Exploring Dashboards as Socio-technical Artifacts: Literature Review-based Insights

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Abstract: In times of Big Data and rapid changes, managers become increasingly reliant on dashboards to make fast and informed decisions. The advantages of dashboards are evident even at the beginning of Business Intelligence deployment in organizations. To address the inability of humans to deal with large amounts of data, dashboards are a typical instrument to represent business-critical information in a comprehensible manner. However, there are many difficulties in managing the needs of individuals, teams, and organizations together with the technology in the context of socio-technical systems. While a broad range of technologies for dashboards' creation exists, the question remains in how far dashboard solutions consider the needs and preferences of their primary addressee – human worker. This paper addresses this question by offering a systematic review of recent literature on dashboards. The study focuses on the end-user perspective and includes domains, goals, design process and dashboard characteristics, technologies, and impacts of dashboards' application in organizations. In conclusion, research gaps and potential directions are summarized.

1 INTRODUCTION

With the exponential growth of data, organizations progressively take measures to valorize the enormous data volumes, using various tools and selecting the data for particular purposes. Dashboards are widely implemented to visualize, analyze, interact with, and present data in various forms. Their application domains are also limitless (Schöffel, Weibell, & Schwank, 2018). Thus, dashboards can serve as city information desks, Business Intelligence tools, and shop floor boards or provide real-time information on emergencies.

Organizations either develop dashboards themselves or use existing software solutions (Aksu, del-Río-Ortega, Resinas, & Reijers, 2019), the latter gaining more and more popularity due to their advanced functionalities and adaptability. The recognized solutions are Microsoft Power BI, Tableau, Qlik, and SAP BI, to name a few (Gartner, 2021). As a rule, dashboards serve to support decision-making, presenting the information in the form of a graph or table. The goal is to make sense of large amounts of data and attract attention to the essential information, enabling informed decision-making on different handling options.

A row of studies evidences that dashboards frequently fail to provide information accurately and efficiently, focusing on the decoration rather than user and content (Aksu et al., 2019). The ultimate role of a dashboard can be described as establishing a kind of "communication bridge" between vast amounts of digital data and human workers who are able to process only a limited amount of it. The user and the ability to make efficient decisions should be at the center of any dashboard design. As fairly stated in (Franklin et al., 2017), in socio-technical systems, there are many difficulties in managing the needs of individuals, teams, and organizations along with the applied technology. Therefore, it is critical to put the end-user in the focus of the dashboard design for value creation. This study aims to analyze recent publications on dashboard design and use in the organizational context of different industrial domains (i) *to identify to which extent the design considers the end-user and his/her environment* so that (ii) *the*

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dashboard can provide the necessary support. The focus lies on the usage of dashboards in the context of various organizational processes' support. Hence, industrial domains, goals, end-users, design process and dashboard characteristics, technologies used for dashboard development, and envisioned impacts are studied in detail.

The remainder of the paper is organized as follows. The next Section 2 provides the background, followed by the research methodology in Section 3. Section 4 and Section 5 present the analysis and results, which are discussed in Section 6. The conclusion in Section 7 summarizes the study findings.

2 BACKGROUND

2.1 Socio-technical Systems and Design Challenges

Nowadays, people use technology to accomplish various tasks and be efficient and productive. A socio-technical approach aims to consider people and technology from an integrated perspective. Originally, socio-technical systems (STS) were used in the organizational redesign. Accordingly, social and technical factors are equally important in the new work system design (Mumford, 1994). At present, STS go far beyond organizational redesign and include technology, social interactions, environmental dynamics, and people's practices (Goggins et al., 2017). However, STS preserve this fundamental logic of joint optimization of social and technical elements in conformity with the organizational goals (Baxter & Sommerville, 2011).

A considerable volume of Information Systems (IS) research is based on the STS paradigm and directly or indirectly draws on its core principles (Hirschheim & Klein, 2012). STS is believed to have the potential to bring together diverse IS dimensions in the future (Sarker, Chatterjee, Xiao, & Elbanna, 2019).

Due to the close interweaving of social and technical elements, the IS design process, while focusing on technical artifacts, cannot be separated from soft, social, cultural, and even psychological components (Nissen, Bednar, & Welch, 2007). Accordingly, the IS design can be naturally considered socio-technical and challenging.

As a rule, these challenges come from different sources. In the context of STS, according to (Bossen, 2018), one can name *two major challenges*. One is caused by the need to choose between various priorities, desires, and motivations for developing a new technology solution, i.e., various design rationales. Another challenge is how one perceives, identifies, and reflects the environment, including work activities and procedures, into which new technology solutions are to be integrated (Bossen, 2018).

In the first challenge, many questions emerge when considering the variety of organizational domains, multiple stakeholders, and goals. For example: *Are there domain specificities in the STS design? What are the goals? Who will be the primary beneficiary?* It becomes evident that often it has to be decided between one or more competing design rationales (Goggins et al., 2017). As a rule, IS designers have difficulty determining the rationale and need to conduct a stakeholder analysis to identify who has what stakes in the new technology solution and their potential to help or impede its progress (Eskerod, Huemann, & Savage, 2015). Furthermore, the design goals might be influenced by the funders (Goggins et al., 2017).

The successful adoption of technology is directly dependent on its appropriateness and specific rearrangements in the users' work. Thus, apart from the funders and their goals, the end-users have to be the first to consider in the design process (Bossen, 2018). This point paved the way for the STS studies being one of the key outcome of Tavistock's socio-technical approach in the 1950s (Trist & Bamforth, 1951), followed by the participatory design at the end of the 1980s (Simonsen & Robertson, 2013) remaining crucial for modern STS studies (Baxter & Sommerville, 2011). To sum up, the design, development, and implementation of new technology solutions are an intrusion into the existing environment and, hence, shaped by the stakeholders, end-users, and their needs and preferences.

Regarding the second challenge, it is important to understand the current state of the environment, i.e., answering the questions: *What are current work procedures? What needs to be changed?* Hereby, another difficulty is a high context dependency and the possibility of multiple interpretations of how the work procedures are perceived. Following (Bossen, 2018), first, STS design strongly advocates for involving the stakeholders and end-users in the design process. Second, STS design entails deciding between various design rationales reflecting different work preferences. Third, STS design demands an adequate representation of current work processes (Bossen, 2018).

2.2 Dashboards and Socio-technical Systems Design

The study (Sarikaya et al., 2019) reveals that the term dashboard denotes an extensive range of entities, defying a typical dashboard definition used in the visualization community, i.e., *"a visual display of data used to monitor conditions and/or facilitate understanding*" (Wexler, Shaffer, & Cotgreave, 2017). At present, dashboards are used almost in every domain. As a result, the dashboard definition has developed beyond single-view reporting screens to incorporate interactive interfaces with many objectives, such as communication, learning, motivation, and traditional monitoring and decision support (Sarikaya et al., 2019).

Dashboards address the problem of large amounts of data, making it "accessible" for humans and enabling informed decision-making. STS design perspective of a dashboard requires at least applying those design principles and practices aligned with the way people see and think (Sarcevic, Marsic, & Burd, 2018). Users should be provided with dashboards that meet their needs and facilitate insight delivery, improving their decisions. Hence, it is critical to include the end-users in the design process and enhance the user experience (Vazquez-Ingelmo, Garcia-Penalvo, & Theron, 2019).

The customization approach addresses this demand by assisting developers and users in configuring customized solutions. For example, the already mentioned Tableau software enables the creation of dashboards without any programming skills. However, in many cases, users have difficulty determining which configuration fits their goals (Padilla, 2018). Whereas many solutions exist, recent studies demonstrate the importance of user goals and context for designing meaningful, engaging dashboards (Aksu et al., 2019; Sarikaya et al., 2019).

Focusing on the STS perspective, the following four categories of dashboard design survey proposed in (Sarikaya et al., 2019), which partially overlay the STS design challenges outlined in Section 2.1, are used: (1) purpose or the intended use of a dashboard which is supposed to determine the visual and functional characteristics; (2) audience which is also known to reflect these characteristics; (3) visual features and interactivity that are critical for users' engagement; (4) additional data semantics, such as alerting about anomalies, breaking of the defined thresholds, and automatic updates based on the new data.

As can be concluded, the design principles of STS and dashboards are congruent in many points and complement each other with specific design characteristics. These points, i.e., *user-centricity* and *goals*, *current and future work procedures*, and *design process and dashboard characteristics*, serve as a guideline to address the first goal stated in the introduction section, i.e., identify to which extent the design process considers the user and his/her environment. To address the second goal of the present study, i.e., identify if the dashboard can provide the necessary support, another important point of the *impacts or results of the dashboard application,* which can be addressed in terms of user feedback or potential propositions of the dashboard designers, is outlined.

3 RESEARCH METHODOLOGY

3.1 Research Objectives and Questions

In the light of existing advanced software solutions on the one hand and reported failures in the dashboard design on the other, this study aims to perform a systematic review of the most recent literature and identify to which extent the dashboard design considers the user and his/her environment and is able to provide the necessary support. Accordingly, the following research questions were posed:

RQ1: In which domains has the dashboard research been recently performed?

RQ2: What are the goals of organizations researching and applying dashboards?

RQ3: Who are the end-users, and to what extent are their needs and preferences considered in the dashboard design?

RQ4: What technologies are used in dashboard design?

RQ5: What are the (envisioned) impacts of dashboard research and application in organizations?

3.2 Selection Criteria and Research Method

The review process is based on the guidelines indicated in (Kitchenham, 2004). The data collection process outlined in the PRISMA diagram (Moher et al., 2009) was used to specify the actions (see Figure 1). **In the first identification step**, the keyword "Dashboard" was used to search for relevant documents in the Scopus database in the title and abstract of the documents. The search was limited to English language and journal and conference proceedings publication type. To review the most recent literature on the topic, the publication period was set to 2017 – 2021. As the study focus is the design of dashboards in the organizational context across different domains, the search was limited to the Engineering, i.e., design, subject area and not to a particular domain. The selection of particular domains would result in a thematically narrow set of studies. **In the second screening step**, the search results were refined by the exclusion of the documents containing keywords that (i) have a strong focus on and are too specific in terms of the technology, for example, “Virtual Reality”, “Internet of Things”, “Smartphones”, “Embedded Systems”, “Advanced Driver Assistance Systems”, “Computer Vision”, “Mobile Applications”, “Data Mining”, “Application Programs”, “Cloud Computing”, “Network Security”, “Learning Algorithms”, “Raspberry Pi” and (ii) are irrelevant for the organizational context, such as “Roads and Streets”, “Vehicles”, “Cameras”, “Smart City”, “Accidents”, “Intelligent Vehicle Highway Systems”. This allowed to balance between width and depth of the study and obtain the results grasping various cases in the organizational context and not explicitly focused on particular technology outside the mentioned context.

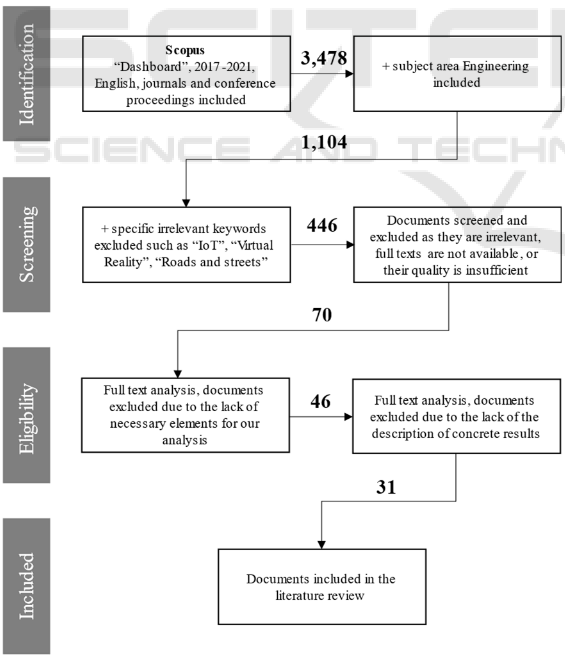

Figure 1: Review process phases and outcomes using the PRISMA flow diagram.

Afterward, the title and abstract of the identified documents were screened, and the documents were excluded due to their irrelevance, insufficient quality, or unavailability of full texts. The relevance was determined based on the research questions, considering the following criteria: ***(1)*** *the articles should include a case study from a particular domain,* ***(2)*** *report on the goals of organizations developing dashboards,* ***(3)*** *report on the end-users,* ***(4)*** *report on the design process,* ***(5)*** *report on the dashboard characteristics such as visualization, interactivity, and data semantics (alerts, automatic updates) ideally supported by a screenshot, figure, or link to a dashboard and the description of technologies used to develop a dashboard,* ***(6)*** *report on the envisioned impacts of the dashboard research and application.* **In the third eligibility step**, the check of full texts was performed, and the documents were excluded due to the lack of the elements necessary for the analysis and insufficient description of the obtained results. Hence, the **final sample** for the review included 31 articles covering 31 unique cases correspondingly (see Figure 1 for details).

4 ANALYSIS

Based on the STS and dashboard related design challenges specified in the background section, each article was checked and coded according to the following aspects: (1) domain and country of organizations developing dashboards *(Are there domain specificities in the STS design?)*, (2) goals and motivations of organizations to develop and apply dashboards *(What are the goals?)*, (3) if there is an evaluation performed with end-users, (4) who are the end-users *(Who will be the primary beneficiary?)*, (5) how the needs and preferences of end-users are considered in terms of the design process (*What are current work procedures? What needs to be changed?*), (6) visual, interaction, or data semantics characteristics of a dashboard, (7) technologies used to develop a dashboard, (8) envisioned impacts of dashboard research and application.

The coding procedure included four main steps. *First*, a simple annotation framework and coding rules were created regarding the goals of dashboard design, dashboard users, design process, dashboard characteristics, technologies, and impacts. *Second*, the framework and rules were discussed following the collegial advice of another independent researcher. *Third*, each paper was carefully studied and coded using the annotation framework. During this process, the annotation framework was adjusted three times. *Fourth*, the results were double-checked, involving the advice of the independent researcher. Important to note that one article could contain several code values in the same category, i.e., several goals, end-user groups, domains, and business areas.

In particular, *to answer the RQ1*, the specific application cases were extracted what resulted in 15 industrial domains and two business areas. *To answer the RQ2*, the same bottom-up procedure was followed. For each article, specific goals were identified and generalized into 26 goals in the form of verbs and verbal expressions. While extracting the information regarding *end-users*, the specific 16 cases were identified. To address the question *to what extent the end-user needs and preferences are considered in the dashboard design*, the following four points were considered: (1) evaluation (if conducted or not), (2) as-is and to-be analysis (if conducted or not), (3) visualization (multiview, suitable logical, simple basic, complex) and interactivity (little / no interactivity, simple basic interactivity in the form of embedded buttons, drop-down menus, advanced in the form of filters, resort, drill-down, hovers) characteristics, (4) data semantics (alerts, automatic updates, no data semantics). *Concerning the RQ4*, the case study implementation section of the articles was examined and identified 17 different technologies and two proprietary solutions used for dashboard development. Finally, *to answer the RQ5*, the design and discussion sections of the articles were considered to analyze the (envisioned) impacts of dashboard research and application in organizations.

5 RESULTS

This section describes the study findings in relation to the research questions obtained using the approaches presented in Section 4[2]. Section 5.1 introduces the domains where recent research on dashboards has been conducted. Section 5.2 summarizes the goals of dashboard research and application in organizations. Section 5.3 describes the end-users, whereas Section 5.4 addresses the points related to the design process, dashboard characteristics, and technologies used for dashboard development. Finally, Section 5.5 presents the (envisioned) impacts of dashboard research and application in organizations, i.e., the envisioned support.

5.1 Domains of Dashboard Research

Dashboards serve to enhance human cognitive and perceptual abilities. As a result, dashboards have become a standard tool to support decision-making in different domains and business areas, the trend proven by the abundance of advanced solutions on the market.

Recent applied research on dashboards evidences a considerable number of studies aimed at solving particular practical challenges. The study sample reveals a high variety of dashboard research domains, with the majority in the **Information Systems** (five cases (Brandt, Striewe, Beck, & Goedicke, 2017; Cardoso, Vieira Teixeira, & Sousa Pinto, 2018; Fleig, Augenstein, & Maedche, 2018; López et al., 2021; Pa, Karim, & Hassan, 2017)), **Manufacturing** (four cases (Raudberget, Ström, & Elgh, 2018; Steenkamp, Hagedorn-Hansen, & Oosthuizen, 2017; Vilarinho, Lopes, & Sousa, 2017; Yusof, Othman, & Yusof, 2018)), **Construction** and **Real Estate** (four cases (Ho, Mo, Wong, & Leung, 2019; Mahadzir, Omar, & Nawi, 2018; Montaser & Montaser, 2017; Utrilla, Górecki, & Maqueira, 2020)), **Healthcare** (three cases (Christen et al., 2020; Franklin et al., 2017; McGlothlin, Srinivasan, & Stojic, 2019)), and **Supply Chain** (three cases (Ho et al., 2019; Lanotte, Ferreira, & Brisset, 2020; Martins, Alves, & Leão, 2018)). However, **Sales** (Noonpakdee, Khunkornsiri, Phothichai, & Danaisawat, 2018; Telaga, Librianti, & Umairoh, 2019) and **HR** (Chattopadhyay et al., 2020; Zajec, Mrsic, & Kopal, 2021) company areas, i.e., primary sources of company performance indicators, are underrepresented along with **Automotive** and **Airspace** domains with only two cases. Machinery (Longo et al., 2018), Banking (Massardi, Suharjito, & Utama, 2018), Academia (Wibowo, Andreswari, & Hasibuan, 2018), Disaster Management (Saha, Shekhar, Sadhukhan, & Das, 2018), Government (Conejero et al., 2021), Telecom (Fraihat, Almomani, Fraihat, & Awad, 2020), and Tourism (Balletto, Milesi, Ladu, & Borruso, 2020) are unique cases in the sample. See Figure 2 for the relative distribution numbers.

The identified domains and cases differ in the research artifact, at which a dashboard is targeted, end-user group, and application area. For example, the cases in IS domain aim at supporting IS managers, designers, or software developers in monitoring the health status of the IS (Cardoso et al., 2018), measuring green IS design (Pa et al., 2017), discovering important processes in IS (Fleig, 2017), supporting software engineering and development (Brandt et al., 2017; López et al., 2021).

[2] Check the complete Excel file with the study results https://github.com/revina825/Dashboards

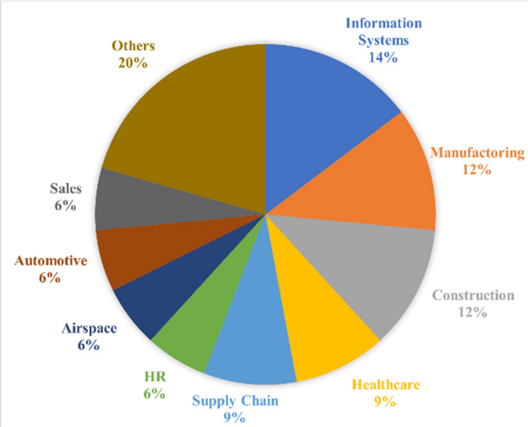

Figure 2: Domain distribution in dashboard research.

The absolute distribution of countries is presented in Figure 3. The majority of cases were conducted in the EU (ten cases). However, considering each EU country separately, Malaysia and Indonesia make up the majority, with three cases per country.

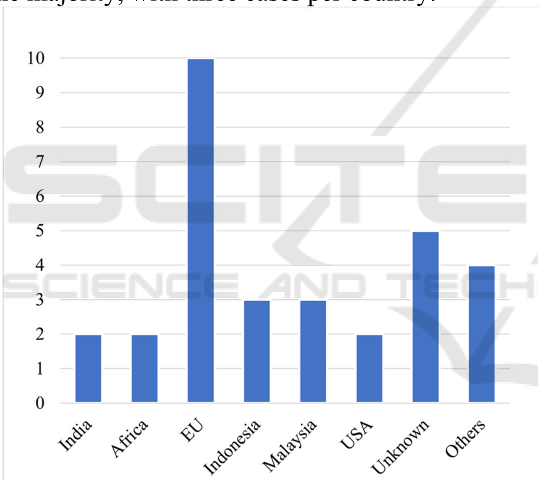

Figure 3: Country distribution in dashboard research.

5.2 Goals of Dashboard Research and Application

Similar to the domains, the analysis shows a broad range of goals in the dashboard research and application. To provide a structured outcome, the identified 26 unique goals were grouped into four categories based on their function (see Table 1). In the Information & Knowledge Management category, along with the typical dashboard goals such as *visualize*, *summarize*, *inform*, two studies highlight specific motivations for dashboard design, i.e., *simplify* and *standardize the information collection* (Raudberget et al., 2018) and *storing* and *retrieving* (Cepeda & Lopes, 2019).

Table 1: Four categories of goals.

Category	Unique goals
Information & Knowledge Management (31% of cases)	visualize, summarize, inform, simplify and standardize, store and retrieve
Project Management (20% of cases)	monitor, alert, organize and coordinate, measure, report, communicate, improve communication, support in project planning, manage
Decision-making (33% of cases)	support decision-making, predict, identify, provide data insights, discover, simulate, explore
Secondary goals (16% of cases)	improve, promote, valorize, evaluate, analyze, reduce

In the Project Management category, both typical characteristic goals (*monitor, measure, report, communicate*) and more comprehensive goals *organize, coordinate* (Christen et al., 2020), and *manage* (Lanotte et al., 2020) are named. Noteworthy, the majority of studies on dashboards set the goals related to the decision-making support. Behind such advanced motivations as *discover* (Fleig et al., 2018) or *simulate* and *explore* (López et al., 2021) are complex technology solutions. Finally, in the row of studies, secondary, often even more important goals are mentioned, for example, *reducing* negative influences (Pa et al., 2017) and *valorizing* certain objects (Balletto et al., 2020).

5.3 End-users of Dashboards

In total, 16 unique end-users are identified in the sample. Afterward, the end-users were grouped into five meaningful categories (see Table 2). The category "Others" contains domain- and case study-specific users such as process owners, product developers, software developers, tourists, and real estate players. It is observed that the end-users are defined and considered in accordance with the domain and case study specificity and goals.

Table 2: End-users of dashboards.

End-users	Source
Managers (51% of cases)	(Brandt et al., 2017; Cepeda & Lopes, 2019; Chattopadhyay et al., 2020; Fleig et al., 2018; Fraihat et al., 2020; Ho et al., 2019; Kapp, Lefebvre, & Monnier, 2019; Lanotte et al., 2020; López et al., 2021; Martins et al., 2018; Massardi et al., 2018; McGlothlin et al., 2019; Montaser & Montaser, 2017; Noonpakdee et al., 2018; Steenkamp et al., 2017; Telaga et al., 2019; Utrilla et al., 2020; Vilarinho et al., 2017; Yusof et al., 2018; Zajec et al., 2021)
Employees (10% of cases)	(Cepeda & Lopes, 2019; Ho et al., 2019; Vilarinho et al., 2017; Yusof et al., 2018)

Table 2: End-users of dashboards (cont.).

Public institutions, healthcare, government (18% of cases)	(Balletto et al., 2020; Christen et al., 2020; Conejero et al., 2021; Franklin et al., 2017; McGlothlin et al., 2019; Saha et al., 2018; Wibowo et al., 2018)
IS administrators, designers, technical staff (8% of cases)	(Cardoso et al., 2018; Longo et al., 2018; Pa et al., 2017)
Others (13% of cases)	(Balletto et al., 2020; Fleig et al., 2018; López et al., 2021; Mahadzir et al., 2018; Raudberget et al., 2018)

5.4 Dashboard Design, Characteristics, and Technologies

In the dashboard design context, the question regarding the as-is and to-be analysis, i.e., current work procedures and what needs to be improved, was addressed in the study. In most cases (65%), both analyses were performed what is in line with the STS design approach. In the dashboard characteristics, *visualization*, *interactivity*, and *data semantics* were considered. According to the developed coding scheme, *visualization* reveals the following distribution: multiview 40%, suitable logical 28%, simple basic 26%, complex 7%. The study results show 29% of dashboards with simple basic *interactivity*, 26% advanced, and 45% of dashboards with little or no interactivity. Regarding *data semantics*, only 16% of cases evidence alert function and 25% - automatic updates.

In order to develop dashboards with mentioned characteristics, a diverse set of technologies was used. 19 technologies were grouped into six categories. As follows from Table 3, Microsoft solutions are in a clear majority.

Table 3: Six categories of technologies.

Category	Technologies
Programming languages (22% of cases)	Java, PHP, Python, R
Microsoft (34% of cases)	MS Access, MS Share Point, MS Excel, VBA, MS Power BI
Other well-known solutions (19% of cases)	Qlick, Tableau, Oracle
Less known solutions (13% of cases)	Pureshare, Freeboard, Axure RP 9, Pajek
Google (6% of cases)	Google sites, Google sheets
Proprietary (6% of cases)	n.a.

5.5 Impacts of Dashboard Research and Application

In this subsection, the envisioned impacts of dashboard research and application in organizations are presented. First, this information was extracted from each of the articles in the sample. Afterward, 16 categories were developed.

The majority of cases (25%) name *performance improvement* as one of the impacts of dashboard application, for example (Ho et al., 2019; Massardi et al., 2018; Telaga et al., 2019). It is followed by closely related *efficiency improvement* (15%), for example (Cardoso et al., 2018; Franklin et al., 2017; Longo et al., 2018), and *better data monitoring* (13%), like in (Steenkamp et al., 2017). *Time improvements* (10%) (Yusof et al., 2018), *better (service) quality* (9%) (Wibowo et al., 2018), and *better organization and coordination* (6%) (Lanotte et al., 2020) are less frequently encountered impacts. *Better planning* (Saha et al., 2018), *sustainability contribution* (Utrilla et al., 2020), *better understanding* (Chattopadhyay et al., 2020), *better awareness* (Fleig et al., 2018), and *cost reduction* (McGlothlin et al., 2019) have been mentioned only in 3% of cases. Finally, only 1% of cases reveal *better valorization* (Balletto et al., 2020), *better policies and strategies, employment improvement* (Conejero et al., 2021), *better documentation* (Raudberget et al., 2018), and *better communication* (Montaser & Montaser, 2017).

6 DISCUSSION

6.1 Dashboard Research and Application Considerations

Although dashboards take their origin in automobiles and other vehicles, they have become increasingly popular in business, government, and nonprofit organizations. At present, dashboards are widely known to provide business executives and managers with company performance-related information, for example, sales, HR, or profit (Eckerson, 2010). On the one hand, it is confirmed by the study results revealing managers (51%) as a major end-user group. On the other, sales (6%) and HR (6%) business areas are underrepresented in the sample.

Noteworthy, with the high domain variety, i.e., Automotive, Healthcare, Construction, Government, Academia, Banking, to name a few, the study results demonstrate *a high interest in dashboards in the IS discipline* itself. The IS researchers set specific goals, such as monitoring IS health status (Cardoso et al., 2018), reducing the environmental impact of ICT products and services (Pa et al., 2017), discovering important business processes (Fleig et al., 2018), extracting and visualizing high-level strategic indicators related to software quality (López et al., 2021), and supporting Software Engineering projects (Brandt et al., 2017). In their majority, these studies make use of programming languages such as Java to develop dashboard solutions.

The larger part of the studies has been performed in the *EU countries* whereby (i) consistent approaches of user involvement in terms of evaluation, as-is and to-be analyses have been followed, and (ii) existing software, such as Microsoft, Qlick, Axure, was used. In general, the analysis reveals a strong trend of leveraging vendor solutions rather than building the dashboards from scratch. In contrast, one decade ago, 45% of companies that participated in the survey declared developing proprietary solutions (Eckerson, 2010). This observation evidences the high customization and usability of commercial software.

As also noted in (Eckerson, 2010), at present, dashboards can be considered Business Information Systems comprising data collection, integration, and processing technologies. In the sample, the studies focus on both (i) *dashboards as mere visual interfaces* (Christen et al., 2020; Franklin et al., 2017; Wibowo et al., 2018) and (ii) *dashboards as part of comprehensive solutions*. Thus, (Conejero et al., 2021) propose a multi-aspect support system using Data Engineering and advanced visualization techniques as well as association rules. (Fleig et al., 2018) develop a decision support system for identifying the most critical business processes in IS comprising the IS layer, data management layer, and visualization layer. Introducing an analytic dashboard visualization for flood management, (Saha et al., 2018) describe an architecture of the decision support system. At the same time, (Wibowo et al., 2018), while evaluating the proposed dashboard, highlight its suitable and logical visualization but declare the need for decision support. *Hence, a dashboard should not be considered as an isolated visual interface but rather a part of a comprehensive decision-making support solution to facilitate value creation and proactively assist the end-user.*

In the context of the design process, STS research highlights the importance of performing both *as-is and to-be analyses* (Bossen, 2018; Goggins et al., 2017). In the sample, most of the studies (65%) follow this approach. Moreover, (Franklin et al., 2017) refer to STS while analyzing the challenges in the implementation and lessons learned. (Martins et al., 2018) use participatory design, which is a key issue in the STS design (Scacchi, 2004), to develop and implement operational monitoring dashboards in a lean context.

Evaluation, an essential step in any design process, has been mentioned in 52% of cases. In 32% of papers, case studies were used to develop a dashboard, however, without any evaluation. In 16%, the whole approach (and not a dashboard in particular) was evaluated. In a few studies, the researchers worked with open-source data (Balletto et al., 2020; Fraihat et al., 2020). In some cases, evaluation is planned as a part of future work (Christen et al., 2020). *It is to note that for successful design and implementation of dashboards as socio-technical artifacts, the evaluation with end-users plays a key role. The evaluation results should be reported straightforwardly and comprehensively, which was not the case in any of the articles in the sample.*

6.2 End-user Support Implied in Dashboards

As stated in the previous subsection, there is insufficient end-user involvement in the design process of dashboards and related solutions. Nonetheless, the end-user support is implicitly contained in the dashboard goals, characteristics, and envisioned impacts.

The analysis of the goals of researching and applying dashboards in organizations shows that the goals are prevailingly concerned with *decision-making support* (33%), i.e., predicting, identifying, discovering, simulating, exploring, and providing data insights. This observation is in line with the declared end-user demands (Wibowo et al., 2018). Along with *the decision-making support*, such typical dashboard goals as *Information & Knowledge Management* (31%) and *Project Management* (20%), and several secondary goals (16%) are mentioned. Whereas all these goals are directed towards assisting and empowering the end-user, he/she is not explicitly discussed in the sense of usability and satisfaction while introducing these goals. *It should be emphasized that in the STS context, the end-user needs to be explicitly addressed while setting the design goals.*

The underrepresented end-user perspective in the goal-setting is also reflected in *the dashboard impacts*. Hereby, a clear focus is set on performance (25%) and efficiency (15%), followed by data monitoring (13%), time improvement (10%), and better (service) quality (9%). *Hence, end-user satisfaction and other benefits related to the workload reduction are STS-related critical missing points in the literature, demanding thorough consideration.*

Many dashboard projects fail as they mainly aim at making a “glitzy” interface (Aksu et al., 2019; Eckerson, 2010). The study results evidence the prevalence of multiview (40%), suitable logical (28%), and simple basic (26%) *visualizations*. Few studies (7%) introduce dashboards with complex information presentation (Conejero et al., 2021; Zajec et al., 2021). In contrast, the *interactivity* and *data semantics* characteristics need to be improved due to the prevailingly no / little interactivity (45%) and missing data semantics (50%). *While high interactivity and data semantics can potentially increase end-user satisfaction, it is to argue that dashboard characteristics, including data, data semantics, visualization, and interactivity types, should be selected in line with end-user needs, tasks, and preferences. Such an aligned dashboard design would lead to end-user satisfaction and acceptance,* as also noted in (Bossen, 2018). It follows that closely studying the interaction between the end-user and the dashboard is an essential factor requiring more focus from the research community and practitioners.

It is to highlight that, similarly to (Isazad Mashinchi, Ojo, & Sullivan, 2020), the analysis did not clearly state if there is a relationship between dashboard characteristics mentioned above (also described in Section 5.4) and envisioned impacts of dashboard application (Section 5.5). I.e., *the question remains if one can improve or influence the impacts by modifying the dashboard characteristics. It is essential to respond to this question since it demonstrates the role of various characteristics in dashboard design.*

6.3 Limitations

A literature review can be considered an excellent methodological instrument for addressing a wide range of research issues (Snyder, 2019). Nonetheless, it has several limitations. In this regard, the study evidences the aspects listed below.

The term dashboard is constantly penetrating different areas and taking on new meanings. Generally denoting visual displays used for showing important information at a glance (Few, 2017), dashboards are applied and researched in diverse domains ranging from the cities and buildings, cars and highways to organizations aiming to support managers in making informed decisions or monitoring various organizational processes. The latter is the focus of the study and, due to its seemingly broad coverage, makes up the significant limitation of the study.

To address this limitation and filter out the unrelated works, the exclusion of irrelevant keywords was used. However, keywords are limited and cannot embrace all the aspects of the work. Moreover, keywords are usually adjusted to fit the scope of the target journal or conference. Hence, while filtering the keywords, relevant studies could be missed.

Authors’ bias is another common limitation of (systematic) literature reviews (Denyer & Tranfield, 2006). Although the transparent procedure attempts to reduce the subjective effect, the authors are never entirely neutral while reviewing the literature (Kraus, Breier, & Dasí-Rodríguez, 2020).

A further challenge is addressing various study contexts, especially in the broad and highly fragmented research fields, like organizational studies and management (Denyer & Tranfield, 2006). Even in comparable studies, in complex social contexts, there are always likely to be minor differences. Synthesizing the studies to achieve a structured outcome can remove critical contextual information (Hammersley, 2001).

7 CONCLUSION

In this study, the analysis of dashboards’ research and application in organizations was performed with a socio-technical emphasis. Based on a systematic literature review, a sample of 31 articles was selected. Various aspects such as domains, goals, design process and dashboard characteristics, technologies, and impacts of dashboards’ application in organizations were considered. It was identified that in the majority of cases, users are involved in the evaluation process. This way, helpful improvement suggestions can be gathered. For example, the users place a special value on the decision-making support functionalities and not visual characteristics.

Further, several gaps have been identified: (i) the evaluation process was lacking thorough and comprehensive documentation and reporting; (ii) the user-centricity, for example, end-user satisfaction, workload and stress reduction, is insufficiently expressed in the dashboards’ goals and envisioned impacts (the focus lies on business performance and efficiency increase); (iii) dashboard characteristics should be selected in line with end-user needs, tasks, and preferences; (iv) missing evidence on the relation between dashboard characteristics and envisioned impacts of the dashboard application. Future studies addressing these gaps and putting more emphasis on (i) dashboards as part of comprehensive decision-making support solutions and (ii) end-user involvement in all stages of the dashboard design and implementation have a high potential to improve value creation and user satisfaction in this field.

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