slicers well positioned and easy to use?		x	x	
	Are drill-through and drill-down options available for detailed analysis when needed?		x		x
	Is navigation between different dashboard sections intuitive?		x	x	
Clarity and Data Understanding	Is the dashboard loading time fast and optimized?	x		x	
	Do all charts and tables have clear or self-explanatory titles?		x	x	
	Are legends and labels used when necessary to facilitate reading?		x	x	
	Are the metrics and units clearly indicated (e.g., millions, %, units)?		x	x	
	Does the dashboard avoid unnecessary technical jargon that may confuse users?	x		x	
Accessibility and Responsiveness	Are short explanations available for more complex metrics, if needed?		x	x	
	Is the dashboard accessible for different types of users?		x	x	
	Is the font size and visual elements appropriate for reading on different devices?		x	x	
	Is the design responsive and does it work well on smaller screens (e.g., tablets or laptops)?		x		x
Validation and Feedback	Does the dashboard allow data export for additional analysis?	x		x	
	Was the dashboard tested by real users before launch?				x
	Were the design and functionalities validated by BI and data visualization specialists?			x	
	Does the dashboard follow best practices recommended in the literature review?		x	x	
TOTAL		4	22	25	3

*Mark with an "X" if applicable.

Like the Data Analyst, the BI Manager's opinion is relatively identical, with 25 positive answers out of 28 questions.

For a more objective assessment and to enable comparison with the experts' answers, it was also filled in by me. Filling it out allowed me not only to compare the experts' answers, but also to carry out a self-assessment to check whether what had been proposed had been fulfilled.

Table 3.5 - Best Practices Checklist for Dashboards - Personal Evaluation

Best Practices Checklist for Dashboards		Current dashboard		Reformulated dashboard	
Theme	Question	Yes*	No*	Yes*	No*
Organization and Information Hierarchy	Does the dashboard have a logical and intuitive structure?	x		x	
	Are important pieces of information highlighted?		x	x	
	Are the data organized in a coherent manner?		x	x	
	Does the layout follow a natural reading flow?		x	x	
Design and Data Visualization	Does the dashboard follow Gestalt principles?		x	x	
	Is there a balance between graphics, tables, and explanatory text?		x	x	
	Is the use of colors consistent and does it facilitate data interpretation?		x	x	
	Are colors used meaningfully (e.g., green for growth, red for decline)?		x	x	
	Does the dashboard avoid excessive use of vibrant colors?		x	x	
	Is the page space used appropriately?		x	x	
	Are the graphs chosen according to the type of data?		x	x	
Usability and Interactivity	Does the dashboard have interactive filters?	x		x	
	Are the filters and slicers well positioned and easy to use?	x		x	
	Are drill-through and drill-down options available for detailed analysis when needed?		x		x
	Is navigation between different dashboard sections intuitive?		x	x	
	Is the dashboard loading time fast and optimized?	x		x	
Clarity and Data Understanding	Do all charts and tables have clear or self-explanatory titles?		x	x	
	Are legends and labels used when necessary to facilitate reading?		x	x	
	Are the metrics and units clearly indicated (e.g., millions, %, units)?		x	x	
	Does the dashboard avoid unnecessary technical jargon that may confuse users?	x		x	
	Are short explanations available for more complex metrics, if needed?		x	x	
Accessibility and Responsiveness	Is the dashboard accessible for different types of users?		x	x	
	Is the font size and visual elements appropriate for reading on different devices?		x	x	
	Is the design responsive and does it work well on smaller screens (e.g., tablets or laptops)?		x		x
	Does the dashboard allow data export for additional analysis?	x		x	
Validation and Feedback	Was the dashboard tested by real users before launch?				x
	Were the design and functionalities validated by BI and data visualization specialists?			x	
	Does the dashboard follow best practices recommended in the literature review?		x	x	
TOTAL		6	20	25	3

*Mark with an "X" if applicable.

As can be seen in table 3.5, the self-assessment is in line with the experts' responses, thus ensuring that the reformulated version is not only better but also meets the criteria of good data visualization practices.

3.1.5.2. Quantitative Insights & Limitations

Although this study did not include formal usability testing or quantitative user experiments, some potential efficiency gains can be inferred based on the improvements introduced in the redesigned version. The new layout prioritizes key performance indicators (KPIs), reduces visual clutter, and introduces a clearer information hierarchy, which is recognized in the literature as contributors to faster data interpretation.

The checklist-based evaluation carried out by specialists reinforced these perceived improvements, highlighting better clarity, logical organization, and easier navigation.

Despite these advances, certain limitations persist. The dashboard remains optimized for desktop usage and is not responsive on tablets or smartphones, which may hinder accessibility for users on mobile platforms. Furthermore, features such as drill-through and drill-down, which allow deeper data exploration, were not fully implemented in this version.

These aspects represent relevant opportunities for future development and testing, especially through structured usability tests that could capture concrete metrics such as task completion time, number of interactions, and user satisfaction.

3.1.6. Communication

The communication phase is the last step in Design Science Research Methodology (DSRM) and plays a critical role in consolidating and disseminating the knowledge generated throughout the research process. Its main objective is to ensure that the developed artifact and the insights derived from its evaluation are appropriately shared with both academic and professional audiences, thus extending the impact of the study beyond the scope of the project itself.

In this dissertation, communication is primarily achieved through the structured documentation of all phases of the research: from the initial identification of the problem and definition of objectives, through the design and development of the reformulated dashboard, to its demonstration and evaluation. This document not only describes the methodological path followed but also presents empirical evidence that supports the improvements implemented, providing a relevant contribution to the field of data visualization and BI.

Moreover, the results of this work are suitable for dissemination within the organizational environment of the BECX project. This includes technical teams, analysts, and strategic decision-makers, who may benefit from the improved dashboard and the best practices identified. Internal knowledge-sharing sessions, workshops, or even the creation of a reference guide summarizing dashboard design guidelines could be viable ways to promote reuse and scalability of the artifact.

Ultimately, the communication stage reinforces the study's dual commitment to scientific rigor and practical relevance, ensuring that the results are accessible, applicable, and reusable by professionals and researchers involved in dashboard development and customer experience analysis.

4. Empirical Study

This chapter presents the empirical implementation of the redesigned BECX dashboard, following the six-step process outlined by the DSRM in the previous chapter.

The methodology described in Chapter 3 was applied directly to the dashboard optimization process. After identifying key limitations in the original version and defining clear objectives for improvement, mockups were created in Power BI and iteratively refined based on design principles such as Gestalt laws, visual hierarchy, and UX/UI guidelines.

The design and development phase resulted in a dashboard prototype with a more intuitive structure, improved color palette, prioritization of KPIs, and enhanced interactivity.

The artifact was then applied to the actual BECX context and validated through expert review, as will be further detailed in the next chapter.

This empirical implementation not only reflects the methodological rigor of the DSRM but also bridges theory and practice by addressing real user needs in a business intelligence context. The next chapter presents the results of the expert evaluation and discusses their implications for usability, decision-making, and future improvements.

5. Results and Discussion

This chapter presents the evaluation of the redesigned BECX dashboard, focusing on the outcomes of its assessment and the implications of the improvements introduced.

To assess the quality of the new version, two experienced BI professionals (Data Analyst and a BI Manager) were invited to review both the original and reformulated dashboards. Using a checklist derived from visualization and usability principles, they provided structured feedback on various aspects such as layout, prioritization of KPIs, color use, and interactivity. Both experts acknowledged a significant enhancement in visual clarity, usability, and navigational flow. The redesigned interface was described as more intuitive, with a clearer structure that facilitates understanding and interpretation of data.

One of the key observations was the improved focus on decision-critical metrics, achieved through the application of visual hierarchy, Gestalt principles, and UX/UI design techniques. The integration of interactive elements such as navigation buttons and filter panels contributed to a more dynamic and user-centered experience, enabling users to explore relevant information without feeling overwhelmed.

Despite the overall positive assessment, some limitations were also identified. Both experts noted the absence of drill-through capabilities, which restricts the depth of data exploration, and pointed out that the dashboard was optimized primarily for desktop use, lacking responsiveness for mobile or tablet devices. These observations do not detract from the progress achieved but rather offer a foundation for future enhancements.

The evaluation confirms that a structured and principled design approach can lead to tangible improvements in dashboard usability and effectiveness. Moreover, the process used in this dissertation, combining methodological rigor with practical validation, offers a replicable framework for future business intelligence projects aiming to align user needs with visual analytics tools.

6. Conclusions and Future Research

The main aim of this dissertation was to evaluate and reformulate the dashboard currently used in the BECX project, to make it more effective, intuitive and in line with good data visualization practices. This need arose from several limitations in the original version of the dashboard, namely in terms of visual hierarchy, information overload, the inadequacy of certain graphic elements and navigability, compromising its usefulness as a decision support tool.

Using the Design Science Research (DSRM) methodology, the existing dashboard was critically and systematically analyzed, its weaknesses identified and a reformulation proposed. The new version was designed based on fundamental principles of dashboard design, such as the application of Gestalt principles, the use of color theory to enhance readability and highlight relevant information, and the adoption of good UX/UI practices to improve the user experience.

The reformulated proposal was evaluated using a checklist of good data visualization practices developed from the literature review, as well as gathering expert opinions from two professionals in the field of BI. The evaluations obtained show a significant improvement in the proposed solution compared to the original version, highlighting the clarity of the information, the valorization of the main indicators (KPIs), visual coherence and increased usability. Although opportunities for improvement were identified, particularly in terms of the depth of analysis (drill-through) and the responsiveness of the interface, the results obtained allow us to conclude that the objectives outlined were fully achieved.

The redesign of the BECX dashboard thus demonstrated that the adoption of structured design principles and good data visualization practices can have a positive impact on the perception and interpretation of information by users, promoting more informed and effective decisions. In addition to the direct contribution to improving the BECX project dashboard, this work is a practical and methodological reference that can be replicated in similar contexts, contributing to the advancement of practices in BI.

Future work may explore four directions: (1) conducting usability tests with a representative sample of end users to obtain more robust feedback on interaction and comprehension; (2) developing a mobile-responsive version of the dashboard to improve accessibility across devices; (3) integrating drill-through and drill-down capabilities to enable deeper data exploration; and (4) applying storytelling techniques and contextual tooltips to highlight key trends and guide interpretation.

In addition to the direct contribution to improving the BECX project dashboard, this work presents both practical and theoretical contributions. On a practical level, it offers a concrete framework for redesigning dashboards based on usability principles, which can be

replicated across similar BI tools. Theoretically, the integration of design and visualization principles into a structured methodology such as DSRM reinforces the importance of user-centered evaluation in dashboard development and adds to the growing academic discussion on effective visual analytics.

In short, this dissertation contributes not only to the concrete improvement of an existing tool, but also to the advancement of applied knowledge in data visualization and BI.

Bibliographical References

Amount of Data Created Daily (2024). (2023, March 16). Exploding Topics.

<https://explodingtopics.com/blog/data-generated-per-day>

Chaudhuri, S., Dayal, U., & Narasayya, V. (2011). An overview of business intelligence

technology. *Commun. ACM*, 54(8), 88–98. <https://doi.org/10.1145/1978542.1978562>

Chen, H., Chiang, R. H. L., & Storey, V. C. (2012). Business Intelligence and Analytics: From

Big Data to Big Impact. *MIS Quarterly*, 36(4), 1165–1188.

<https://doi.org/10.2307/41703503>

Começar com o Google Trends | Central da Pesquisa Google | Documentação. (n.d.).

Google for Developers. Retrieved January 13, 2025, from

<https://developers.google.com/search/docs/monitor-debug/trends-start?hl=pt-br>

COVID-19 Map. (n.d.). Johns Hopkins Coronavirus Resource Center. Retrieved January 12,

2025, from <https://coronavirus.jhu.edu/map.html>

dastaffo. (n.d.). *Training for Power BI*. Retrieved January 13, 2025, from

<https://learn.microsoft.com/en-us/training/powerplatform/power-bi>

Data Governance & Business Intelligence: Your Ultimate Guide! (n.d.). Retrieved January

13, 2025, from <https://atlan.com/data-governance-business-intelligence/>

Domo Resource—Benefits and Challenges of Data Governance. (n.d.). Retrieved January

13, 2025, from <https://www.domo.com/learn/article/data-governance-benefits>

Easy Data Governance with BI Solutions | Grow.com. (n.d.). Retrieved January 13, 2025,

from <https://www.grow.com/blog/easy-data-governance-with-bi-solutions>

Getting started with dashboards—Microsoft Support. (n.d.). Retrieved January 13, 2025,

from <https://support.microsoft.com/en-us/office/getting-started-with-dashboards-edc6a32c-85c5-443d-9103-56dcc7bb24a4>

Guest, S. A. P. (n.d.). *SAP BrandVoice: How Big Data Keeps Planes In The Air*. Forbes.

Retrieved January 13, 2025, from <https://www.forbes.com/sites/sap/2015/02/19/how-big-data-keeps-planes-in-the-air/>

- Information Dashboard Design: The Effective Visual Communication of Data* / S. Few. (n.d.). ResearchGate. Retrieved June 22, 2025, from https://www.researchgate.net/publication/31860304_Information_Dashboard_Design_The_Effective_Visual_Communication_of_Data_S_Few
- Kelley, S. W., & Turley, L. W. (2001). Consumer perceptions of service quality attributes at sporting events. *Journal of Business Research*, 54(2), 161–166. [https://doi.org/10.1016/S0148-2963\(99\)00084-3](https://doi.org/10.1016/S0148-2963(99)00084-3)
- Khatuwal, V. S., & Puri, D. (2022). Business Intelligence Tools for Dashboard Development. *2022 3rd International Conference on Intelligent Engineering and Management (ICIEM)*, 128–131. <https://doi.org/10.1109/ICIEM54221.2022.9853086>
- Marr, B. (n.d.). *How Walmart Is Using Machine Learning AI, IoT And Big Data To Boost Retail Performance*. Forbes. Retrieved January 13, 2025, from <https://www.forbes.com/sites/bernardmarr/2017/08/29/how-walmart-is-using-machine-learning-ai-iot-and-big-data-to-boost-retail-performance/>
- Moss, L. T. (with Internet Archive). (2003). *Business intelligence roadmap: The complete project lifecycle for decision-support applications*. Boston, MA : Addison-Wesley. <http://archive.org/details/businessintellig0000moss>
- O BECX. (n.d.). BECX. Retrieved September 28, 2024, from <https://becx.pt/o-becx/>
- O ECSI Portugal agora é BECX - ECSI Portugal. (n.d.). Retrieved September 28, 2024, from <https://ecsiportugal.pt/>
- Oliver, R. L. (2014). *Satisfaction: A Behavioral Perspective on the Consumer: A Behavioral Perspective on the Consumer* (2nd ed.). Routledge. <https://doi.org/10.4324/9781315700892>
- Pappas, L., & Whitman, L. (2011). Riding the Technology Wave: Effective Dashboard Data Visualization. In M. J. Smith & G. Salvendy (Eds.), *Human Interface and the Management of Information. Interacting with Information* (pp. 249–258). Springer. https://doi.org/10.1007/978-3-642-21793-7_29

(PDF) *A Primer on Partial Least Squares Structural Equation Modeling (PLS-SEM)*. (n.d.).

ResearchGate. Retrieved June 22, 2025, from

https://www.researchgate.net/publication/354331182_A_Primer_on_Partial_Least_Squares_Structural_Equation_Modeling_PLS-SEM

Qlik Sense—Market Share, Competitor Insights in Data Visualization. (n.d.). 6sense.

Retrieved January 13, 2025, from <https://www.6sense.com/tech/data-visualization/qlik-sense-market-share>

Sarikaya, A., Correll, M., Bartram, L., Tory, M., & Fisher, D. (2019). What Do We Talk About

When We Talk About Dashboards? *IEEE Transactions on Visualization and*

Computer Graphics, 25(1), 682–692. IEEE Transactions on Visualization and

Computer Graphics. <https://doi.org/10.1109/TVCG.2018.2864903>

Tavera Romero, C. A., Ortiz, J. H., Khalaf, O. I., & Ríos Prado, A. (2021). Business

Intelligence: Business Evolution after Industry 4.0. *Sustainability*, 13(18), Article 18.

<https://doi.org/10.3390/su131810026>

The 9 Best Analytics Tools For Data Visualization Available Today. (n.d.). Retrieved January

12, 2025, from [https://www.forbes.com/sites/bernardmarr/2020/05/22/the-9-best-](https://www.forbes.com/sites/bernardmarr/2020/05/22/the-9-best-analytics-tools-for-data-visualization-available-today/)

[analytics-tools-for-data-visualization-available-today/](https://www.forbes.com/sites/bernardmarr/2020/05/22/the-9-best-analytics-tools-for-data-visualization-available-today/)

The Big Book of Dashboards Visualizing Your Data Using Real-World Business Scenarios.

(n.d.). Studylib.Net. Retrieved January 13, 2025, from

<https://studylib.net/doc/26128745/the-big-book-of-dashboards--visualizing-your-data-using-r...>

The Great KPI Misunderstanding. (2015). In *Key Performance Indicators* (pp. 1–23). John

Wiley & Sons, Ltd. <https://doi.org/10.1002/9781119019855.ch1>

Understanding Customer Experience Throughout the Customer Journey—Katherine N.

Lemon, Peter C. Verhoef, 2016. (n.d.). Retrieved January 13, 2025, from

<https://journals.sagepub.com/doi/10.1509/jm.15.0420>

What Is Business Intelligence (BI)? | IBM. (2021, August 9).

<https://www.ibm.com/think/topics/business-intelligence>

What is Data Governance? | IBM. (2024, September 20).

<https://www.ibm.com/think/topics/data-governance>

Zeithaml, V. A., Bitner, M. J., & Gremler, D. D. (2017). *Services Marketing: Integrating Customer Focus Across the Firm*. McGraw-Hill Education.

