Chapter 6 / Capítulo 6

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Sustainable balance between usability and aesthetics in hardware and software design within the organizational context
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User-centered design (UCD) as a methodological framework

El diseño centrado en el usuario (DCU) como marco metodológico

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ABSTRACT

Context: In this chapter, the implementation and governance of User-Centered Design (UCD) are analyzed. At present, organizations are adopting the international principles of the ISO 9241-210 standard and moving away from linear software and hardware development schemes. The standard adopts a constructivist approach that places human needs and capabilities at the center of the sociotechnical cycle of technology. Objective: The purpose of the study is to set out the normative epistemology of ISO 9241-210, to distinguish analytically between user-centered and human-centered design, and to describe what the iterative operational cycle consists of, together with the techniques of empirical measurement and participatory co-design. Method: A theoretical-descriptive documentary review was carried out on the basis of international criteria in ergonomics, psychophysical methods for interface evaluation, and co-creation dynamics for information architectures. Results: The findings indicate that iterating through the operational cycle, together with quantitative techniques such as eye-tracking and the SUS and UMUX scales, prevents both the aesthetic trap and cognitive overload. Nevertheless, challenges persist, such as the management of multidisciplinary teams and the reduction of the complex human being to purely instrumental roles. Conclusions: Through cyclical and participatory iteration, companies obtain an auditable process that lowers the costs of subsequent corrective redesign. It is advisable for collaborative design practices to be institutionalized in order to strengthen usability and the reflective dimension of the brand.

Keywords: Context of use; Participatory co-design; Ergonomics of interactive systems; Cyclical iteration

RESUMEN

Contexto: En este capítulo se analizan la implementación y la gobernanza del Diseño Centrado en el Usuario (DCU). En la actualidad, las organizaciones están adoptando los principios internacionales de la norma ISO 9241-210 y se alejan de los esquemas lineales de desarrollo de software y hardware. La norma adopta un enfoque constructivista que sitúa las necesidades y capacidades humanas en el centro del ciclo sociotécnico de la tecnología. Objetivo: El propósito del estudio es exponer la epistemología normativa de la ISO 9241-210, diferenciar analíticamente entre el diseño centrado en el usuario y el diseño centrado en el humano, y describir en qué consisten el ciclo operativo iterativo y las técnicas de medición empírica y de co-diseño participativo. Método: Se realizó una revisión teórico-descriptiva y documental a partir de criterios internacionales de ergonomía, metodologías psicofísicas de evaluación de interfaces y dinámicas de co-creación de arquitecturas de información. Resultados: Los resultados indican que el paso iterativo por el ciclo operativo, junto con técnicas cuantitativas como el eye-tracking y las escalas SUS y UMUX, previene la trampa estética y la carga cognitiva. Aun así, persisten desafíos como la gestión de equipos multidisciplinares y el aislamiento del ser humano complejo en roles puramente instrumentales. Conclusiones: Las empresas obtienen de la iteración cíclica y participativa un proceso auditable que abarata los costos del rediseño correctivo posterior. Es recomendable que los diseños colaborativos se institucionalicen, a fin de robustecer la usabilidad y el poder reflexivo de la marca.

Palabras clave: Contexto de uso; Co-diseño participativo; Ergonomía de sistemas interactivos; Iteración cíclica

6.1. NORMATIVE EPISTEMOLOGY OF UCD (ISO 9241-210)

Alekvs (2025) suggests that a formal methodological governance framework can effectively link the empirical findings on the aesthetic-usability effect to software engineering and hardware development in organizations.

The ISO 9241-210:2019 standard (Ergonomics of human-system interaction — Part 210: Human-centred design for interactive systems) is regarded as the new contemporary international benchmark for this approach, having superseded and refined the former guidelines of the ISO 13407 standard (ISO, 2019).

This international standard does not function as a rigid technical recipe; rather, it is a project management ontology that places human needs, capabilities, limitations and perceptions at the very center of the technology development life cycle (ISO, 2019; Luján, 2026).

From an epistemological standpoint, the ISO 9241-210 standard radically opposes the classical paradigm of development rationality and technological thinking, as well as the technocentric paradigm, in which systems engineering dictated the logical flows and required users to adapt their cognitive schemas to the limitations of the software.

The epistemology of user-centered design (UCD), or human-centered design (HCD), is empirical, constructivist and phenomenological in nature: it holds that the true quality, usability and perceived value of an interactive product do not depend on the abstract backend code, but rather emerge exclusively in the lived experience of the person in the context of use.

The ISO 9241-210 standard accordingly formalizes a normative epistemology. It stresses that, for a development process to qualify as "user-centered," the institutional adoption of six design principles is mandatory (Alekvs, 2025; ISO, 2019).

- Explicit understanding of users, tasks and environments: An in-depth and exhaustive field study must be conducted to map the organization's sociotechnical context.
- Active involvement of users during design: Break the asymmetry of the traditional analyst role by incorporating the company's operator as a direct validator of the requirements.
- User-centered analysis drives and refines the design: both empirical performance and perceived usability govern the acceptance of the project phases.
- The process is cyclical: it rests on the ontological premise that designing a successful interface is not linear; building one requires a continuous cycle of testing and refinement.
- The design explicitly considers the total user experience (UX) as an integrated whole that holistically includes both the pragmatic components (functional use) and the emotional components (aesthetics of...
- The design explicitly addresses the total user experience (UX): it holistically integrates both the pragmatic components (functional usability) and the emotional components (surface visual aesthetics).
- The development team has multidisciplinary skills and perspectives: it has fostered a symbiosis among software engineers, visual designers, cognitive psychologists and business managers.

The operationalization of this epistemology is structured around a loop of four methodological phases, which must be carried out iteratively until the technological product meets the organization's strategic goals.

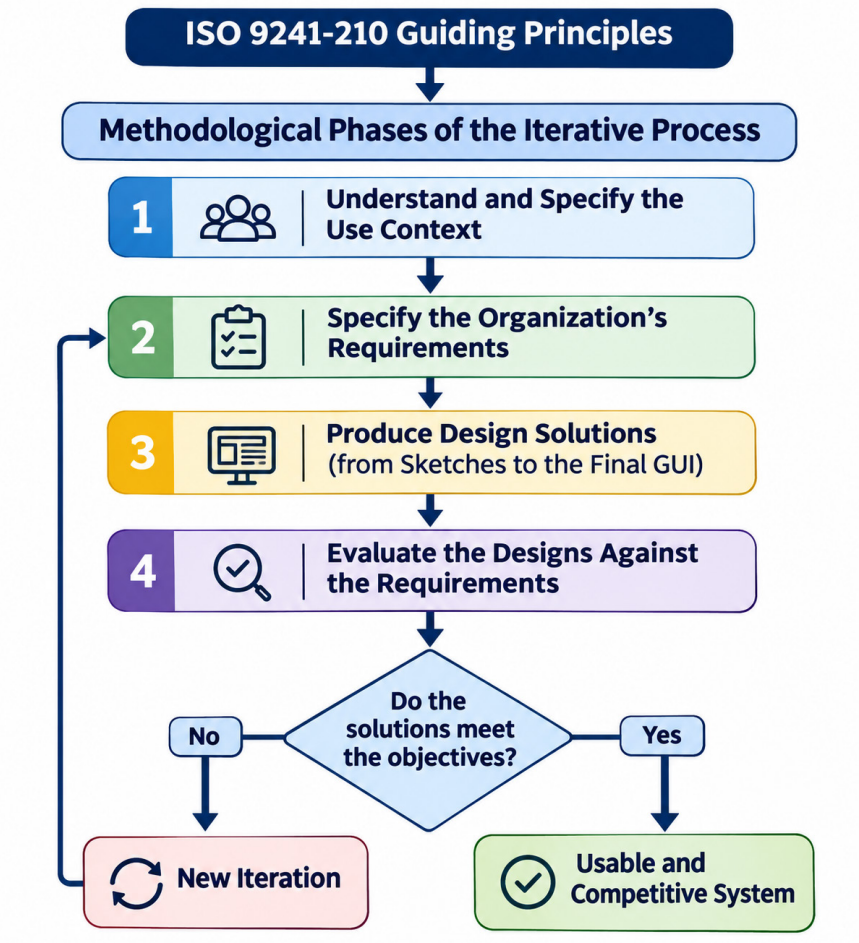
- Fase uno: comprender y concretar el contexto de uso. Implica la recolección exhaustiva de datos sobre quién utilizará la tecnología, para qué actividades del negocio y bajo qué condiciones físicas y ambientales.

•Stage two: determining user and organizational needs. A document is prepared that sets out the functional requirements, technical constraints and specific usability objectives derived from the identified needs. This document is aligned with the ISO 9241-11 standard.

- Fase 3: Producirsoluciones de diseño. Es el momentoen which ideas are the product of their thinking and instrumental in nature. According to the model of Jesse James Garrett (2011), aesthetics and the Gestalt laws are taken into account to optimize apparent usability, from the structuring of the information architecture (structure plane) through to the design of the final graphical user interface (GUI) (surface plane) (IxDF, 2021).

•Evaluate the designs against the requirements. This is the empirical core of the cycle. Usability tests are conducted in laboratories or simulated environments to collect metrics of effectiveness, efficiency and satisfaction. If the interface creates cognitive load or conceals severe problems behind an aesthetic trap, the material collected immediately enables a new, disruptive iteration back to the top of the cycle.

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The formal adoption of ISO 9241-210 provides companies, specifically senior management and the management of modern technology projects, with a methodology for mitigating risks of high economic impact (Ermete, 2024). It ensures that software and hardware development depends not on the programmer's sound intuition or aesthetic improvisation but on a scientific, evidence-focused process. Such a process drastically reduces subsequent redesign and corrective maintenance costs, closes the system upon itself, safeguards internal productivity and maximizes the perceived value of the product in globalized markets.

6.2. CONVERGENCE AND DIVERGENCE: USER-CENTERED DESIGN VS. HUMAN-CENTERED DESIGN

In HCI and the strategic management of interactive projects, User-Centered Design (UCD) and Human-Centered Design (HCD) are generally used interchangeably in the scientific literature.

However, sociotechnical ecosystems and modern international normative frameworks of reference distinguish between the two constructs (Giacomin, 2014; ISO, 2019). Unlike UCD, which frames the functional relationship between a subject and a digital interface and operates as an instrumental system per se, HCD reflects a broader perspective. It is situated within an ethical, systemic and utopian context and analyzes the impact of technology on the well-being of individuals, communities and collective spaces.

Despite their differences in scope, both approaches share an identical epistemological and procedural core: the absolute rejection of technocentric design, in which software or hardware is custom-developed in isolation to impose rigid logical flows on people.

Both UCD and HCD fully agree on the following pillars of project governance.

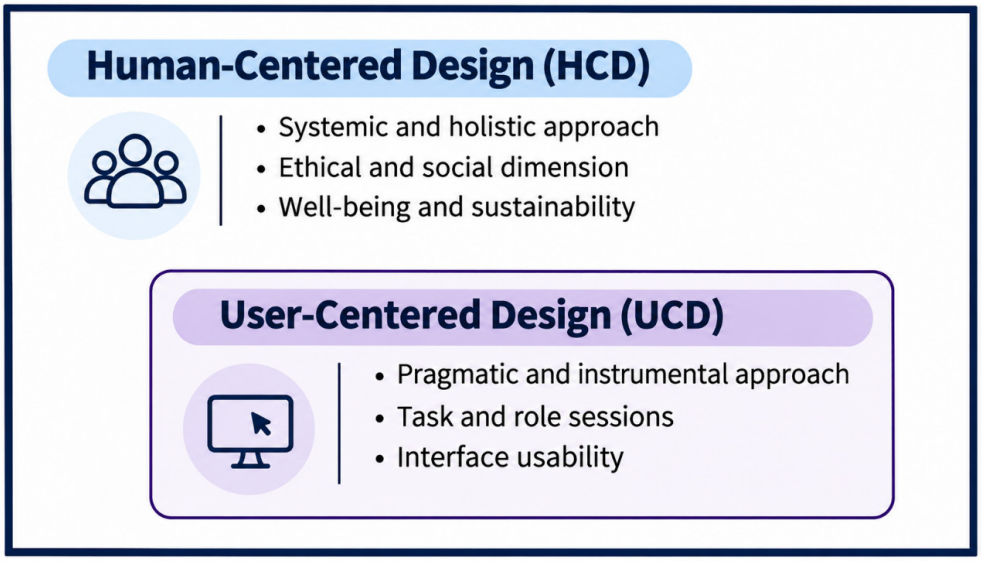
• La Reiteración Estructurada. Se presume con enfoque metodológicos que la optimización de algún producto interactivo requiere de un ciclo continuo de diseño, evaluación, feedback and empirical refinement.

•Operational Empathy. In-depth field research is the first and most fundamental principle, and it must be met before coding begins. Decisions based on developer intuition and superficial

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aesthetic trends must be abandoned.

• Diversas disciplinas. Exigen la integración sinérgica de equipos diversos que unifiquen las ciencias de la computación con la psicología cognitiva, el diseño visual y los objetivos monetary of the company.



Analytically speaking, the distinction between these two concepts lies primarily in how each defines and delimits the subject who interacts with the system (Giacomin, 2014; Norman, 2013). User-Centered Design (UCD) conceives of the subject solely as an operational user, that is, an operator defined by a job role, a specific usage session and, within it, a series of tasks to be performed in the software in question (for example, an analyst carrying out processing in an ERP or a customer making a transfer at an ATM). The metrics and success indicators of the ISO 9241-11 standard are instrumental: workflow effectiveness, click efficiency, and momentary satisfaction with the graphical user interface (GUI)

In contrast, Human-Centred Design (HCD), the term that formally gives ISO 9241-210 its name, goes beyond a purely pragmatic perspective and studies the individual as a complex human being embedded in a social and cultural environment.

HCD recognizes that the impact of technology extends beyond the limited on-screen time of the session.

On this basis, the assessment considers the changes it will bring about in psychological and physical well-being over time, the technostress burden it generates in organizational settings, its potential to provide universal access to people with diverse cognitive or sensory abilities, and its ethical dimension or the privacy requirements entailed by the corporate use of data.

Drawing on the specialized literature of the discipline, this analytical distinction can be summarized in the following table:

Table 3. Contrast Matrix: Usability and UX

Analysis Criterion	User-Centered Design (UCD)	Human-Centered Design (HCD)
Subject Definition	An operator with a defined functional role and specific tasks.	A social being with emotions, cultural values and a complete life cycle.
Operational Scope	The Graphical User Interface (GUI) and the logical navigation flow.	The complete sociotechnical ecosystem, integrating hardware, software and the work environment.
Primary Metrics	Effectiveness (success rates), efficiency (task times), error prevention.	Long-term well-being, reduction of cognitive load, design ethics, accessibility.
Regulatory Framework	ISO 9241-11 (Usability Metrics and Instrumental Interaction)	ISO 9241-210 (Holistic governance and organizational principles)

According to Ermete (2024) and Shi et al. (2021), the highest levels of contemporary digital project management should view the HCD model as a systematic evolution of the UDC model, without which there is no commercial and operational sustainability. Diverting quality control efforts toward a UCD approach may lead the organization to aesthetic encapsulation or to producing software that proves operationally viable in short tests (apparent usability) but that, when implemented at scale in the company's daily routine, generates high rates of mental fatigue

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or voluntary rejection.

Choosing Human-Centered Design gives companies the opportunity to align their technology with its pragmatic functionality and visceral aesthetics, as well as with their long-term value commitment. By building solutions that safeguard people's dignity, capabilities and ergonomics, organizations not only improve the profitability of their internal processes; they also build differentiated brand trust (Norman's reflective level). Moreover, they strengthen their competitive position in demanding international markets.

6.3. OPERATIONAL PHASES AND CYCLICAL ITERATION OF UCD

For ISO 9241-210 to be applied within software and hardware engineering workflows, organizations must abandon linear development paradigms (that is, the traditional Waterfall model of project management) and instead implement a structure based on cyclical iteration. This approach assumes that it is impossible to design a perfect interface in a single attempt, because users' mental models and the organization's socio-technical patterns emerge from multiple interactions.

To this end, the operational cycle of User-Centered Design (UCD) is sustained through a loop of four recurring technical phases; their systematic execution ensures that the final product empirically reduces cognitive load and, therefore, raises business performance to optimal levels (ISO, 2019; Luján, 2026).

Phase 1: Research and Analysis of the Context of Use

Empirical Immersion Stage

Fieldwork is conducted before the functions and graphic guidelines are defined. It determines who the users are (required cognitive skills, technical expertise), which business tasks the technology must support (complexity/difficulty/frequency of task execution), and under what environmental or physical conditions the technology will have to operate.

Phase 2: Writing User Requirements

Definition of Metrics and Indicators

This translates the empirical findings of Phase 1 into prescriptive design specifications and quantitative performance metrics. Quantifiable thresholds are prescribed for each parameter: effectiveness (i.e., the percentage of tasks completed), efficiency (e.g., the time required), and subjective satisfaction; each of the three variables has a dedicated conceptual framework, as specified by ISO 9241-11.

Phase 3: Production of Design Solutions

From Structural Abstraction to Visual Surface

This is the construction of ideas and images. Work proceeds hierarchically, following Jesse James Garrett's (2011) five-plane integration model: it starts with the information architecture and navigation flows (the skeleton), and the final graphical user interface (GUI) is consolidated last, as shown at the surface. Here, we apply the Gestalt laws and the principles of symmetry with absolute rigor to maximize apparently effective initial usability and elicit positive visceral emotional responses.

Planned Phase 4: Empirical testing of the designs

Laboratory validation and usability testing

This brings us to the crucial stage of psychophysical quality control. Representative users interact directly with the developed prototypes or systems while actual performance metrics are recorded. These metrics include error rates, visual fixation measured with eye-tracking techniques, and perceived mental workload.

The adaptive core of UCD rests on the decision-making that follows the fourth phase (ISO, 2019). The usability tests (the quantitative and qualitative data captured at this stage) are thoroughly compared against the requirements detailed in phase 2.

Exit decision rule: If the LBMD establishes that an alternative will overload the employee's cognition or cause a pathological incidence of performance errors or regular work-related stress due to an aesthetic trap (visual masking of operational failure), then production is automatically rejected.

This wealth of technical variation then drives a new iteration cycle and restarts the methodological process to develop a better information architecture, correct visual consistency or reformulate system commands (ISO, 2019). This cyclical process is repeated several times in an orderly manner until there are enough observed facts to assert that the interactive system meets all intrinsic usability criteria.

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In the operational cycle, usability and visual aesthetics become robust variables that can be predicted or audited, with the aim of reducing the monetary costs of corrective maintenance after the system is deployed in real-world settings: content generation becomes a set of highly efficient tools that feed its human capital.

6.4. EMPIRICAL MEASUREMENT AND PARTICIPATORY CO-DESIGN TECHNIQUES

- For the operational phases of the ISO 9241-210 standard to gain scientific validity and stop depending on subjective assessments, Human-Centered Design (HCD) must implement rigorous mechanisms for empirical measurement alongside participatory design methodologies (ISO, 2019; Sanders & Stappers, 2008).
- The convergence of quantitative psychophysical metrics with the contextual qualitative knowledge provided by co-design enables organizations to optimize the system's inherent usability, mitigate the risk of the "aesthetic trap" and increase the perceived value of the final product.
- Instrumental usability, based on the dimensions of effectiveness, efficiency and satisfaction set out in the ISO 9241-11 standard, is measured with various methodological tools applied in testing laboratories or controlled field settings. The techniques most commonly used to collect objective empirical data are described below:
- Task-Based Usability Testing: Representative users from the organization are placed in front of the interface and asked to execute critical business workflows (Nielsen, 1993). Observing and recording the session yields direct metrics such as the Task Success Rate (effectiveness), the Process Completion Time (efficiency), and the Count and Typology of operational errors made by the participant.
- Eye Tracking: A psychophysical technique that uses infrared hardware to record the operator's exact gaze position, the duration of visual fixations, and the saccadic paths (eye movements) across the GUI. It provides heat maps and gaze traces that show whether the spatial layout and the applied Gestalt laws are guiding the user's attention smoothly or whether the graphical interface instead causes visual confusion and attentional dispersion.
- Think-Aloud Protocol: A qualitative technique in which users are instructed to continuously verbalize their thoughts, expectations, doubts and dissatisfaction while interacting with the software or hardware. It allows researchers to map the participant's mental model in real time and to identify cognitive friction points that are invisible in purely quantitative records.
- Standardized Satisfaction Scales (SUS and UMUX): Psychometrically validated instruments administered immediately after the interaction session (Brooke, 1996). The System Usability Scale (SUS), consisting of 10 Likert-type items, provides a single composite score (from 0 to 100) that reflects the perceived overall usability and acceptability of the system. The Usability Metric for User Experience (UMUX) offers a shorter alternative, rigorously aligned with the requirements of the ISO 9241-11 standard (Finstad, 2010).

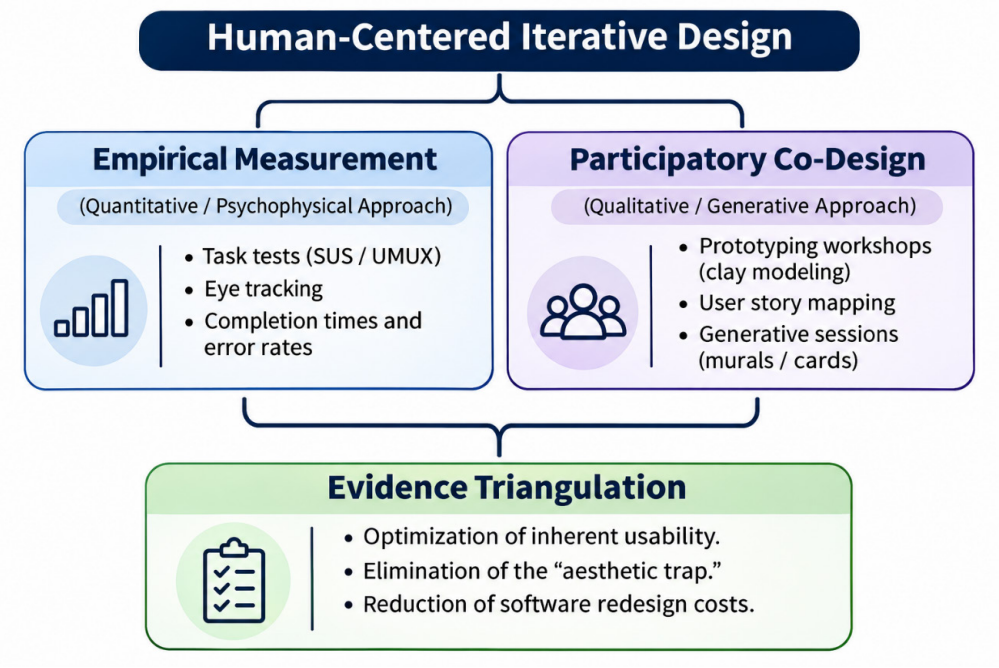
Control theory is based on empirical measurement or on a solution that is already tangible, which means the project team can control the extent to which its citizens are integrated into participatory co-design. In this generative paradigm, operators are not merely passive test subjects: they know their own work and their everyday context best (Giacomin, 2014; Sanders & Stappers, 2008).

The key operational dynamics of participatory co-design in the development of corporate software and hardware include:

- Generative sessions with low-fidelity tools: collaborative workshops in which physical blocks, cardstock cards, clay modeling or paper cut-outs are used to model users' own ideal interface solutions and hardware forms. What emerges, without being sought, are operators' latent desires and aspirations rooted in a wish for spatial organization, together with unexpressed needs.
- Card sorting: a participatory method intended to design the top-level architecture of Jesse James Garrett's (2011) model. For certain functions, users organize and group items using cards, and the content of these groups aligns with their relational logic. The statistical results of these sessions are used mathematically to advise on how the navigation menu and the information architecture should be structured, so that the software speaks a conceptual language as close as possible to the one that civic human capital would use.
- Participatory user story mapping (User Story Mapping): a co-creation activity in which the multidisciplinary team (software engineers, visual designers, administrators) and the users jointly

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build a chronological map starting from a step required to complete an operational process [ISO2019]. This collective alignment prevents orphan features and redundancies in information flows that undermine overall business optimization.



This fusion of the analytical rigor commonly associated with empirical measurement and the qualitative richness often linked to the dynamics of participatory co-design can prevent unforeseen failures in the adoption of technology not yet developed. It enables corporate development teams to design interfaces that produce a striking, visceral aesthetic effect at the visual layer while relying on functionally sound architectures, empirically tested by the people who will use them every day in your company.

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