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THE USE OF UX MODELS AND TECHNIQUES IN THE CREATION OF BI DASHBOARDS: A SYSTEMATIC REVIEW OF THE LITERATURE

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ABSTRACT

This study presents a systematic review of the literature focused on the integration of User Experience (UX) techniques in the design of dashboards for Business Intelligence (BI). In a context of increasing volume and accessibility of data, dashboards emerge as essential tools to transform raw data into visual and actionable information, facilitating organizational decision-making. Through UX practices, it is possible to optimize the interaction and understanding of these interfaces, ensuring an intuitive and efficient experience for users. The search was conducted in the Web of Science and Scopus databases. The initial search resulted in 607 articles, later reduced to 10 studies after a careful analysis of relevance and adherence to the central theme. The methodology involved a bibliometric analysis and categorization of the selected studies, with the aim of identifying the most used UX practices, gaps in the literature, and directions for future research.

The results indicate that the application of UX techniques in BI dashboards increases their usability and effectiveness, promoting a better interaction experience with the interface. A diversity of approaches was observed, including, among others, the use of continuous feedback, user-centered design, and aesthetic-functional design principles. However, the review revealed limitations in the studies analyzed, especially with regard to the specificity of the types of dashboards and the detailed characterization of the target audiences, which may hinder the replicability and practical application of the proposed models.

This article contributes to the field of BI dashboard design by highlighting UX best practices, suggesting a path for developing methodologies that balance aesthetics, functionality, and usability. The relevance of the findings is evident to BI and UX practitioners and researchers, offering a foundation for advancing academic and practical understanding in creating more intuitive and effective dashboards.

Keywords: User Experience, Dashboards, Business Intelligence, User Experience, Business Intelligence.

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INTRODUCTION

International Data Corporation (IDC) has published its annual DataSphere and StorageSphere forecasts, which measure the amount of data created, consumed, and stored in the world each year. According to IDC's findings, the amount of data created and replicated experienced exceptionally high growth in 2020 due to the dramatic increase in the number of people working, learning, and playing from home. "In 2020, 64.2 Zettabytes were created or replicated." (adaptation of free translation). (IDC, 2021) (accessed on 09-04-2023). As a consequence, the volume of structured and unstructured data produced grows exponentially every day, boosting, among other factors, competition between companies and the decision-making process.

The dissemination of information through the internet, as well as the popularization of computing devices, has democratized access to data and technology. Castells (2011, p. 1) observes that "at the end of the second millennium of the Christian Era, several events of historical importance transformed the social scenario of human life. A technological revolution concentrated in information technologies has begun to reshape the material base of society at a rapid pace." This revolution has directly impacted the way organizations collect, process, and use not only their data, but also public data.

In this scenario, the use of Business Intelligence (BI) has emerged as a strategic resource in the business context, providing tools and methodologies to transform raw data into valuable information for decision-making.

From the significant reduction in the cost of computers and data processing, a new type of BI emerged, called self-service, whose objective is to bring data analysis tools closer to end users, facilitating the development of reports without the need for in-depth technical knowledge. The company Qlik, one of the references in the BI sector, describes that self-service BI:

> Enables business users to explore data and generate insights, as well as create dashboards or reports, without relying on IT, data scientists, or analysts. The premise of self-service BI is to give all employees access to insights that will help them make better decisions, regardless of their analytical skills. (Qlik, accessed on 06/16/2024).

Tools such as Power BI, Tableau, and Qlik Sense have made it possible for professionals without technical training in computing to manipulate large volumes of data, synthesizing them into presentations, reports, and dashboards useful for the decision-making process. Simão (2021, p. 28) points out that "this new BI modality emerged with the intention of bringing the tools closer to the people who will perform the data analysis, and it is not necessary to have in-depth knowledge of the technology to start developing reports."

One of the most widely used types of data outputs today are dashboards, which, as defined by Few (2013, p. 26), is "a visual display of the most important and necessary information to achieve one or more objectives, consolidated on a single computer screen so that it can be monitored quickly." Dashboards are essential tools for data visualization, allowing critical information to be accessed quickly and efficiently, facilitating decision-making.

A dashboard can turn business questions into visuals with little or, hopefully, almost no bias, allowing the user to make decisions as clearly as possible. It works as an interpretation of data transformed into information that becomes knowledge when the user makes a value judgment, absorbs the visuals and moves in the direction of making a decision. It should be noted that the poor development of a dashboard can induce the user to make a wrong decision, compromising the effectiveness of the decision-making process.

To ensure that dashboards fulfill their role effectively, it is necessary to use the best practices of service design, including User Experience (UX) techniques. A good user experience can significantly improve the usability and efficiency of a dashboard, ensuring that users can navigate and interpret data intuitively and without frustration.

The application of UX practices in dashboard design is one of the main steps to create interfaces that not only present data clearly, but also facilitate interaction and understanding by users, promoting more assertive and accurate decision-making.

This study aims to carry out a systematic review of the literature to survey the state of the art on the use of UX models and techniques in the creation of BI dashboards. Through this review, it is intended to identify the best practices, the main trends and the gaps existing in the current research, providing a solid basis for future studies and for the development of methodologies that integrate UX and BI effectively.

METHODOLOGY

The stages of search, extraction and treatment of bibliographic references will be described below, thus ensuring the possibility of replicating the methodology, making it systematic.

The search was carried out between May and June 2024, in the "Web of Science" and "Scopus" databases, two of the main repositories of academic articles in the areas of Design and Business.

The search was made in the title and abstract options, being carried out individually, using the string "("user experience" or "UX") AND ("dashboard" OR "dashboards" OR "data

visualization" OR "dataviz")". The string creation tactic was based on the combination of the three keywords and their variations, thus filtering relevant articles for the search.

The result is below.

Table 1 – Search *string* result

Base	Search Type	Combined keywords	Returns
Scopus	Title	(“user experience” or “UX”) AND (“dashboard” OR “dashboards” OR “data visualization” OR “dataviz”)	18
Scopus	Summary	(“user experience” or “UX”) AND (“dashboard” OR “dashboards” OR “data visualization” OR “dataviz”)	403
Web of science	Title	(“user experience” or “UX”) AND (“dashboard” OR “dashboards” OR “data visualization” OR “dataviz”)	10
Web of science	Summary	(“user experience” or “UX”) AND (“dashboard” OR “dashboards” OR “data visualization” OR “dataviz”)	176
Total			607

Source: The authors

The next step was to tabulate the metadata of the results, considering the variables Title, Author(s), Year of publication, DOI, Type of document and source base. With the structured table, 194 duplicate titles were identified and excluded.

The next step consisted of reading the titles of each article to raise their adherence to the UX theme and BI dashboards. For the title to be selected, it had to respect one of the following rules:

- Have one of the strings ("BI dashboard" or "BI" or "business intelligence" or "business data" or "business management" or "business analytics" or "business process"); or
- Have one of the strings ("UX" or user experience" or "usability") and ("visualization" or "data visualization" or "dataviz" or "information design" or "data design" or "service design" or "user interface design")

As a result, 376 articles were excluded, leaving 37 for abstract analysis.

The final selection of articles for individual analysis was prepared considering a simple matrix that combines content relevance and adherence to the central theme, based on the following evaluation criteria:

- Content Relevance:
  - Level 1: The summary mentions UX or BI dashboards in a superficial way, without going deeper.
  - Level 2: The brief covers UX or BI dashboards, but does not explore the intersection between the two themes.
  - Level 3: The summary discusses the intersection between UX and BI dashboards, but does not offer a detailed study or robust conclusions.

- Level 4: The summary provides a detailed and well-founded analysis on the intersection between UX and BI dashboards, with case studies, empirical data, or a comprehensive theoretical review.

- Adherence to the Central Theme:
  - Level 1: The abstract is tangentially related to the objective of the systematic review.
  - Level 2: The abstract has some relationship, but it is not the main focus.
  - Level 3: The abstract is aligned with the purpose of the review, but may differ in some aspects.
  - Level 4: The abstract is fully aligned with the objective of the systematic review.

It is noteworthy that abstracts without any adherence or relevance were discarded. As a rule of maintenance in the list, articles with levels 3 and 4 were selected. After the process, 27 studies were excluded, leaving 10 for full reading and analysis.

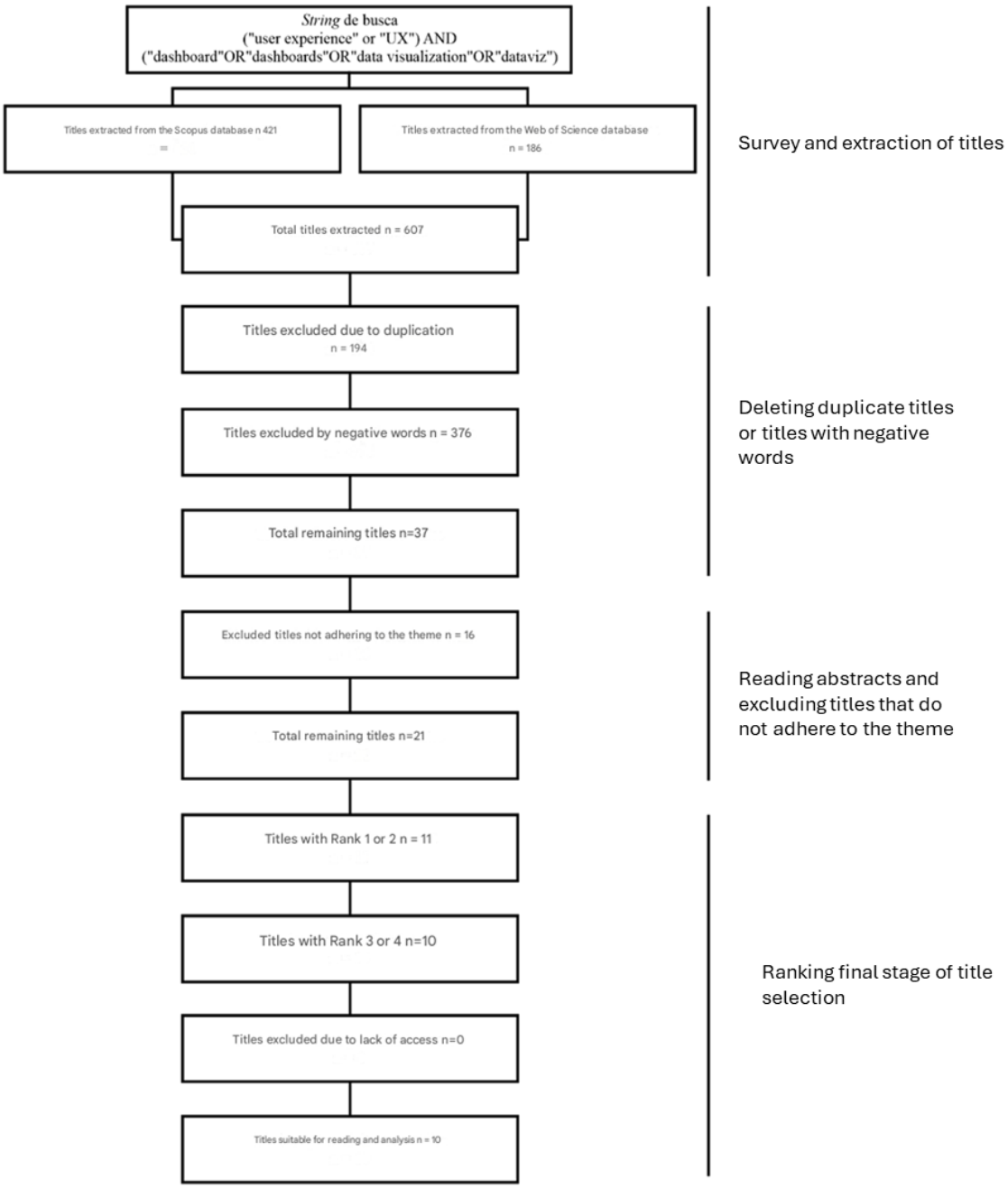
The next step was to download the documents. The final list of studies to be analyzed included eight documents, listed below.

Table 2 – List of Articles for analysis

ID	Title	Level Interest
ID-01	Beyond Usability and Performance: A Review of User Experience-focused Evaluations in Visualization	3
ID-02	Data Visualization Model Based on the User Experience	3
ID-03	Proposing a Perceived Expertise Tool in Business Data Analytics	3
ID-04	A Conceptual UX Model for Designing and Developing the Business Intelligence Dashboards	4
ID-05	APPLIED DESIGN THINKING FOR KIMBALL LIFECYCLE TO IMPROVE BUSINESS INTELLIGENCE DASHBOARD USABILITY	4
ID-06	Design Principles in the Development of Dashboards for Business Management	4
ID-07	Proposed User-Experience Model for the Design and Development of BI Dashboards	4
ID-08	Towards a Conceptual UX Framework for BI dashboards	4
ID-09	USE OF EMOTION IN DESIGNING BI DASHBOARDS	4
ID-10	User-Experience in Business Intelligence – A Quality Construct and Model to Design Supportive BI Dashboards	4

Source: The authors

Figure 1 - Summary of the process of selecting articles for analysis



Source: The authors

RESULTS

The systematic review began with 607 works that could be used. After a screening process, ten relevant titles were selected for reading and a survey of the state of the art. The details of these works are presented below.

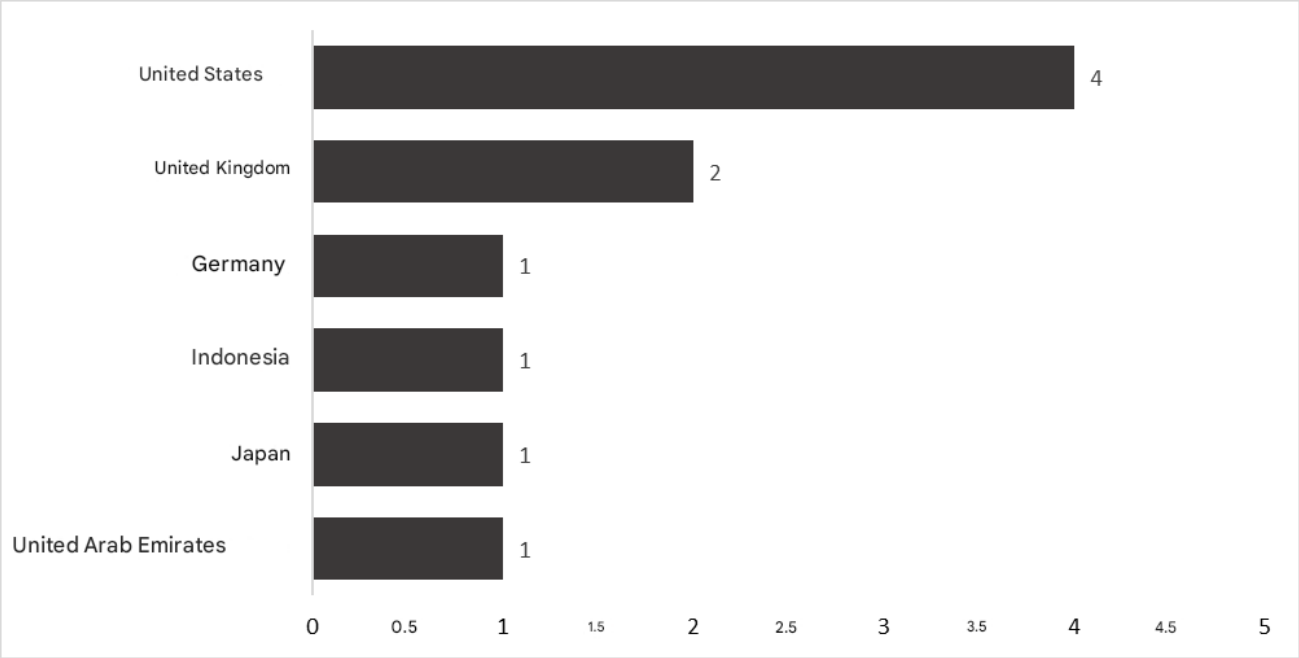
Table 3 – Details of the selected titles

ID	Title	Authors	Anus	Newspaper	Languag e	Country of Publication
ID-01	Beyond Usability and Performance: A Review of User Experience-focused Evaluations in Visualization	Bahador Saket, Alex Endert and John Stasko	2016	BELIV '16: Proceedings of the Sixth Workshop on Beyond Time and Errors on Novel Evaluation Methods for Visualization	English	United States
ID-02	Data Visualization Model Based on the User Experience	Wen Wang, Yanan Hu and Jiaofei Huo	2020	Journal of Physics: Conference Series	English	United Kingdom
ID-03	Proposing a Perceived Expertise Tool in Business Data Analytics	Panagiotis Germanakos, Zacharias Lekkas, Christos Amyrotos e Panayiotis Andreou	2021	UMAP '21: Adjunct Proceedings of the 29th ACM Conference on User Modeling, Adaptation and Personalization	English	United States
ID-04	A Conceptual UX Model for Designing and Developing the Business Intelligence Dashboards	Apoorva Muppidi, Ahmad Sobri Hashim, Mohd Hilmi Hasan and Aminu Aminu Muazu	2023	Journal of Computer Science	English	United Arab Emirates
ID-05	APPLIED DESIGN THINKING FOR KIMBALL LIFECYCLE TO IMPROVE BUSINESS INTELLIGENCE DASHBOARD USABILITY	Johannes Farrell Landutama and Andry Chowanda	2023	International Journal of Innovative Computing, Information and Control	English	Japan
ID-06	Design Principles in the Development of Dashboards for Business Management	Nuno Martins, Susana Martins and Daniel Brandão	2022	Perspectives on Design II	English	United States
ID-07	Proposed User-Experience Model for the Design and Development of BI Dashboards	Apoorva Muppidi, Ahmad Sobri B Hashim e Mohd Hilmi Bin Hasan	2022	International Conference on Intelligent Cybernetics Technology & Applications (ICICyTA)	English	Indonesia
ID-08	Towards a Conceptual UX Framework for BI dashboards	Marcus Eriksson e Bruce Ferwerda	2019	Journal of Computer Information Systems	English	United Kingdom
ID-09	USE OF EMOTION IN DESIGNING BI DASHBOARDS	Petr Průcha e Petra Kašparová	2021	Researchgate	English	Germany
ID-10	User-Experience in Business Intelligence - A Quality Construct and Model to Design Supportive BI Dashboards	Corentin Burnay, Sarah Bouraga, Stephane Faulkner e Ivan J. Jureta	2020	SpringerLink	English	United States

Source: The authors

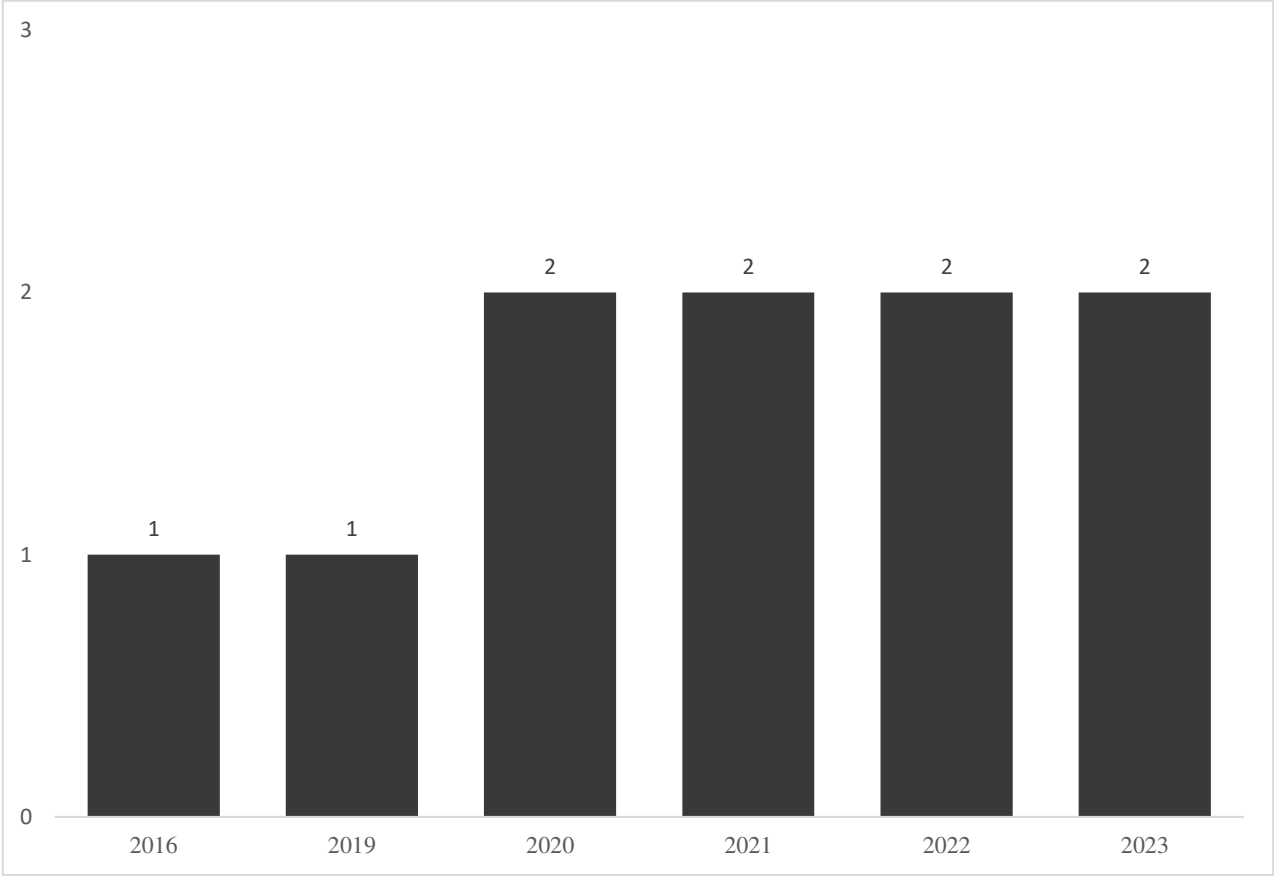
The ten articles were published in different journals or academic events, from 2016 to 2023. All studies were written in English. The distribution of articles by place and year of publication is presented below.

Graph 1 - Distribution of articles by place of publication



Source: the authors

Graph 2 - Number of titles by year of publication



Source: the authors

The analysis of the previous graphs reveals that 60.0% of the works were published in the last three years, evidencing the relevance of the theme in the contemporary academic context. This concentration of recent publications highlights the growing

importance of integrating UX into BI dashboards, suggesting an emerging research trend and the need to deepen knowledge in this area.

The next step was to read the ten previously selected articles. To ensure a systematic and uniform analysis, allowing the identification of patterns, gaps and best practices in the application of UX techniques in BI dashboards, ten guiding questions were created, described in the following table.

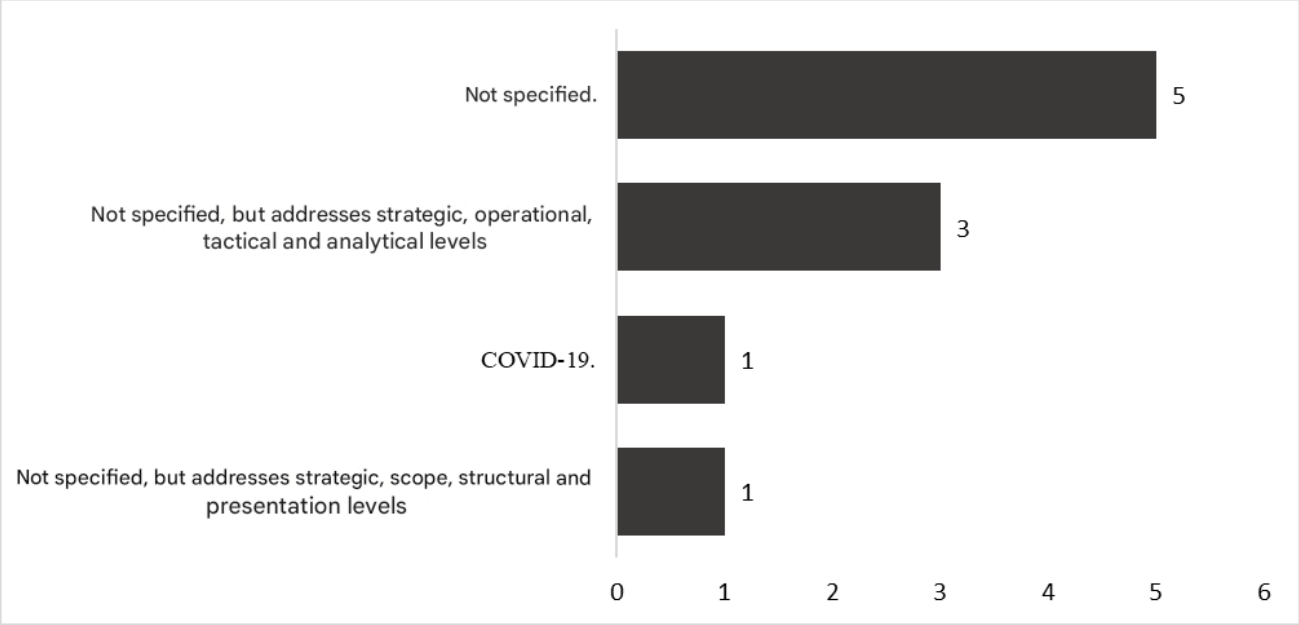
Table 4 – Guiding questions

Group	Question
General	What types of dashboards are described in the articles?
	Who are the target audiences for the dashboards discussed?
	Does the article cover creating visuals (graphs and charts)?
UX Techniques and Methodologies	What UX techniques are applied in the construction of these dashboards?
	What are the main UX challenges identified in the creation of dashboards?
Methodology and Approach to Studies	What is the methodology used in the article?
	Is the research qualitative, quantitative or qualitative-quantitative?
	If the study collected and processed data, did it use primary or secondary sources?
Results and Evaluations	What was the result of the survey?
	What are the limitations pointed out by the study?

Source: the authors

The following is the result of the reading and analysis based on the guiding questions.

Graph 3 – What types of dashboards are described in the articles?



Source: the authors

The vast majority (90.0%) of the articles analyzed did not describe a certain type of dashboard used as an example in the research, and only one study (ID-05) presented a specific model, with analysis of the layout of a dashboard that has COVID-19 as its theme around the world.

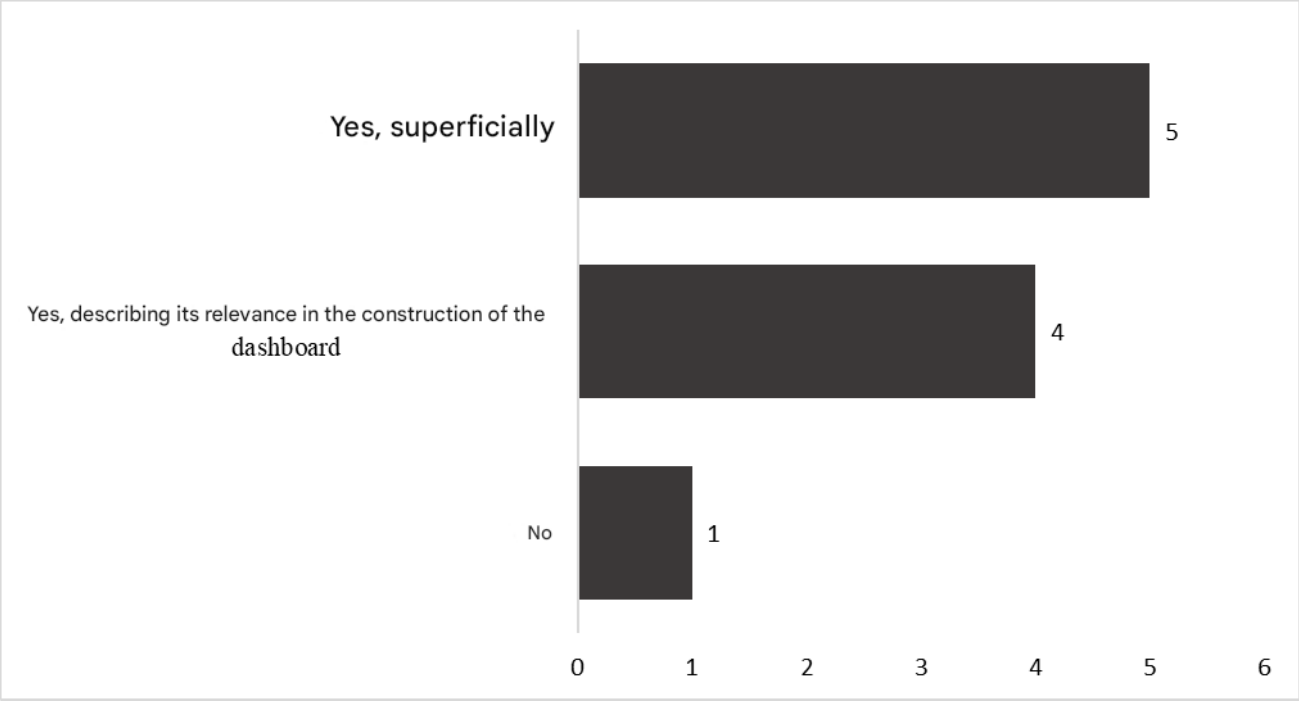
Of the total number of articles, five (50.0%) did not mention anything about the characteristics or types of dashboards used in the BI process and four (40.0% | ID-02; ID-04; ID-06; ID-07) mentioned the divisions of dashboard levels, but without giving real examples.

The lack of specificity indicates that most of the articles (90.0%) focused on more general or theoretical aspects of the dashboards, without delving into their functional or visual particularities.

It is concluded that there is a gap in the exemplification and characterization of dashboards in UX and BI studies. This deficiency may hinder the replicability and practical application of the conclusions of these studies. The lack of specificity in the description of the types of dashboards analyzed suggests a need for greater clarity and precision in future research.

It is evident that there is a balance between the articles that specified the target audience of their dashboards and those that did not. In some studies, the focus was on the dashboard developer rather than their users. Although all of them mentioned the relevance of the user experience, the absence of specification of the target audience in half of the articles suggests that there is a gap in the contextualization of the use of dashboards, a fact that compromises the replication of proposed models.

Graph 4 - Does the article address the creation of visuals (graphs and tables)?



Source: the authors

The correct choice and optimization of the visual configuration (graphs and tables) represent a relevant factor in the construction of a dashboard layout, as a decision can be influenced from its interpretation.

Of the total universe of articles analyzed, only one (10.0% | ID-03) did not mention anything about graphs and tables. Despite five (50.0% | ID-01; ID-05; ID-07; ID-08; ID-09) studies addressed the topic superficially and the rest (four, 40.0%, ID-02; ID-04; ID-06; ID-10) highlight the relevance of the best choice and configuration of the visual, none of them describes in more depth how visuals can influence the UX, a fact that can weaken the study due to the importance of this stage of dashboard elaboration.

Table 5 – What UX techniques are applied in the construction of these dashboards?

Tool	ID-01	ID-02	ID-03	ID-04	ID-05	ID-06	ID-07	ID-08	ID-09	ID-10	Total
User literacy	0	0	0	1	0	0	1	0	0	0	2
Analysis of the number of graphic elements	0	0	0	0	0	0	0	0	1	0	1
Business Intelligence Model (BIM)	0	0	0	0	0	0	0	0	0	1	1
Dashboard Development Cycle (DDLC)	0	0	0	1	0	0	1	0	0	0	2
Collection of requirements from users	0	0	0	0	0	0	1	1	0	0	2
Context of use	0	0	0	0	0	0	0	1	0	0	1
Creating white space	0	0	0	0	0	1	0	0	0	0	1
Design based on cognitive levels	0	1	0	0	0	0	0	0	0	0	1
Tactile and auditory interaction design	0	1	0	0	0	0	0	0	0	0	1
Interface design	0	0	0	0	0	1	0	0	1	0	2
Design thinking (empathy, definition, ideation, prototyping, and testing)	0	0	0	0	1	0	0	0	0	0	1
Fun	1	0	0	0	0	0	0	0	0	0	1
Commitment	1	0	0	0	0	0	0	0	0	0	1
Quality frameworks	0	0	0	0	0	0	0	0	0	1	1
Continuous feedback integration	0	0	0	0	0	0	0	1	0	0	1
UX laws not mentioned	0	0	0	0	1	0	0	0	0	0	1
Memorability	1	0	0	0	0	0	0	0	0	0	1
Modeling Notations	0	0	0	0	0	0	0	0	0	1	1

Perceived Expertise Tool (PET)	0	0	1	0	0	0	0	0	0	0	1
Agile and lean design principles	0	0	0	0	0	0	0	1	0	0	1
Information retention	1	0	0	0	0	0	0	0	0	0	1
Emotion recognition software (FaceReader)	0	0	0	0	0	0	0	0	1	0	1
Typography	0	0	0	0	0	1	0	0	0	0	1
Usability	0	0	0	1	0	0	1	0	0	0	2
Proper use of colors	0	0	0	0	0	1	0	0	0	0	1
Use of visual feedback	0	0	0	0	0	0	0	0	1	0	0
Total	4	2	1	3	2	4	4	4	4	3	31

Source: the authors

In all, 26 different UX techniques were addressed in the analyzed articles, representing a great diversity of tools. Among all, five (19.23% | User literacy; Dashboard Development Cycle (DDLC); Collection of requirements from users; Interface design; Usability) were mentioned in more than one article, presenting an indication of the most used UX tools for the elaboration of dashboard layouts.

Of the ten articles analyzed, seven (70.0% | ID-01; ID-04; ID-06; ID-07; ID-08; ID-09; ID-10) merged three or more UX techniques simultaneously. Despite evidencing results from experimental tests with focus groups, almost all of the tools did not have their concepts or forms of execution detailed.

Finally, the table illustrates a wide range of UX tools in the current literature, and this amount is only a cut of the total universe developed, a fact that reflects the complexity and multidimensionality involved in creating effective and user-centered dashboards.

Table 6 - What are the main UX challenges identified in the creation of dashboards?

ID	Answer: Key challenges include:
ID-01	Accurate measurement of memorability, the need to balance usability with fun, and the creation of visualizations that are both informative and enjoyable to use.
ID-02	Adapting visualizations to the different cognitive needs of users, creating a user experience that is intuitive and effective, and integrating different types of perceptions (visual, tactile, and auditory) in a cohesive way.
ID-03	Need to create visualizations that are understandable to users with different levels of expertise and the difficulty of measuring perceived expertise in a standardized way.
ID-04	Adaptation of visualizations to the different levels of knowledge of users, the integration of UX elements from the early stages of development and the maintenance of the quality of the data presented.
ID-05	Adapting visualizations to user needs, reducing visual complexity to avoid cognitive overload, and creating an intuitive user experience that allows for easy navigation and understanding of data.
ID-06	Creation of an interface that balances functionality and aesthetics, the appropriate choice of graphic elements to avoid information overload and ensure clarity, and the need to customize dashboards for different levels of users and contexts of use.
ID-07	Adapting visualizations to different levels of user expertise, ensuring that the data presented is relevant and understandable, and creating an interface that balances functionality and aesthetics.
ID-08	Adapting dashboards to different user skill levels, ensuring that the data presented is relevant and understandable, and creating an interface that balances functionality and aesthetics.
ID-09	Creating designs that balance the amount of information with visual clarity, avoiding cognitive overload for users, and adapting the designs to evoke positive emotions such as happiness and minimize negative emotions such as frustration.
ID-10	Ensuring the completeness and relevance of the information presented, avoiding information overload, and creating an interface that balances efficiency and expressiveness.

Source: the authors

The analysis of the challenges identified highlights, among other factors, the retention of information, the need to adapt visualizations to the different levels of expertise and degree of knowledge of users, the creation of interfaces that balance functionality and aesthetics, and the reduction of visual complexity to avoid cognitive overload.

These challenges reflect a central concern with the usability of dashboards, seeking to ensure that people with diverse types of skills and prior knowledge can interpret and use data effectively.

In short, the analysis of the challenges revealed the need to have a multidimensional view when creating BI dashboards, where the balance between aesthetics, functionality and usability plays a relevant role in the success of the solutions developed.

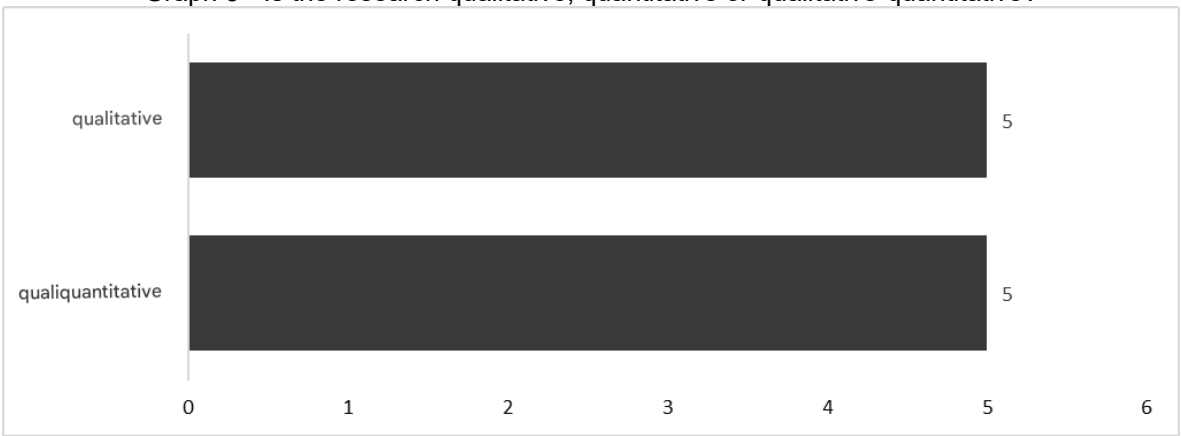
Table 7 - What is the methodology used in the article?

ID	Answer: The methodology
ID-01	involves a systematic review of the literature, categorizing studies based on UX objectives such as memorability, engagement, and fun, and evaluating the techniques and metrics used in these studies.
ID-02	It involves the proposal of a data visualization model based on cognitive levels, with the decomposition of the process into four layers: strategy, scope, structure, and presentation. Includes case studies to exemplify the application of the model.
ID-03	includes the creation and validation of the *Perceived Expertise Tool* (PET) based on theoretical models and psychometric properties. Preliminary validation was performed with 54 data analysis professionals.
ID-04	includes the literature review to identify UX and BI elements, the proposition of a UX model, and the validation of this model through focus group discussions (FGD) and thematic analysis using the NVivo 12 software.
ID-05	combines the traditional Kimball lifecycle with the design thinking process, incorporating the steps of empathy, definition, ideation, prototyping, and testing within the "BI *Application Track*" of the Kimball lifecycle. The usability evaluation was carried out through non-moderated usability tests.
ID-06	It includes a literature review on design principles and the application of these principles in the creation of dashboards for business management. The study also uses practical examples and use cases to illustrate how design principles are implemented in real dashboards.
ID-07	This study includes a literature review to identify UX factors and elements of BI dashboards, followed by the proposition of a UX model for the design and development of BI dashboards. Preliminary model validation is based on focus group discussions and thematic analysis.
ID-08	The use of the questionnaire includes a literature review to identify relevant UX factors, followed by unstructured and semi-structured interviews with professionals in the BI industry in Sweden. The development of the framework was iterative, with construction and evaluation stages.
ID-09	includes an experiment with six different BI dashboard designs, measuring users' emotions through FaceReader software as they performed specific tasks. The metrics analyzed include task time, clarity, appearance, and emotions (happiness, sadness, anger, surprise, fear, and disgust).
ID-10	The use of this study is Action *Research*, conducted with three Belgian companies, involving the collection of qualitative data through interviews, focus groups, participatory observations and field notes. Research was conducted over several iterations to develop and validate the UX framework.

Source: The authors

The diversity of methodologies presented, combined with the recent time period of publication of the works, reveals the relevance of the theme of this study in the current context of our society, very characterized by the profusion of data and the need for better practices in the decision-making process.

Graph 5 - Is the research qualitative, quantitative or qualitative-quantitative?

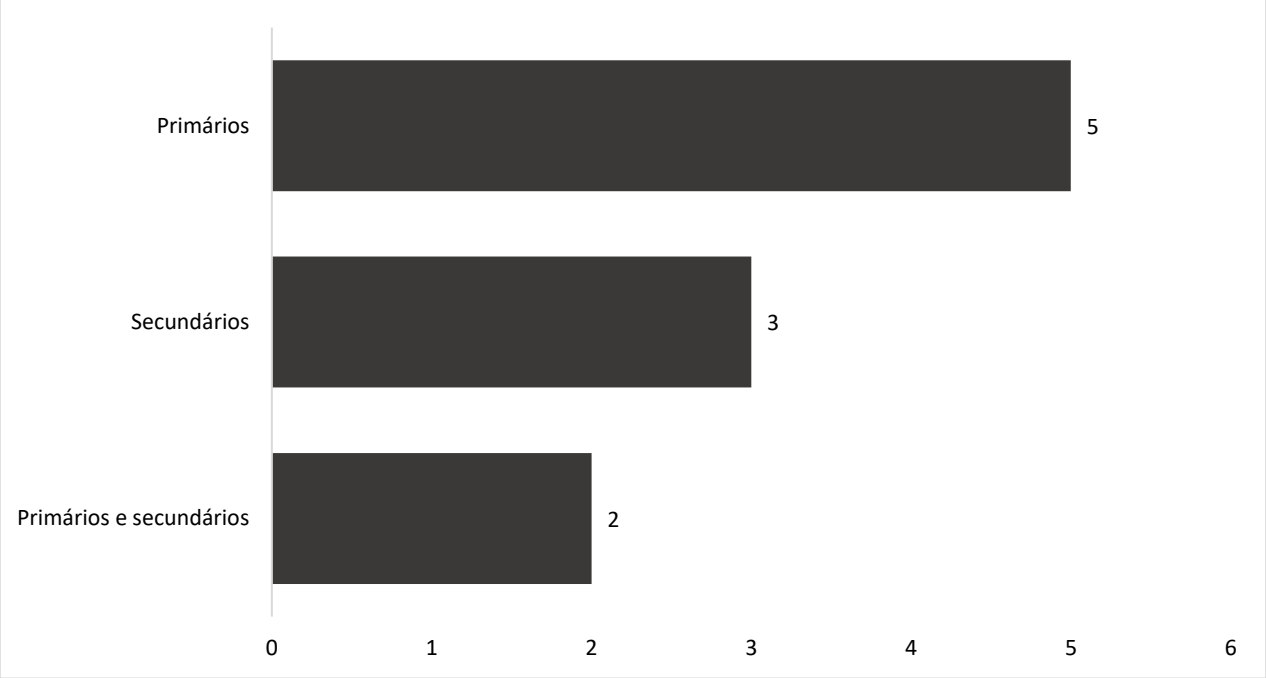


Source: The authors

Most studies (80.0%; ID-02, ID-03, ID-04, ID-05, ID-07, ID-08, ID-09 and ID-10) is focused on the creation of solutions, frameworks or models capable of assisting the development of BI dashboard layouts considering UX techniques. As a result of this characteristic, it is expected that qualitative or qualitative research will predominate, a fact that is proven by the graph above.

The structure of the qualitative and quantitative surveys combined analyses of practice tests with focus groups or interviews with structured data such as task time or information retention.

Graph 6 - If the study collected and processed data, did it use primary or secondary sources?



Source: the authors

The graph above corroborates the previous analysis, evidencing the predominant characteristic of studies in the creation of practical solutions for effective BI dashboard layouts.

Table 8 - What is the result of the research?

ID	Answer: The main result is
ID-01	Signaling that visualizations that include emotional elements, such as fun and engagement, can improve usability and the overall user experience.
ID-02	the proposal of a UX-based data visualization model, structured in four levels, which facilitates understanding and decision-making by integrating principles of human cognition and visual design.
ID-03	the preliminary validation of the Perceived Expertise Tool (PET), the model proposed in the article.
ID-04	the validation of a model, incorporating critical UX and BI elements that can be used as a guide for developers.
ID-05	the demonstration that integrating design thinking into the Kimball lifecycle significantly improves the usability and user experience of BI dashboards.
ID-06	the identification and recommendation of design principles that can be applied in the creation of dashboards to improve usability and effectiveness.
ID-07	the proposition of a new UX model for the design and development of BI dashboards, incorporating critical UX and BI elements that can be used as a guide for developers.
ID-08	the proposition of a scalable UX framework for BI systems, which covers everything from planning and strategy to implementation, maintenance and evaluation, aiming to improve usability and user experience.
ID-09	the confirmation that good UX and UI design is correlated with positive emotions like happiness, while messy and overloaded designs are associated with negative emotions like anger and disgust.
ID-10	the proposal of a new UX model for BI dashboards, called BIXM, which incorporates quality elements such as relevance, efficiency, and load balancing.

Source: the authors

Table 9 - What are the limitations pointed out by the study?

ID	Answer
ID-01	No limitations were pointed out.
ID-02	No limitations were pointed out.
ID-03	It is recommended that the replication of the model should perform exploratory and confirmatory factor analysis to verify the structure of the relationship between the variables, in addition to tests with a larger and more diverse sample.
ID-04	No limitations were pointed out.
ID-05	Developing BI with design thinking takes longer than the original Kimball lifecycle, due to the collaborative and iterative nature of design thinking. This time constraint represents a challenge that needs to be explored in future research to create a more efficient UX framework for time-constrained BI processes.
ID-06	No limitations were pointed out.
ID-07	The proposed model was not evaluated. It was mentioned that it will be evaluated in future works.
ID-08	No limitations were pointed out.
ID-09	The study suggests replicating the results in other applications, such as websites, software and mobile applications.
ID-10	No limitations were pointed out.

Source: the authors

DISCUSSION

The present work presents some discussions that should be considered in the interpretation of its results, namely:

- Review Period: The systematic review was carried out in a specific period, between May and June 2024. Consequently, new studies relevant to the topic may have been published after the end of data collection, which may impact the scope and timeliness of the conclusions presented.
- Databases Used: The search for articles was restricted to the Web of Science and Scopus databases. Although these databases are widely recognized for their quality

and comprehensiveness, it is possible that relevant studies indexed in other databases were not included in the review. This limitation may result in a partial view of the state of the art, underestimating the diversity of approaches and results available in the literature.

- Translation and Interpretation: Although rigorous methods have been employed to ensure accuracy in the translation and analysis of texts, there is the possibility of errors in value judgment, which can influence conclusions. Such errors can stem from linguistic or contextual nuances that are not always unambiguously captured during the translation process.

Such limitations do not diminish the relevance of the research results, but suggest the need for future studies that consider a broader range of databases and that are carried out in different periods to capture the continuous evolution of the field of study. Additionally, conducting reviews by multiple evaluators can help mitigate potential translation and interpretation biases, contributing to a more robust and reliable analysis.

CONCLUSION

The objective of this systematic review was to survey the state of the art of research that deals with the use of UX tools in the elaboration of BI dashboard layouts. Although the theme is quite specific, it was possible to conclude that there are relevant contemporary materials to continue the research and contribute scientifically to the evolution of society, improving the structure of these pieces so used in companies.

The methodology used in the selection and analysis of the pertinent bibliographic works followed a rigorous systematic process, detailed in this text and with the possibility of being replicated by other researchers. This process ensured the inclusion of significant studies, providing a comprehensive and up-to-date view on the integration of UX in BI dashboards.

The main findings of this review indicate that the application of UX techniques can effectively improve the usability and effectiveness of BI dashboards, facilitating decision-making in organizations. The diversity of UX approaches and tools identified suggests that there is a vast field of exploration for future research. Highlighted best practices include the need for a balanced interface between functionality and aesthetics, adapting to user needs, and continuously integrating feedback.

The relevance of the findings is evident to UX and BI professionals, who can apply this information to the development of more intuitive and efficient dashboards. This work is

positioned as a step towards the advancement of the academic and practical understanding of data visualization in BI dashboards, with ambitions to advance knowledge in the field of information design and strategic management in organizations.

The aforementioned limitations are reiterated, such as the specific period of data collection and the restriction to the Web of Science and Scopus databases, which should be considered in the interpretation of the results.

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