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Use of Visual Dashboards in Construction Projects

Somik Ghosh, PhD, Nirmalya Mukherjee, MS, and Tammy McCuen, PhD
University of Oklahoma
Norman, Oklahoma

The increasing adoption of visual dashboards in the construction industry holds potential for improved project management, elevated communication, transparency, and decision-making. This study explores the utilization of visual dashboards in construction projects, analyzing strengths, limitations, and improvement opportunities. Surveying construction professionals with over five years of experience, the analysis identifies key features of effective visual dashboards, including real-time data, interactivity, user-friendliness, and customizability. Challenges include real-time data integration intricacies. Participants advocate for user-centric designs, comprehensive data tracking, and regular updates. Further research could investigate dashboards' impact on project performance, address integration challenges, and explore ethical considerations.

Key Words: Visual dashboard, project management, data tracking, data integration, decision-making

Introduction

A visual dashboard is a data visualization tool that allows users to monitor and track various metrics and Key Performance Indicator (KPI) relevant to their businesses or organizations. These dashboards typically provide a graphical representation of data, making it easier for users to understand and act on the information they provide. Visual dashboards have been used in various fields, such as manufacturing, healthcare, finance, and similar. In manufacturing, visual management dashboards are often used to display KPIs such as production rates, efficiency levels, and waste reduction (Valente et al., 2019). In construction project management, visual dashboards are used to track the progress of tasks, budgets, and deadlines and to identify potential issues or risks. Visual dashboards can be used in data analytics to display complex data in an easily understandable format, such as graphs, charts, and maps. Overall, visual dashboards primarily provide clear and concise information in a visual format that can be easily understood and used to make informed decisions (Gara et al., 2021).

Recent studies have shown that visual dashboards have significant benefits for construction projects (Gara et al., 2021). However, there is limited research available on how these tools are currently being used and their limitations, which suggests a potential gap in knowledge. To address this gap and better

understand the role of visual dashboards in construction projects, further research is needed. Therefore, this study conducted a review of existing literature and a survey among practitioners to gain insight into visual dash boards' use, their strengths and limitations, and potential areas for improvement. The significance of this research lay in its potential to improve the effectiveness of visual dashboards in construction projects. By identifying the current state of visual dashboards in construction project management, this study's aim was to provide a better understanding of how these tools are being used and their limitations. This understanding can enable project teams to make more informed decisions about how to effectively use visual dashboards to support their work. By knowing the potential benefits and limitations of visual dashboards, project teams can make better-informed decisions about which dashboard features to use and how to customize them to meet their unique project needs. Ultimately, the findings of this study are expected to add value to project teams looking to improve their use of visual dashboards in construction projects.

The research employed a survey-based methodology to study the current state of visual dashboards in construction projects. This involved developing a survey instrument targeted toward current users of visual dashboards, which was distributed among a sample of users, and their responses were collected and analyzed to gain insight into how visual dashboards were currently being used, their strengths and limitations, and potential areas for improvement. This paper aims to contribute to this area of research by analyzing the effectiveness of visual dashboards in construction projects. In the following sections, the paper presents the literature review, the methodology employed for this research including data collection and analysis, followed by a discussion and conclusion.

Overview of Visual Dashboards

With the increasing amount of data generated by construction projects, visual dashboards are becoming an essential tool for project managers to monitor and control their projects. The literature review included 27 articles that highlighted the different types of visual dashboards being used in the construction industry displaying the project status, construction progress monitoring, safety, and BIM-related dashboards. Visual dashboards are a tool for tracking and monitoring construction projects. According to Gara et al. (2021), the development of real-time integrated dashboard offers significant advantages in progress monitoring of construction projects. By leveraging advanced data acquisition technologies and web interfaces that can adapt to any device screen size, the integrated dashboard can gather accurate information from multiple sources and present it in an easily comprehensible format. The literature review reveals that visual dashboards in the construction industry are typically used to monitor various metrics, such as progress, cost, quality, and safety, in real-time. For instance, Gara et al. (2021) developed a real-time integrated dashboard for monitoring progress of road construction projects, which allowed project stakeholders to track project schedule, cost, and quality in real-time, providing early warning signals of potential issues and enabling timely corrective actions. Previously, Lamptey and Fayek (2012) had developed project status dashboard for construction project progress reporting, which provided a snapshot of project progress and allowed project stakeholders to quickly identify project delays, cost overruns, and other issues. The availability of real-time project information through visual dashboards has the potential to significantly enhance project communication, collaboration, and decision-making, leading to improved project outcomes.

Visual dashboards have become an increasingly popular tool in construction project management, with numerous successful implementations reported in the literature by Abou-Ibrahim and Hamzeh (2020). One example of a dashboard designed for a specific construction process is the enterprise dashboard developed by Maximino (2020) for monitoring and managing waterproofing systems in

wood construction. These dashboards allowed project stakeholders to monitor critical metrics such as moisture content, temperature, and humidity in real-time, enabling early detection of potential issues and timely corrective actions. This approach is particularly useful in complex construction projects where real-time monitoring is essential to ensure project success. Another example is the location-based dashboard for construction management developed by Guerriero et al. (2012), which provided a visual representation of the construction site, with information on the progress of individual tasks, resource allocation, and potential risks. Project stakeholders could access project information by location, making it particularly useful in large-scale construction projects where stakeholders may be distributed across different locations and need to access project information remotely.

The integration of emerging technologies into visual dashboards has the potential to further enhance their effectiveness in construction project management. Abou-Ibrahim and Hamzeh (2020) demonstrated this potential by developing a visual dashboard that could monitor the dynamics of building information models. This dashboard allowed project stakeholders to visualize real-time changes to the BIM model, enabling early detection of potential issues and improving the accuracy of decision-making. The integration of BIM with visual dashboards has been shown to improve project collaboration, reduce errors, and improve project outcomes. Similarly, Mora-Sánchez et al. (2020) validated an Internet of Things (IoT) infrastructure for construction projects on a living lab platform. This infrastructure allowed project stakeholders to monitor critical metrics such as temperature, humidity, and noise levels in real-time, providing valuable data for informed decision-making. The use of IoT in conjunction with visual dashboards has the potential to provide project stakeholders with an unprecedented level of real-time data, enabling them to identify potential issues before they become critical and improving project outcomes (Mora-Sánchez et al. 2020).

Benefits and Challenges of Using Visual Dashboards

The literature review suggests that visual dashboards provide numerous benefits to construction projects. For example, Ezzeddine et al. (2021) found that implementing an integrated dashboard (referred to as construction control room) on a fast-paced project can improve project control and communication through real-time monitoring of various metrics. Furthermore, as per Bajjou et al. (2017), it was found that visual dashboard as part of lean implementation can be an effective tool in promoting lean construction and safety in construction projects. The study found that visual dashboards could enhance communication and collaboration among workers, leading to a better understanding of safety procedures and practices. Similarly, Bhat (2017) developed a data visualization dashboard to support decision-making in construction projects by providing insights into requests for information. The dashboard enabled better communication among project stakeholders and helped prevent safety issues through improved collaboration. These findings underscore the benefits of visual dashboards as a means of promoting lean construction and safety in construction projects.

In line with the benefits of visual dashboards, Hamzeh et al. (2020) developed an early warning dashboard for advanced construction planning metrics. The researchers emphasized the importance of proactively identifying potential project risks and delays through real-time monitoring of key performance indicators. The dashboard was designed to enable project teams to track metrics such as labor productivity, schedule performance, and quality control, and provide early warnings of potential issues. Hamzeh et al. (2020) found that the use of the dashboard resulted in improved

communication and collaboration among team members, as well as enhanced project control and decision-making. Similarly, Sarikaya et al. (2019) and Al-Sulaiti et al. (2021) found in their studies that dashboards could facilitate communication and collaboration between stakeholders by providing shared view of project metrics. Additionally, they highlighted the challenge of assessing the effectiveness of dashboards, citing the absence of standardized metrics and evaluation methods as a pertinent issue. Mohammadfarid et al. (2019) underscored the limited knowledge of dashboard systems among public works clients, potentially impeding their effectiveness. Similarly, Lopes and Boscarioli (2020) pointed out the expertise gap in business intelligence and analytics within certain construction companies, affecting the development of proficient dashboards. Additionally, Ratajczak et al. (2019) highlighted the integration challenges between Augmented Reality (AR) applications and Location-Based Management Systems, which are pivotal for real-time tracking of resources in construction projects.

The review identified the essential characteristics of effective visual dashboards, including real-time data, interactivity, user-friendliness, and customizability. The reviewed articles emphasized the importance of integrating various data sources and leveraging emerging technologies like IoT and AR. There is a need for further investigation into the advantages and drawbacks of visual dashboards, especially in terms of their impact on project performance.

Methodology

A purposive sampling technique was used to ensure representation from various types of construction projects and stakeholders, including owners, general contractors, sub-contractors, designers, architects, and others with work experience across the USA. The data was collected through online surveys, both primary and secondary sources, with a combination of closed- and open-ended questions, totaling 26 questions across three sections: background information, usage insights, and challenges and scope of improvements. Out of the 100 surveys sent out to construction professionals, only 36 responses were gathered, with 31 participants providing complete answers, which were used for the data analysis. The survey was conducted using Qualtrics online survey platform, sent over email and LinkedIn, ensuring anonymity and confidentiality of the data, with only position and organization type recorded. The instrument underwent content validation by four professionals with over 20 years of industry experience, and feedback was incorporated into the survey design before circulation for data collection.

To ensure external validity, a convenience sampling technique was employed, which ensured a representative sample of construction projects and their associated visual dashboards. The participants were selected based on their organization type, and the sample was representative of every organization type. However, it is important to note that the results of this study may not be generalizable to all construction projects and their associated visual dashboards. Overall, the methodology of this study ensured that the data collected was both valid and reliable, allowing for accurate analysis and interpretation of the results.

Findings

This section will provide background information on the participants of this study. The survey used in this study did not include questions related to personal demographic factors such as age or gender; instead, the survey collected information on the type of organizations that the participants were working for.

The data revealed that most of the participants worked either for general contractors or owners.

Specifically, 26% of the participants identified as working for general contractors while 49 % identified as working for owners. The remaining 26 % of participants were comprised of suppliers/vendors, architects/designers/engineers, and construction management consultants. When asked about their job titles, the most common job title was project manager/project engineer (72%), followed by executives (12%), and then safety, procurement, and other staff members making up the remaining 16%. The survey also gathered information on the types of projects that the participants had worked on. Commercial projects were the most common (27%), followed by industrial (23%), infrastructure (16%), healthcare (13%) and residential along with other combined to 22%.

The survey inquired about participants' years of experience in the construction industry. The results showed that 23% of participants had over 15 years of experience, while 47% had five years of experience or less. Participants with 6-10 years of experience made up 23%, and those with 10-15 years comprised 7%. These findings indicate that the participants were generally experienced, with a majority having more than five years of industry experience.

Furthermore, the survey collected data on the average value of projects participants have been involved with. Results showed that 45% of participants worked on projects valued between $1 to $50 million, while 20% worked on projects with a value of either $51 to $100 million or less than $1 million. Additionally, 16% of participants worked on projects valued between $101 to $500 million. These findings suggest that most participants are involved in mid-sized projects, with a smaller percentage working on either larger or smaller projects.

Insights on the Usage of Visual Dashboards

Survey responses indicate that 30% of participants use visual dashboards daily, with 7% using them weekly, 15% bi-weekly, and 19% monthly (Figure 1a). Regarding the type of visual dashboards used, results show that 45% employed digital dashboards, while 13% used analog dashboards, making digital dashboards the more prevalent type. Additionally, 26% of participants used both types, and 16% reported using other visual dashboard types. With a small proportion of participants using both digital and analog dashboards, it suggests they might prefer different display types depending on the context or data being presented. In terms of the specific digital dashboard tools employed by the study participants in their projects, a diverse range of options were reported. Power BI was the most common choice used by 48% of the participants followed by Procore and Tableau. 20% of the participants indicated using digital dashboard tools such as BIM360, G-suit, and similar, combined as “other’ in Figure 1b.

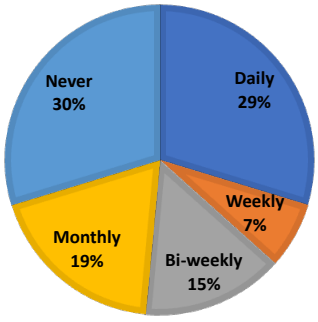

Figure 1a: Frequency of use of visual dashboards

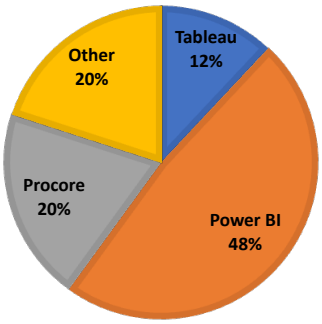

Figure 1b: Platforms used for visual dashboards

The data is indicative of a pattern between project values and dashboard usage. Participants who worked on projects valued up to $100 million, participants used both analog and digital dashboards, but with a higher preference for digital dashboards, which were used daily. For projects valued at $101 to $500 million, digital dashboards were exclusively used, with some participants using them daily. These findings imply that visual dashboards are more frequently utilized in higher-value projects. This could be due to the need for more intricate and detailed monitoring that can be supported by the real-time data visualization and analysis features of digital dashboards. Additionally, the increasing popularity of advanced digital dashboard tools, offering more sophisticated analytics, may contribute to this trend.

Content of Visual Dashboards

The survey asked the participants to indicate the information fields they would like to see on a visual dashboard. The results shown in Table 1 shows their preferences. The authors acknowledge that there may have been bias due to the participants' job roles, which was addressed in the limitation section of this document. The differences in preferences suggest that each job role has specific information needs that are essential for their work. Understanding these needs can help in designing a visual dashboard that is tailored to meet the requirements of each role.

Participants who were executives appear to be most interested in the financial data linked to projects, with a significant preference for enterprise-level finance figures (23%) which suggest that they needed to have overall view of the projects' financial health and performance. In addition, executives placed a high importance on safety performance and schedule related information. This suggests that executives need to monitor the projects' progress and ensure that they are being carried out safely. In contrast, project managers/engineers, showed a more diverse set of interests. They showed more interest in information related to schedule (19%), project cost (15%), project documents (12%), and project management (16%). This suggests their involvement in the day-to-day management of the project, necessitating oversight of various aspects.

Table 1

Job Roles and their Preferences for Information Fields in Visual Dashboards

Job Roles / Information	Executives	Project Managers/ Engineers	Superintendents/ Field Engineers	Safety and Procurement
Financial data at enterprise level	23%	3%	6%	0.00%
Safety performance	23%	5%	6%	29%
Schedule	23%	19%	13%	14%
Project budget	23%	15%	13%	14%
Project documents	0.0%	12%	13%	0.0%
Project management	8%	16%	13%	0.0%
Process improv. initiatives	0.0%	3%	6%	0.0%
Inventory tracking	0.0%	4%	13%	14%
Material tracking	0.0%	14%	13%	14%

Superintendents/field engineers gave equal importance to information fields related to project schedule, budget, project management, inventory tracking, and material tracking. Surprisingly, they

put lesser importance on information related to safety and process improvement tools. As anticipated, the safety and procurement personnel, had the highest preference for safety performance data (20%). This suggests their involvement in ensuring that the projects were being carried out safely. In addition, safety and procurement personnel have similar preferences for schedule, project budget, and inventory related information. This indicates that they needed to keep track of the projects' progress and ensured that they were being carried out efficiently. They also needed to manage the projects' inventory to ensure that materials were available when needed.

Challenges and Limitations of Visual Dashboards

In this section, findings related to the challenges and limitations faced by participants in managing and tracking project data using visual dashboards has been presented. The most common challenge reported by participants is the absence of real-time data, with 44% citing this issue. This highlights the significance of having up-to-date information for informed decision-making and effective project management. Another challenge faced by the participants was the difficulty in tracking changes and updates, mentioned by 41% of participants. This challenge can lead to miscommunication and errors in project management, emphasizing the necessity for robust change management processes.

Concerning the use of visual dashboards for tracking project progress, the results indicate that limited customization options were identified as a challenge by 23%, while inaccurate or incomplete data was cited by 35% of participants. This underscores the importance of customizable dashboards and accurate data collection and management processes. Nearly 40% of participants noted that the data in the dashboards lacked understandability and integration with other tools, making it challenging to utilize the available data. This indicates a need for intuitive visual dashboards that make the data self-explanatory, enhancing the user experience.

In the survey, the participants were requested to offer recommendations for addressing the current limitations and enhancing future visual dashboards. The following section outlines these recommendations, that can be used for development and implementation of improved construction management tools and practices while optimizing data collection and management processes.

Recommendations to Mitigate Current Challenges

Below are the recommendations provided by the participants for enhancing visual dashboards in the construction industry. A more intuitive and user-friendly design was the top preference, chosen by 39% of participants. Other recommendations for improvements include enhanced integration with other software tools (19%) and more comprehensive data tracking and reporting (23%). These suggestions underscore the importance of prioritizing ease of use and integration with other systems in project dashboards to assist construction professionals in managing project data more efficiently.

The participants emphasized that the most crucial feature of project dashboards is a better visualization and understanding of project progress, with 38% of participants choosing this option. Real-time data tracking was also deemed important, selected by 35% of participants. These recommendations highlight the need for project dashboards to prioritize clear and informative data visualization and real-time tracking, aiding construction professionals in monitoring project progress more effectively. Regarding the frequency of updates, most participants preferred weekly updates for project dashboard information, with 84% selecting this option. These findings indicate that project dashboards should prioritize weekly updates to ensure construction professionals have access to the

most up-to-date information on project progress. In terms of responsibility for updating project dashboard data, it was evident from the responses that most participants believe multiple individuals from every department should be responsible, with 61% choosing this option. Only 10% of participants believe that one dedicated individual at the company level should be responsible for updating project dashboard data.

Conclusion

The utilization of visual dashboards in the construction industry has seen a significant rise in recent years, offering the potential to improve management of construction projects through enhanced communication, transparency, and decision-making. This study aimed to gain insights into the utilization of visual dashboards in construction projects, identifying their strengths, limitations, and areas for improvement. Data from 31 construction professionals, each with more than five years of industry experience, were collected and analyzed using descriptive analysis.

The analysis identified several common features of effective visual dashboards, such as real-time data, interactivity, user-friendliness, and customizability. It also highlighted the importance of integrating different data sources and integrating real-time data tracking into dashboards from various sensors which can be Iot devices and AR integration. However, the study also identified challenges that need to be addressed, such as the difficulty in real time data integration, and customizability of dashboards. The participants recommended more user-focused layout of future dashboards, comprehensive data tracking, and regular updates to ensure the effectiveness of visual dashboards. Further research is needed to investigate the impact of visual dashboards on project performance, data integration challenges, and ethical considerations. Overall, visual dashboards have the potential to enhance construction project management, and their adoption can lead to improved decision-making, increased transparency, and better communication among project team members.

Further research is needed to investigate several areas related to visual dashboards in construction. These include how dashboards can address data integration challenges and enhance construction safety, the impact of dashboards on project team dynamics and the importance of information access for team members. Research should also focus on the user experience and pain points of different dashboard interfaces, as well as how IoT data can be integrated with VDC and BIM to create dashboards that combine model data with real-time data.

Limitations

The study utilized a purposive sampling approach, targeting existing users of visual dashboards in construction projects. This method, based on the researchers' subjective judgment, could have introduced bias in participant selection. Consequently, the findings derived from this study might have limited generalizability to the broader population, potentially limiting the external validity of the study.

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