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User-Cantered Analytics Dashboard Design for Effective Business Management Decisions

Nor Hasimah Abd Rahman[1,*], Mohd Zool Fazlee Basir[2]

[1] Department of Information and Communication Technology, Polytechnic Sultan Abdul Halim Mu'adzam Shah, 06000 Jitra, Kedah, Malaysia
[2] Department of Civil Engineering, Polytechnic Sultan Abdul Halim Mu'adzam Shah, 06000 Jitra, Kedah, Malaysia

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ABSTRACT

The widespread use of business analytics dashboards has transformed how managers interpret data and make business decisions. However, many dashboards fail to effectively support decision-making due to usability problems, unclear visualizations, and weak alignment with managerial needs. Unlike traditional Decision Support Systems (DSS) that emphasize model-driven and what-if analysis, analytics dashboards primarily support decision-making through performance monitoring, trend analysis, and data sense-making. This conceptual paper examines how user-centred analytics dashboard design enhances managerial decision effectiveness. Drawing on User-centred Design, the Technology Acceptance Model (TAM), the Information Systems Success Model (ISSM), and Cognitive Load Theory, the study synthesizes prior literature to identify key usability-related design constructs. A conceptual framework is proposed linking dashboard usability, UI/UX design quality, data visualization clarity, and information relevance to managerial decision effectiveness, measured through decision quality, efficiency, confidence, and action ability. This paper contributes by clarifying the role of analytics dashboards as decision support artefacts and offering a theoretically grounded framework to guide future empirical research and practical dashboard design.

1. Introduction

Business analytics dashboards have become ubiquitous tools in modern organizations, transforming how managers monitor performance and make decisions by consolidating complex data into visual, at-a-glance summaries. These dashboards serve as interfaces between large data repositories and decision-makers, enabling the tracking of key performance indicators (KPIs), the identification of trends, and timely responses to business challenges. As documented by Davenport and Harris [1] and LaValle *et al*., [2], top-performing firms increasingly leverage analytics dashboards to gain competitive insights and improve decision outcomes.

Despite their potential, many dashboards fail to deliver meaningful managerial value. As Few [3] and Ware [4] observe, poorly designed dashboards frequently suffer from information overload, unclear visualizations, and misalignment with user needs, which raises cognitive load and impedes

* *Corresponding author.*
E-mail address: norhasimahkktm@gmail.com

effective decision-making. In practice, dashboards are often cluttered with excessive metrics, inconsistent design elements, and confusing layouts that hinder rather than help decision-makers; such defects can produce user frustration, misinterpretation of data, and suboptimal decisions.

Academic research in business analytics and information systems has traditionally emphasized data quality, technical capabilities, and system performance. Scholars commonly evaluate dashboards using metrics such as system usage frequency or user satisfaction, drawing on models like the Technology Acceptance Model and the DeLone and McLean Information Systems Success Model to explain adoption and perceived impact (as described by Siponen *et al*., [5] and DeLone and McLean [6]). While these models highlight important drivers including perceived usefulness, perceived ease of use, and information quality they do not fully specify which concrete design features translate into decision effectiveness. As a consequence, the direct linkage between user-centered dashboard design and managerial decision outcomes remains underdeveloped in the literature.

Because managerial decision-making is complex and context dependent, evaluating decision effectiveness requires more than a binary right or wrong judgement. We therefore assess effectiveness using criteria such as decision quality, speed, confidence, and actionability. Addressing the theoretical and practical gap requires a conceptual framework that integrates user-centered design and data visualization with decision science to explain how well-designed dashboards can improve managerial decisions. This paper develops such a framework by synthesizing recent literature (2022–2025) across analytics dashboards, user-centered design (UCD), UX, visualization, and decision support, integrating insights from HCI and IS theories including UCD principles, TAM/UTAUT, the IS Success Model, and cognitive load theory.

In short, the proposed model posits that key design characteristics such as dashboard usability, UI/UX design quality, visualization clarity, and information relevance will improve managerial decision outcomes by reducing cognitive overload and enhancing comprehension. User satisfaction and perceived ease of use are conceptualized as mediators linking design quality to decision effectiveness. The remainder of the paper first reviews the relevant literature, then presents the conceptual framework, compares it with prior models, discusses practical implications and organizational recommendations, outlines limitations and avenues for empirical validation, and concludes with the paper's contributions.

Although prior studies have drawn on multiple theoretical perspectives to explain dashboard adoption and use, the integration of these theories remains insufficiently articulated. In particular, UCD, TAM, ISSM, and Cognitive Load Theory are often cited in parallel without clarifying their complementary explanatory roles. This paper addresses this gap by positioning these theories as a layered explanatory framework rather than overlapping models. UCD serves as the guiding design philosophy that informs dashboard features and interaction flows; Cognitive Load Theory explains the cognitive mechanisms through which design affects information processing and sense-making; TAM captures users' perceptual and attitudinal responses such as perceived ease of use and usefulness; and the IS Success Model provides the logic linking system and information quality to individual-level impacts. By clarifying how these theories jointly explain dashboard-supported decision-making, this study offers a more coherent theoretical foundation for analytics dashboard research.

1.1 Dashboards, Analytics and Business Decision-Making

Dashboards are commonly defined as visual displays of the most important information required to achieve specific objectives, consolidated on a single screen for monitoring at a glance [3]. In business management contexts, analytics dashboards compile data from multiple sources and present it in digestible formats to support managerial tasks. By providing rapid access to relevant metrics and trends, dashboards can enhance data-driven decision making and enable managers to respond to operational and strategic issues [1,2].Evidence indicates that firms which use visual analytics effectively and particularly when visualizations are aligned to business questions tend to realize competitive advantages in domains such as marketing and sales [8,9].

An experimental study by Hjelle *et al*., [7] demonstrates that the informational characteristics of dashboards (format, timeliness, completeness) materially affect decision outcomes. In their findings, dashboards that present well-formatted, current, and comprehensive information reduced perceived task complexity and increased information satisfaction, thereby improving decision quality. This suggests that presentation and organization of information, not solely data availability, determine whether dashboard-generated insights become sound managerial actions.

Dashboard adoption and impact also depend heavily on alignment with users' needs. If managers do not perceive a dashboard as useful or easy to use, adoption and ongoing use decline, consistent with TAM logic [5]. Implementation studies have shown that dashboards frequently fall into disuse when they are not tailored to user workflows or lack iterative refinement; Rossi *et al*., [11] argue that embedding human-centered design practices through the dashboard lifecycle from needs exploration to iterative refinement is pivotal for sustaining value.

Interactive features such as drill-downs, filters, and scenario analysis play a central role in decision processes. Experimental research Meyer *et al*., [14] and Pei *et al*., [15] finds that interactivity accelerates problem solving and increases user confidence because it enables exploration and verification of insights. Thus, interactivity and user control should be considered core design elements connecting visualization to decision effectiveness.

1.2 User-Centered Design and UX in Dashboard Development

User-centered design is the practice of designing systems around the needs, abilities, and contexts of end users [24]. In dashboards, UCD entails involving managers and analysts in requirements elicitation, prototyping, usability testing, and iterative refinement. Xu *et al*., [8] document practical UCD workflows where initial interviews inform prototypes that are then refined through rounds of usability testing, yielding dashboards better aligned to users' mental models and tasks.

Refer to Alhamadi *et al*., [25], frequent problem is a mismatch between designers' assumptions and users' data literacy or task constraints. This disconnect can be mitigated by active user involvement and by providing design choices such as customization, personalization, or adaptive interfaces to tailor views to roles and preferences. Empirical evidence indicates that dashboards offering sensible default configurations with optional personalization achieve both usability for novices and flexibility for experts [7,21]. Consequently, UCD practices that combine strong defaults with user tailoring support broader adoption and deeper use.

1.3 Data Visualization Principles and Cognitive Considerations

Data visualization principles are central to dashboard effectiveness. Core recommendations include reducing clutter, enforcing visual hierarchy, selecting appropriate chart types, maintaining consistent color semantics, and providing contextual annotations [3,4,14]. Cognitive load theory provides a rationale for these practices: as working memory is limited, dashboards must present information in perceptual encodings that humans process effectively (such as position or length) and minimize extraneous cognitive processing that would otherwise detract from analytical reasoning [4].

Recent systematic syntheses by Neri *et al*., [16] support interactive and customizable visualizations as strategies to balance analytic complexity and usability. Interactive features permit exploration without cluttering overviews, and customization enables alignment with individual cognitive styles. Importantly, designers should link visualizations to action by highlighting anomalies, supplying clear labels and thresholds, and providing concise interpretative commentary so that managers can rapidly translate insights into decisions [10].

1.4 Theoretical Integration and Positioning

While TAM and the IS Success Model have been widely applied in analytics and dashboard research, their use has often resulted in conceptual overlap, particularly between perceived usefulness (TAM) and information quality (ISSM). In this study, this overlap is addressed by distinguishing between objective design attributes and subjective user perceptions. Information relevance, visualization clarity, usability, and UI/UX quality are conceptualized as objective design characteristics, whereas perceived ease of use and user satisfaction are treated as subjective mediating variables. This distinction reduces redundancy and clarifies construct boundaries within the integrated framework.

Furthermore, Cognitive Load Theory is incorporated to explain the cognitive processes through which dashboard design influences decision-making. While TAM and ISSM explain adoption and perceived impact, they do not explicitly account for how interface design affects human cognitive capacity during analytical tasks. Cognitive Load Theory complements these models by explaining how poor visualization, excessive information, or weak hierarchy increases extraneous cognitive load, thereby impairing comprehension and judgment. Conversely, dashboards designed according to user-centered and visualization principles reduce cognitive burden and facilitate effective sense-making.

The framework deliberately focuses on individual managerial decision-making and therefore excludes certain organizational and social factors such as organizational culture, group decision dynamics, and governance structures. These factors are acknowledged as important contextual moderators but are excluded to maintain theoretical parsimony and analytical focus. Future empirical studies may extend the framework by incorporating these variables as boundary conditions.

2. Methodology

This study adopts a conceptual research methodology aimed at theory development and integrative synthesis rather than empirical hypothesis testing. Conceptual research is appropriate when existing knowledge is fragmented across multiple disciplines and requires consolidation to explain complex organizational phenomena, following the guidance of Webster and Watson [26].

Accordingly, this study synthesizes prior research to identify key constructs, relationships, and explanatory mechanisms relevant to analytics dashboard design and managerial decision-making.

The development of the conceptual framework involved a structured review and synthesis of literature related to business analytics dashboards, user-centered design, decision support systems, and managerial decision effectiveness. Seminal and recent studies were examined to identify recurring design dimensions, user-related mechanisms, and decision outcomes. Rather than applying a systematic review protocol with strict inclusion criteria, this study emphasizes integrative synthesis to combine insights from diverse research streams into a coherent conceptual model.

Key theoretical perspectives were selected based on their relevance to explaining user interaction and decision processes. User-centered design provides the foundation for aligning dashboard features with managerial needs and contexts, as outlined in ISO 9241-210 [24]. Information systems success theory explains how system and information quality influence individual-level impacts, as explained by DeLone and McLean [6]. Through iterative abstraction and comparison, core dashboard design dimensions were identified and conceptually linked to business management decision effectiveness. As no primary data were collected, the emphasis of this methodology is on conceptual clarity, theoretical rigor, and internal coherence, providing a foundation for future empirical validation.

As this study adopts a conceptual research design, the proposed relationships should be interpreted as theoretically grounded propositions rather than empirically validated causal effects. The framework does not claim that user-centered dashboard design will automatically result in improved managerial decisions. Instead, it proposes that under specific cognitive and perceptual conditions such as reduced cognitive load, high perceived ease of use, and user satisfaction dashboard design characteristics are expected to support more effective decision processes. Empirical validation through experimental, survey-based, or field studies is therefore necessary to test the strength and boundary conditions of the proposed relationships.

3. Result and Discussion

3.1 Overview of the Conceptual Framework

Building on the literature, the proposed user-centered framework as shown in Fig. 1 posits that four design constructs which are dashboard usability, UI/UX design quality, visualization clarity, and information relevance act as antecedents that, via mediators (user satisfaction and perceived ease of use), shape managerial cognitive processes (reducing extraneous cognitive load and improving comprehension) and yield proximal decision outcomes: decision quality, decision efficiency, decision confidence, and actionability of insights. The sequence is therefore: User-Centered Design → Positive User Perceptions → Enhanced Decision Process → Effective Decisions. This chaining integrates the logic of IS success [6], the mechanisms of TAM/UTAUT [5], and cognitive visualization theory [4,14].

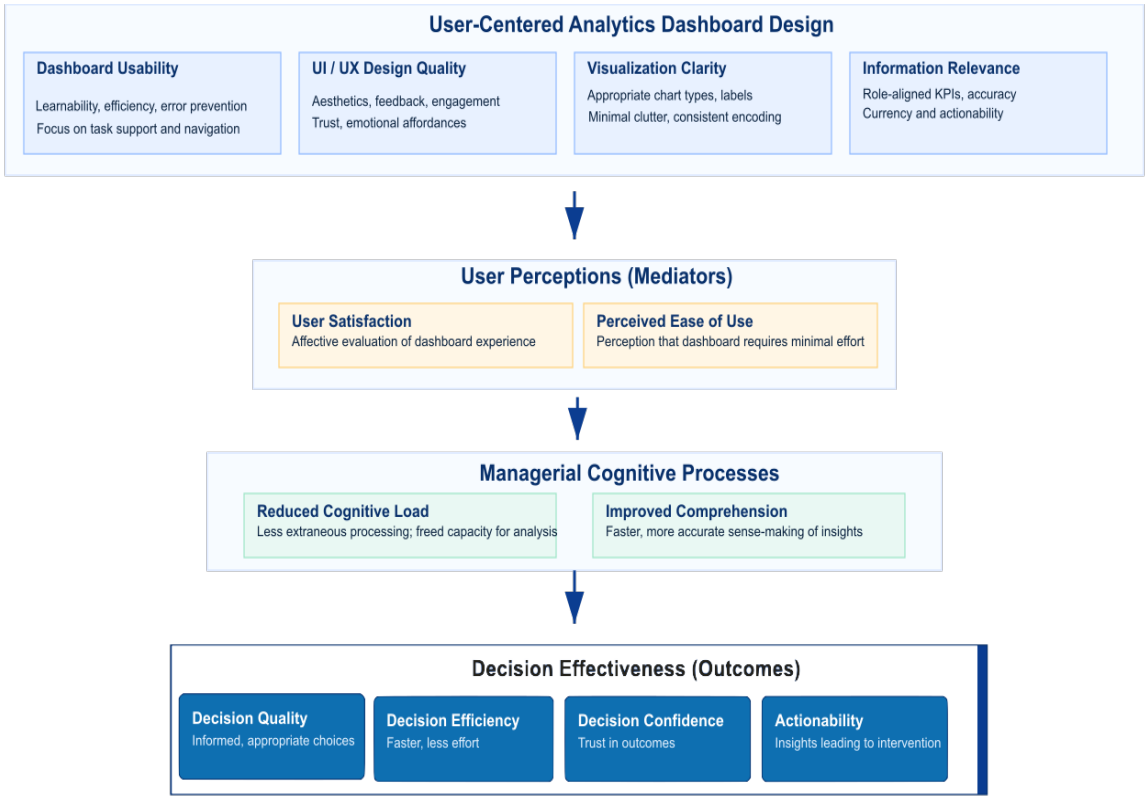

Fig. 1. Conceptual framework of user-centered analytic dashboard design and business management decision effectiveness

3.2 Design Constructs (Operationalization)

Dashboard usability refers to learnability, efficiency, memorability, and error prevention; it reduces operational friction and allows managers to focus on analysis rather than interface manipulation [3,19]. UI/UX design quality encompasses aesthetic coherence, interaction feedback, and emotional affordances that foster trust and engagement; a positive UX increases users' propensity to explore and rely on the dashboard [20]. Visualization clarity concerns appropriate visual encodings, labeling, color semantics, and minimal clutter; clarity supports perceptual processing and accurate interpretation [4,14]. Information relevance emphasizes role-aligned metrics, currency, and accuracy so that dashboard content maps directly to managerial decisions [6,12].

These design dimensions interact: for example, visualization clarity enhances perceived usability, and information relevance drives satisfaction and perceived usefulness. Contemporary reviews and empirical studies [7,12] validate the centrality of these constructs in dashboard practice.

3.2.1 Implementing UCD

Implementing UCD in dashboards follows a staged iterative process. The first stage is understanding decision contexts and mapping required Key Performance Indicators (KPIs) through interviews, observations, and contextual inquiry [8]. The second stage translates these needs into information architecture, appropriate visualization selections, and interaction design; here, designers select chart types that fit tasks (e.g., trend analysis vs. comparison) and structure the dashboard to surface priorities. The third stage focuses on prototyping and iterative evaluation with users; empirical studies report concrete outcomes of this cycle terminology alignment, readability

adjustments, improved filtering and sorting that materially improve usability and navigation [21]. Experimental work also demonstrates that excessive or poorly structured information increases cognitive load and impairs decision performance [13].

3.3 Mediating Mechanisms

User satisfaction and perceived ease of use mediate the effect of design on decision outcomes. According to TAM and IS success logic, design attributes influence satisfaction and ease, which in turn increase consistent and effective system use, leading to improved decision outcomes [5,6]. Empirical studies notably by Hjelle *et al*., [7] and Pei *et al*., [15] support the mediating roles of information satisfaction and perceived ease in the pathway from design to performance.

3.4 Decision Effectiveness (Outcomes)

Decision effectiveness is conceptualized through four proximal dimensions. Decision quality reflects the appropriateness and informativeness of choices; decision efficiency concerns the speed and effort required to reach decisions; decision confidence captures managers' self-assuredness and trust in outcomes; and actionability denotes the degree to which dashboard insights translate directly into managerial interventions. Evidence from interventions and systematic reviews indicates that dashboards designed for clarity, relevance, and usability improve detection of issues and timeliness of response [20,22,23]. Thus, the framework hypothesizes that design improvements will lead to measurable gains across these dimensions via reduced cognitive load and increased satisfaction/acceptance.

3.5 Comparison with Prior Models

The proposed framework complements and extends prior scholarship in several ways. Whereas TAM/UTAUT [5] explains adoption through perceived usefulness and ease, it treats the system as a black box with little guidance on which design elements produce those perceptions; our model opens the black box by specifying usability, visualization clarity, and relevance as explicit design levers. The IS Success Model [6] articulates quality → satisfaction → impact chains; this work narrows the outcome focus to decision effectiveness and prescribes concrete design facets to achieve quality. Practitioner design guidelines, Few [3] and Shneiderman *et al*., [18] offer valuable best practices, but seldom link those practices to proximate decision outcomes; our framework translates design rules into testable hypotheses about decision quality, speed, confidence, and actionability. Finally, classic DSS and cognitive fit theories provide insights into task-format alignment; the present model integrates these ideas while offering a holistic account of how multiple design elements, interacting with user perceptions, produce decision results.

The primary theoretical contribution of this study lies not in introducing entirely new constructs, but in re-specifying the relationships between established concepts and redirecting their explanatory focus toward decision effectiveness. Unlike prior applications of TAM and the IS Success Model that treat information systems as black boxes, this framework explicitly identifies dashboard design characteristics as antecedents to user perceptions and decision outcomes. In addition, by incorporating cognitive load as an explanatory mechanism, the framework explains why certain dashboard designs are more likely to support high-quality, efficient, and confident managerial decisions. This positioning advances dashboard research from adoption-centric explanations toward a decision-centric understanding of analytics systems.

3.6 Practical Implications and Recommendations

The proposed framework yields several practical implications for dashboard designers, IT managers, and organizational decision-makers by translating theoretical constructs into concrete design, evaluation, and implementation guidance. For dashboard designers, development should begin with decision-focused task analysis, ensuring that each metric, visualization, and interaction explicitly supports a specific managerial decision or action. Designers are encouraged to engage representative end-users from the outset through interviews, persona development, and use-case definition, followed by iterative prototyping and systematic usability testing to identify and resolve mismatches between dashboard design and user cognition [8,21]. In line with cognitive load theory, designers should apply principles of cognitive economy by limiting the number of visual elements per screen, prioritizing perceptually efficient visual encodings such as position and length, maintaining consistent colour semantics and labelling, and avoiding decorative elements that dilute the data signal [4,14]. Detailed information should be deferred through interactive mechanisms such as drill-downs, filters, and tooltips to balance overview and analytical depth.

In addition, dashboards should provide role-based default views aligned with managerial responsibilities to support novice users, while offering optional personalization and customization features for advanced users. From an evaluation perspective, dashboard effectiveness should not be assessed solely through usage frequency or user satisfaction. Instead, organizations should incorporate decision-oriented evaluation criteria, including task completion time, perceived cognitive load, decision confidence, and the extent to which dashboard insights translate into concrete managerial actions. These indicators align more closely with the framework's emphasis on decision effectiveness rather than system adoption alone.

For IT managers, the framework underscores the importance of adopting user-centered and agile development processes supported by cross-functional teams that integrate data engineering, UX design, and domain expertise. Robust data pipelines, data validation mechanisms, and integration with operational workflows are essential to maintain data trustworthiness and enable actionability. Instrumenting dashboards to collect usage analytics and structured user feedback supports continuous refinement and ensures sustained relevance. Dashboards should therefore be treated as evolving decision support artefacts rather than static reporting tools, requiring ongoing maintenance and improvement [11,20].

At the organizational level, leaders play a critical role in realizing the value of analytics dashboards. They should align dashboard objectives with strategic KPIs, foster a data-driven culture by modelling analytical use in decision forums, invest in data literacy and training, and establish accountability mechanisms that ensure insights lead to timely actions. In collaborative or committee-based decision contexts, dashboard design should also support shared sense-making and discussion, recognizing that organizational factors may moderate the impact of design on decision outcomes. Overall, these recommendations reinforce the view that user-centered dashboard design is not merely a technical activity but an organizational change endeavour requiring coordinated attention to people, processes, and technology.

3.7 Limitations and Future Research Directions

The proposed framework is conceptual and requires empirical validation. Key limitations include the absence of systematic empirical testing, potential contextual variability across decision types and domains, the omission of some organizational and socio-technical factors (e.g., group decision dynamics and culture), and the dynamic nature of dashboard use over time (learning curves and

possible unintended consequences such as over-reliance). Measurement challenges also exist: operationalizing decision quality and connecting subjective perceptions to objective decision outcomes requires careful multi-method research design. Future work should test the framework with experiments, field studies, and longitudinal designs; investigate boundary conditions (e.g., high-velocity operations vs strategic planning), explore added design facets (e.g., dashboard intelligence, mobile usability), and consider moderators such as user expertise and organizational data culture.

4. Conclusions

This paper contributes a theoretically integrated and decision-centric framework for understanding how user-centered analytics dashboard design can support managerial decision-making. By clarifying the complementary roles of UCD, Cognitive Load Theory, TAM, and the IS Success Model, the study provides a coherent explanation of how dashboard design characteristics influence cognitive processing, user perceptions, and decision outcomes. While conceptual in nature, the framework offers a strong foundation for empirical testing and provides practitioners with actionable guidance for designing dashboards that support not merely information access, but effective business decisions.

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