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South American Publishing

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PROLOGUE

The development and design of interactive hardware and software products have evolved beyond purely technical concerns or isolated exercises in algorithmic programming to become central determinants of commercial viability, operational efficiency, and the sustainable success of contemporary organizations.

In a global sociotechnical environment characterized by mature digital markets, the widespread adoption of cloud-based solutions, and the ubiquity of smartphones, businesses face an unprecedented structural challenge. Contemporary industrial practice reveals a troubling reality, marked by fragmentation across different fields of knowledge and engineering disciplines.

Many organizations consequently devote their entire capital investment to maximizing backend performance and achieving numerical results, while neglecting the people who operate their systems, their experiences, and their ergonomic needs.

At the opposite extreme are companies that allow superficial design details, fleeting aesthetic trends, or transient visual preferences to dominate virtually their entire brand investment. In such cases, fundamental information architecture and the basic operational clarity required for effective interaction receive minimal attention.

This strategic imbalance is by no means economically inconsequential. On the contrary, it represents a powerful mechanism of value destruction. The consequences of disrupting the harmonious relationship between form and function become immediately apparent in low adoption and retention rates, adverse effects on brand reputation, substantial increases in the financial costs of post-deployment corrective maintenance, and the resulting loss of market share in highly competitive environments.

Structured around eight comprehensive chapters, this volume presents an innovative epistemological triangulation that synergistically integrates software engineering, industrial design, user experience (UX), and strategic business planning. The authors guide readers from the historical foundations and paradigm shift in technological functionalism that emerged during the 1970s to contemporary methodologies of User-Centered Design (UCD) and Human-Centered Design (HCD).

The analytical framework draws upon internationally recognized standards, particularly ISO 9241-11 and ISO 9241-210:2019. By decomposing usability into operational and empirically measurable dimensions, including effectiveness, efficiency, and subjective satisfaction, and examining these dimensions alongside established frameworks such as Jakob Nielsen's five usability attributes, the authors establish a foundation for management dashboards based on objective criteria. This approach seeks to replace assumptions and arbitrary graphical decisions with evidence-based practices during technical validation.

One of the volume's most significant theoretical contributions lies in positioning visual aesthetics and the formal properties of the graphical user interface (GUI) as essential cognitive scaffolding in human-computer interaction. Drawing on the foundational research of Masaki Kurosu and Kaori Kashimura (1995), together with Donald Norman's neuropsychological perspective on emotional design, the authors examine how a well-designed GUI, structured according to the psychophysical principles of Gestalt theory (proximity, similarity, common region, continuity, and figure-ground organization), can positively influence users' cognitive processing at a visceral level.

Such interfaces provide meaningful visual information that may alleviate technological anxiety and engage neurological reward mechanisms associated with dopamine-mediated responses.

This biological experience of pleasure underlies the Aesthetic-Usability Effect, a heuristic bias through which users develop a favorable initial perception of apparent usability, leading them to assume that visually sophisticated software is supported by robust and reliable internal engineering.

The volume further explores the halo effect and the cognitive buffering mechanism it produces, which may expand users' attentional resources and increase their flexibility and persistence when confronted with temporary system errors or interaction difficulties. Although the visual appeal of a product is widely recognized as an important determinant of its success, the scientific rigor of the analysis presented here also highlights a critical boundary condition.

The empirical findings are compelling. When catastrophic failures or critical backend problems occur, the mediating influence of aesthetics breaks down statistically. This finding underscores the need for caution when relying on visual attractiveness, as it may create an aesthetic trap: an interface whose appeal generates expectations that the underlying system cannot sustain in the event of a catastrophic failure. Under such circumstances, visual attractiveness becomes a misleading attribute rather than a genuine indicator of product quality.

By establishing a direct connection between cognitive psychology and business profitability, the book skillfully situates Jesse James Garrett's Five Planes Model within the broader economic framework of Michael Porter's generic competitive strategies and the models of vertical and horizontal differentiation in oversaturated markets.

At this intersection, the optimization of usability and interface aesthetics emerges as a strategic imperative for senior management, with the potential to substantially reduce internal operating expenditures (OPEX) by minimizing command errors, decreasing the need for continuous employee training, and reducing the volume of technical support tickets.

Furthermore, the refinement of the GUI's visual presentation is associated with an increase in the customer's effective cost per visit (eCPV). This refinement may also contribute to reducing the price elasticity of demand, protecting profit margins by strengthening the ability to command premium prices, and increasing customer lifetime value.

The final sections address the methodological dimension through the development of the Integrative Usability-Aesthetics Model (MIUE) and the specification of its pathways for quantitative empirical validation and advanced psychophysical triangulation.

Through Structural Equation Modeling (SEM) and Analysis of Variance (ANOVA), combined with objective biometric eye-tracking data, standardized psychometric instruments (SUS/UMUX), and qualitative think-aloud protocols, the authors demonstrate how UX can be approached as a rigorously measurable and systematically managed discipline.

The book concludes with an educational framework that extends the discipline toward emerging technological frontiers, including conversational artificial intelligence interfaces (Zero UI) and spatial computing within the broader landscape of extended reality (XR).

Readers are thus presented with a major scholarly contribution that redefines the understanding of technological design. This volume constitutes an essential resource for professionals, researchers, and policymakers seeking to establish sustainable competitive advantages while safeguarding human dignity, comfort, and productivity.

INTRODUCION

The moment a person begins to interact with a digital system, several judgments occur at once. Can the next action be identified? Does the screen make sense? Is the device responsive? Does the appearance inspire confidence, or does it create uncertainty? Such questions arise in a workplace application as readily as in a consumer product. They demonstrate why the quality of technological design cannot be reduced to computational capacity or visual attractiveness in isolation.

Over the period examined in this volume, principally 2004 to 2024, smartphones, cloud-based services, and increasingly widespread organizational digitalization changed the circumstances in which hardware and software are encountered. Interactive systems became part of ordinary work rather than tools reserved for technical specialists. This expansion brought a corresponding responsibility: products needed to account for diverse users, tasks, expectations, and working conditions.

Yet organizational design processes often separate matters that users experience together. Engineering teams may concentrate on system behavior and technical performance while visual decisions are treated as a later stage. Elsewhere, attention to appearance may outpace consideration of navigation, learnability, or the clarity of information. The consequences are not exclusively aesthetic or technical. They can appear as preventable mistakes, slower task completion, additional support needs, premature abandonment, and diminished confidence in a product or organization.

The chapters that follow examine this tension through the fields of human-computer interaction and user-centered design. Early discussions trace the movement from function-first computing toward approaches that attend more closely to the circumstances of use. The conceptual treatment of hardware, software, and graphical user interfaces then establishes the interface as a meeting point between technical possibilities and human interpretation. Usability is examined through the dimensions of effectiveness, efficiency, and satisfaction associated with ISO 9241-11, while ISO 9241-210:2019 informs the discussion of human-centered design processes.

The book next considers visual organization and emotional response. Gestalt principles, visual hierarchy, and theories of emotional design help explain why the arrangement and appearance of an interface may shape a person's first expectations. Particular attention is given to the aesthetic-usability effect and to its limits. Perceived ease of use is relevant, but it must be distinguished from observed success, accessibility, and the ability of a system to withstand serious errors.

The subsequent discussion turns to organizational decision-making: iterative evaluation, the participation of users, cross-disciplinary coordination, and the possible relationship between design quality and competitive differentiation. The concluding chapter introduces the Integrative Usability-Aesthetics Model (MIUE), along with proposed ways of examining its relationships through usability measures, qualitative observation, and biometric or statistical approaches. These proposals create questions for investigation rather than eliminating the uncertainty surrounding causal claims.

The manuscript draws primarily on documentary and conceptual analysis, public corporate examples, and two expert interviews from industrial and academic settings. Its conclusions therefore require attention to the contexts represented and should not be treated as statistically generalizable across all firms or populations. Within these boundaries, the central proposition remains clear: an interface is not merely the visible edge of a technical system. It is where organizational intentions become actions that people must understand and perform. Studying usability and aesthetics together offers a more complete basis for assessing that encounter.

Abstract

The relationship between usability and visual aesthetics shapes how people encounter hardware and software, interpret interfaces, and assess the value of digital products. Within organizations, this relationship is frequently fragmented across technical development, visual design, and business decision-making, even though users experience these dimensions together. This volume examines their intersection through an interdisciplinary perspective grounded in human-computer interaction, cognitive and emotional responses to design, and organizational strategy. The discussion traces the transition from function-oriented computing toward user-centered approaches, considering graphical interfaces as the point where technical capabilities become meaningful actions. It examines usability through effectiveness, efficiency, and satisfaction, drawing on ISO 9241-11 and the human-centered design principles of ISO 9241-210:2019. Visual hierarchy, Gestalt principles, emotional design, and the aesthetic-usability effect provide a basis for exploring how appearance may influence expectations and perceived ease of use. Particular attention is paid to the limits of aesthetic appeal when systems present serious functional problems. The organizational chapters consider product adoption, support demands, perceived value, and competitive differentiation. The volume culminates in an Integrative Usability-Aesthetics Model (MIUE), presented as a conceptual framework with proposed avenues for empirical assessment. Based principally on documentary analysis, public industry examples, and expert perspectives, the work does not claim universally generalizable causal findings. Instead, it argues for treating visual form and functional performance as connected responsibilities, while recognizing that design quality must ultimately be judged in relation to specific users, tasks, and contexts.

Keywords: usability; visual aesthetics; aesthetic-usability effect; user-centered design; graphical user interface; business competitiveness

Index

Chapter 01. Introduction and contextualization of the object of study | Introducción y contextualización del objeto de estudio..... 1

Chapter 02. Conceptual foundations of design and technological interfaces | Fundamentos conceptuales del diseño e interfaces tecnológicas..... 9

Chapter 03. Dimensions of usability and international standards | Dimensiones de la usabilidad y estándares internacionales 14

Chapter 04. Aesthetics, visual design and emotional responses | Estética, diseño visual y respuestas emocionales..... 21

Chapter 05. The aesthetic-usability effect and strategic balance | El efecto estética-usabilidad y el equilibrio estratégico..... 28

Chapter 06. User-centered design (UCD) as a methodological framework | El diseño centrado en el usuario (DCU) como marco metodológico..... 37

Chapter 07. Impact of technological design on business competitiveness | Impacto del diseño tecnológico en la competitividad empresarial..... 45

Chapter 08. Proposal for an integrative conceptual model | Propuesta de un modelo conceptual integrador 54

Chapter 1 / Capítulo 1

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Introduction and contextualization of the object of study

Introducción y contextualización del objeto de estudio.

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ABSTRACT

This chapter introduces and contextualizes the study of the balance between usability and aesthetics in hardware and software design over the period 2004-2024, marked by smartphones, cloud computing and business digitalization. It traces the shift from the functionalist paradigm of early computing to graphical user interfaces and user-centred design, drawing on the aesthetic-usability effect described by Kurosu and Kashimura, Don Norman's work on emotional design, and the ISO 9241-11 and ISO 9241-210 standards. Current practice is described as fragmented: some companies pursue immediate commercial visual appeal, while others confine themselves to technical functionality. According to the chapter, this imbalance leads to low adoption, user frustration and higher after-sales support costs, and many technology SMEs lack standardized user-centred design methods. The stated purpose is to examine the relevance of the balance between usability and aesthetics and its effect on user experience and organizational competitiveness, in order to provide conceptual foundations and methodological criteria for integrating both dimensions. The research follows a mixed-methods design with a qualitative predominance and a descriptive-analytical scope, combining a documentary review of specialized literature, international standards and public corporate cases such as Apple, Microsoft and Google with two semi-structured interviews with an industry engineer and an academic researcher. The chapter argues that integrating form and function constitutes a legitimate strategy of competitive differentiation. It acknowledges limitations: restricted access to proprietary corporate data, no claim to universal causal laws or statistical representativeness, and the need to adapt its conclusions to smaller firms and other contexts.

Keywords: Business competitiveness; Visual aesthetics; User experience; Usability

RESUMEN

El capítulo describe el desarrollo del diseño de hardware y de software entre 2004 y 2024, periodo atravesado por la digitalización y por la computación en la nube. En la práctica actual se observa una fragmentación en la forma de concebir el método de trabajo: por un lado, hay empresas que solo buscan el atractivo estético comercial inmediato y, por otro, empresas que se aíslan en lo técnico-funcional. Según el texto, este desequilibrio genera baja adopción y frustración en el usuario, e incrementa los costos organizacionales por soporte posventa. El objetivo planteado es comprender cómo una empresa puede optimizar su sitio web para que el usuario obtenga un resultado positivo, considerando que el tiempo de permanencia en un sitio y los motivos de abandono deben ser evaluados por un equipo de profesionales desde la perspectiva de la usabilidad web. En cuanto al método, el trabajo se enmarcó en un diseño mixto con predominio cualitativo y alcance analítico-descriptivo. La recolección de información incluyó una revisión documental de normas internacionales (ISO 9241-11 e ISO 9241-210) y entrevistas semiestructuradas a expertos académicos y de la industria tecnológica global. Como resultado, se plantea que el balance de diseño activa el «efecto estética-usabilidad», según el cual lo atractivo hace más tolerable lo fallido o menos útil. Se concluye que las pymes tecnológicas no cuentan con metodologías interactivas de Diseño Centrado en el Usuario (DCU) y que el encuentro entre la forma y la función constituye una estrategia legítima de diferenciación competitiva.

Palabras clave: Competitividad empresarial; Estética visual; Experiencia de usuario; Usabilidad

HISTORICAL BACKGROUND AND EVOLUTION OF TECHNOLOGICAL DESIGN

The history of hardware and software development reflects a profound shift in the human–computer relationship. At the origins of modern computing, in the 70s, the outcome of any given technological development was pursued within the functionalist paradigm. Unless it could be done easily and quickly, developing a system to perform repetitive tasks made little sense. It is widely known that any process that can be defined by a mathematical rule or that is mechanically repeatable can be mechanized using early hardware.

A notable milestone dating back to this period came in 1975, when the Micro Instrumentation and Telemetry Systems (MITS) corporation, under Ed Roberts, designed and sold the Altair 8800, which is considered one of the first microcomputers with commercial and industrial impact (Pilapil, 2026). This device had an architecture whose sole purpose was extreme technical functionality, and it laid the operational foundations needed for the later deployment of the ecosystem (Pilapil, 2026).

Software development for this device was a key moment in launching a much more integrated ecosystem: the founding of Microsoft by Bill Gates and Paul Allen, followed by the creation of Altair BASIC, established one of the first business models explicitly based on integrating software and hardware within the microcomputing market (Jvarela, 2025; Telefónica, 2024). However, at this foundational stage the priority was strictly operational: systems had to respond correctly to commands, while visual appearance and the aim of making them pleasant to use were relegated to secondary importance.

The shift in methodological and perceptual approaches began to take shape early in the decade beginning in 1980, with the commercialization of Graphical User Interfaces (GUIs). The move from command-line environments to visual, intuitive ones greatly improved human-computer interaction and steered it toward more intuitive manipulation environments. This historical milestone ushered in a new era in which the overall user experience began to take priority within the industrial and technical development process (IONOS, 2021; Jvarela, 2025; K R Pavan Tej, 2025).

Later, in the decade beginning in 2000, and from 2004 to the present (up to 2024), world markets went through a drastic transformation. The expansion and growth of smartphones, cloud software and the sweeping digitalization of business forced technology organizations and corporations to dramatically rethink how they designed and structured their products. In this new interactive setting, operational usability and visual aesthetics were no longer independent attributes; they became strategic factors that determine competitiveness in the global technology market (Escalante, 2021; K R Pavan Tej, 2025).

This shift in the corporate sector has been legitimized by a solid line of interdisciplinary academic research. In 1995, researchers Masaki Kurosu and Kaori Kashimura of the Hitachi Design Center found, in controlled empirical studies, that visual aesthetic appearance has a statistically significant influence on individual perceptions of usability. The scientific literature refers to this phenomenon as the aesthetic-usability effect (Escalante, 2021; Moran, 2024; Pilapil, 2026). This important finding revealed that aesthetics is not merely “decoration” but an element that affects human-computer interaction at a cognitive level (Marciante, 2024).

At the same time, researcher Don Norman examined in greater depth the relationship between design, emotion and user experience, noting that a visually attractive product can elicit a positive emotional response at the affective level. These responses facilitate the user’s mental processes, significantly increasing tolerance of minor errors and subjective satisfaction during the interaction (Moran, 2024; Pilapil, 2026). Subsequent empirical studies reconfirmed that people systematically tend to perceive visually attractive products as more functional, even when their internal functionality does not differ substantially from that of other, less aesthetically pleasing alternatives (Escalante, 2021; Moran, 2024).

The need to systematize these functional and perceptual dimensions led to the adoption of globally applicable normative standards. International standardization, embodied in ISO 9241-11, consolidated an operational definition of usability that can be addressed through its three empirical and measurable dimensions: effectiveness (the accuracy and completeness with which users achieve specified goals), efficiency (the cognitive and time resources required), and satisfaction (how comfortable and acceptable the system is) (Martínez et al, 2022; Supfab, 2025).

This international standardization led user experience evaluation to set aside subjective judgments and become part of systematic User-Centered Design (UCD) processes. The methodological guidelines of this approach were later formalized in the international standard ISO 9241-210:2019, which states that there must be at least six basic principles. The first is an

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explicit understanding of users and their environments. The second is that users must be actively involved throughout the co-design process. The third is iterative, user-driven evaluation. Finally, the fourth is that the whole human experience must be taken into account (alekvs.com, 2025; Luján, 2026).

In today's leading business ecosystem, large international companies such as Apple and Microsoft have demonstrated its profitability. Apple's commercial resurgence at the end of the decade that began in 1990, with the launch of the iMac G3 designed by Jonathan Ive, convinced the markets that combining aesthetic simplicity with a high level of functionality and performance is commercially sound. Later, the launch of the iPhone fully consolidated this approach by prioritizing visual experience, fluidity, and intuitive touch interactivity over the usual technical complexity (Intecat, 2024).

In parallel, Google developed the Material Design ecosystem, a design language and system that seeks to systematize visual harmony, clear interaction, and efficient operation across digital platforms (Google Design, n.d.; Interaction Design Foundation, 2026). Microsoft applied similar principles and strategies when it launched its "Metro" design language, which evolved into the modern "Fluent Design" interface. Microsoft's efforts reveal a framework that rigorously addresses typographic clarity, interfaces that truly belong to the content, and strict visual consistency across interactive devices (Jvarela, 2025; K R Pavan Tej, 2025; Microsoft Research, 2016).

Despite these significant historical and regulatory advances, large segments of today's business sector still show mismatches and tensions between the form and function of systems. It is now common to see some organizations devote all their efforts to purely technical backend performance while severely neglecting the visual experience and interactive fluidity of the human operator. At the other extreme, visual impact and ephemeral trends are prioritized for short-term commercial purposes, even though they fail to ensure even minimal operational clarity or the most basic information architecture required by the task (Escalante, 2021; Moran, 2024).

This alarming lack of strategic and methodological integration triggers severe organizational consequences that undermine competitiveness, such as low product adoption and retention rates, unfavorable brand reviews, a drastic increase in the costs of after-sales and corrective technical support, and the consequent loss of market share. In technology SMEs, moreover, it has been noted that many organizations completely lack objective, standardized methodological criteria for comprehensively evaluating the form-function relationship. Interface design still relies on empirical intuitions, subjective whims, or commercial graphic fashions rather than on systematic analyses or the iterative processes dictated by user-centered design methods, Martínez et al. (2022).

In this context, the relationship between functional usability and the visual aesthetics of design in industrial and engineering-design hardware and operating systems clearly merits scientific study and formalization. Analyzing the link between design and an organization's quality will make it possible to lay the conceptual foundations for explaining how the harmonious integration of both factors will not be an ornamental luxury but rather a strategy for corporate differentiation in the present. It will also enable the design of empirical methodologies that organizations can use to evaluate and optimize this balance.

PROBLEM STATEMENT IN THE BUSINESS CONTEXT

Considering the historical, theoretical and empirical evidence, which taken together would indicate that functionality and visual design influence technology acceptance, today's business environment faces a structural difficulty that hinders the balanced integration of usability and aesthetics into hardware and software development processes.

In a competitive and innovative environment, with increasingly demanding customers, organizations are compelled to offer products that are not only efficient but also simple and attractive.

Within organizations, however, there is a persistent and polarized phenomenon: in one part of the system, resources go to visual design with a commercial orientation and in the absence of usability and information architecture concepts, whereas in another part the focus is on technical functionality and backend performance rather than on the aesthetic and emotional value for the user (Martínez et al., 2022; Moran, 2024).

The overall user experience suffers, the "aesthetic-usability effect" is disrupted, and ultimately the three levels of emotional design proposed in human–computer interaction are undermined. The breakdown of this balance means that our perception of a product's value, and consequently

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of the company's competencies, decreases.

Software and hardware products that are visually appealing but difficult to use cause immediate frustration, complaints and early abandonment of the digital tool, as well as a drastic increase in the financial costs of corrective technical support. Conversely, solutions that offer extensive functionality but do not stand out for their visual appeal or the coherence of their visual design suffer in initial acceptance and onboarding, in premium market positioning and, especially, in long-term user loyalty, since they fail to pass the operator's initial evaluation (Escalante, 2021; Moran, 2024; Pilapil, 2026).

The research to be conducted addresses how, despite compelling theoretical evidence of the potential relevance of unifying usability and aesthetics, many technology companies, including small and medium-sized enterprises (SMEs), lack systematic methods based on objective criteria or standards such as the ISO 9241 series.

In the absence of these institutional frameworks, software and hardware design is often based not on an iterative user-centered design process that incorporates continuous evaluation with users in a specified context of use, but rather on ephemeral visual trends, the engineer's subjective hunches or short-term commercial pressure.

There is a scientific need to study why the balance between functionality and aesthetics is key to a company maintaining its competitiveness. It is also necessary to understand the organizational consequences of such poor integration, such as low product adoption, increased support costs, loss of brand reputation and, consequently, loss of market share. A further task is to determine which formal metrics allow this relationship to be measured and managed systematically. (alekvs.com, 2025; Martínez et al., 2022; Moran, 2024)

Therefore, this study seeks to examine the relevance of the balance between usability and aesthetics in hardware and software design, as well as the effect of this relationship on user experience and on the competitiveness of organizations in the technology market. The aim is to provide conceptual foundations and methodological criteria that support the integration of both dimensions.

RESEARCH OBJECTIVES

To provide a scientific and systematic response to the methodological and engineering problem of fragmentation set out in the problem statement, a methodological matrix is formulated to guide the research process. This matrix makes it possible to determine the analytical scope of the work. It is organized around a general question, a specific question, a general objective and a specific question.

GENERAL OBJECTIVE

An analysis of the balance between functionality and aesthetics in hardware and software design. At the university level, it may address the influence of this implementation on usability and on the development of organizational competitiveness.

SPECIFIC OBJECTIVES

To describe the influence of usability dimensions on user experience (UX) and on the acceptance and adoption of enterprise technology products.

To examine the impact of visual aesthetics and the formal properties of the user interface on customer-perceived value and on customers' hardware and software purchasing decisions.

To identify and measure the adverse consequences for business organizations that result from the mismatch between technical utility and visual aesthetics in interactive products.

To determine the strategic factors, based on international human–computer interaction (HCI) standards and user-centered design methodologies, that facilitate the structured integration of usability and aesthetics in the technology sector.

1.4. RESEARCH QUESTIONS AND WORKING HYPOTHESES

Why is the strategic balance between functional usability and visual aesthetics in hardware

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and software design decisive for ensuring business competitiveness in today's technology market?

How does usability operationally influence the overall user experience and the adoption rates of technology products in the business environment?

How do the aesthetics and visual design of interfaces affect the construction of customer-perceived value and the intention or decision to purchase hardware and software?

What financial and organizational consequences arise from the lack of a harmonious balance between usability and aesthetics for the competitive performance of organizations?

What strategic and methodological factors, grounded in international design standards, enable the effective integration of usability and visual aesthetics throughout the technology development life cycle?

1.5. STRATEGIC, ACADEMIC AND SOCIAL JUSTIFICATION

In the contemporary corporate and computing ecosystem (that is, the acceleration of digital transformation, the maturity of software and hardware markets, and hyperglobalized competition), the design of interactive products requires scientific processes that (a) are not merely empirical and (b) do not focus on the short term, favoring marketing intuition.

Formalizing and discussing where the balance between functional usability and visual aesthetics is struck cannot be treated as marginal activities in the development of a system; rather, they are guiding axes of product viability and of the organization's sustainable success. This research is therefore strongly justified along three essential dimensions: strategic (business), academic (epistemological), and social (technological).

From the perspective of senior management and differentiation strategy, this work is justified because one of the main drivers of value destruction today is the commercial failure of functionally powerful systems with poor user experiences, or of visually appealing products whose interaction architecture does not work. When there is no balance between "form" and "function," organizations suffer severe consequences, including reduced corporate profitability, for example through low adoption, user dissatisfaction, brand criticism, and losses in the millions (Escalante, 2021; Moran, 2024).

Building on its analysis of this problem, the research provides organizations with clear methodological perspectives and criteria that will enable them to ground their development decisions in scientific evidence, with a focus on usability and design, so as to improve the commercial performance of technological products. In a market where differentiation is key, understanding how this integration manifests and how it affects perceived value becomes a sustainable competitive advantage.

Epistemologically, this research is an important step in the interdisciplinary study of software engineering, industrial design, user experience (UX) and business strategy, as it formally articulates theoretical variables that are studied in isolation in the scientific literature (Pilapil, 2026).

Numerous bodies of work already focus, in isolation, on quantitative analyses of usability, such as the effectiveness, efficiency and satisfaction parameters established by the ISO 9241-11 standard. Others examine, also in isolation, visual design or the foundations of visual appeal, such as the so-called "aesthetic-usability" analyzed by Kurosu and Kashimura (1995) and Don Norman's principles of emotional design. However, further analysis of their systemic balance as a competitiveness factor for technology organizations is still lacking.

This work unifies several frameworks into an analytical and theoretical foundation that can serve as a basis for academic research in the field of technology and organization (Martínez et al., 2022; Moran, 2024; Pilapil, 2026; Supfab, 2025).

Finally, in the social and technological sphere, the impact of this study lies in the changes to the everyday lives of users, who use multiple interactive digital devices and systems daily, both at work and in their personal lives. Products that lack a balance between usefulness and aesthetics not only affect the productivity of corporate workflows but also degrade people's everyday experience.

Guiding organizations in the rigorous use of User-Centered Design (UCD) methodologies, endorsed by the international standard ISO 9241-210, contributes to reducing these problems. A design that strikes a harmonious balance between functionality and aesthetics will make it possible to create more software and hardware that improve effectiveness, reduce the operational error rate, facilitate learning, and generate fully satisfying interactions for society (alekvs.com, 2025; Luján, 2026).

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1.6. DELIMITATION OF THE RESEARCH

This research is rigorously delimited from thematic, temporal, geographical and methodological perspectives to ensure the validity of its conclusions. The study is confined to analysing the systemic balance between the functional dimensions of usability and the attributes of visual aesthetics in hardware and software design, in terms of their direct influence on user experience, perceived value and business competitiveness. Other hardware or software quality attributes, such as cybersecurity, numerical backend performance, code maintainability, etc., will therefore not be addressed in depth, except where they influence usability or the user's aesthetic perception (Martínez et al., 2022; Moran, 2024).

The historical and documentary analysis is formally delimited to the period 2004-2024. The temporal criterion is the same one used in the three preceding sections: technological maturity. In this case, the selected period corresponds to the stage of mass consolidation of smartphones, the deployment of cloud software, the profound digitalization of businesses, and the widespread global adoption of unified design across the industry (Escalante, 2021; K R Pavan Tej, 2025).

The study is geographically and organizationally delimited to these companies, which are already established, globally recognized technology corporations, with the market leadership attributed to Apple, Microsoft and Google (Jvarela, 2025; Lomener, 2024; Microsoft Research, 2016). These organizations are international examples of good practice in integrating technological design techniques into the user experience, according to Google Design, (n.d.); Interaction Design Foundation; 2026; Marciante, 2024. Although the results and the proposed theoretical model are transferable, with the necessary adjustments, to small and medium-sized start-ups, no specific field studies will be conducted on regional microenterprises (Martínez et al., 2022).

In methodological terms, the research follows a predominantly qualitative mixed-methods design with a descriptive-analytical scope. The qualitative component draws on a systematic documentary review of specialized literature, corporate case studies and two semi-structured interviews with relevant stakeholders in the sector: one from the international industrial domain (Eng. Fernando Suárez, test engineer at Hewlett Packard Enterprise, California, USA) and another from the scientific and pedagogical domain (Dr. Carolina Tripp, lecturer and researcher at the Facultad de Informática Mazatlán of the Universidad Autónoma de Sinaloa).

The interpretive analysis of metrics and indicators already documented in the cutting-edge literature (e.g., adoption rates, response times, and satisfaction levels, all reported in experiments), together with their level on qualitative-quantitative rating scales during the interviews where possible, is included in the quantitative component. This component, of course, rules out probabilistic statistical generalization (Shi et al. 2021).

1.6.1. SCOPE AND DIMENSIONS OF THE STUDY

This research has a descriptive-analytical scope within a mixed-methods approach that is predominantly qualitative. First, the study is descriptive: it seeks to systematically identify, catalog and characterize the elements that shape the usability and visual aesthetics of a company. It also describes how these elements affect user experience, perceived value and the competitiveness of organizations, drawing on the literature and the international standards of the ISO 9241 series.

The second scope of the research is analytical, since it goes beyond mere conceptual description to critically analyze the dynamic nature of the user experience (UX) and visual design as two strategic differentiating factors that affect acceptance and performance in the market and in business. It does so by contrasting theoretical analyses with the practical approaches obtained from the field interviews.

The analysis will be grounded in this purpose according to the study, as a special feature of this ongoing program, where applicable, the offer of a fund. The documented case studies of all the world's leading companies in the sector, such as Apple, Microsoft and Google, use empirical frameworks when analyzing design and user experience.

In addition, the qualitative analysis was complemented by two semi-structured interviews with specialists from the industrial and academic fields. The business interview with engineer Fernando Suárez (Hewlett Packard Enterprise) shows how usability influences real-world processes of technical validation and adoption in complex corporations, thereby addressing specific objective 1. The academic interview with Dr. Carolina Tripp (Universidad Autónoma de Sinaloa) presents the conceptualization and teaching of usability in professional education.

This research aims to establish a comprehensive framework of understanding for

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scientifically demonstrating that the balance between usability and aesthetics is a strategic factor that determines the commercial success of hardware and software products.

1.6.2. LIMITATIONS AND CONSTRAINTS OF THE FIELD

As with all scientific research, this study explicitly acknowledges its methodological and institutional limitations so that the analysis remains transparent.

One limitation is that all the companies analyzed are large corporations, so retailers do not have access to their information, which is kept more confidential internally. Because industry-leading companies do not publicly disclose their full proprietary methodologies, private retention metrics, or internal strategic design processes, the analysis is grounded in a rigorous study of the academic literature, public case studies, patents, and industry statements.

An important limitation arises from the mixed-methods approach itself, in which qualitative guidelines predominate. As this is not a purely quantitative study based on statistical measurements in large samples or on controlled laboratory experiments, the results and the conceptual model developed do not seek to establish universal causal laws, nor to be representative in a sampling sense or to have probabilistic statistical significance. They should always be interpreted within the specific context and interpretive framework of the study.

Similarly, the analysis of large firms with global reach is restricted to the period 2004-2024. This implies that the conclusions and indicators formulated at a general level would most likely need specific adaptations for small, emerging local firms, as well as for specialized medical or industrial technology sectors and/or geographical contexts with differing levels of digital maturity.

Ultimately, the interviews offer qualitative perspectives that do not purport to represent the opinion of experts. The companies' input should therefore be read as a contextualized contribution from corporate network engineering and not as a complete representation of all phenomena in the global IT sector, just as the academic contribution reflects the perspective of professional training in the context of Mexican higher education.

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Chapter 2 / Capítulo 2

Sustainable balance between usability and aesthetics in hardware and software design within the organizational context
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Conceptual foundations of design and technological interfaces

Fundamentos conceptuales del diseño e interfaces tecnológicas

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ABSTRACT

This chapter examines the technological interface from a sociotechnical and interdisciplinary perspective. It describes the shift from the functionalist paradigm, which valued products by algorithmic performance, electronic stability and compliance with technical requirements, towards user-centred design, which holds that interactive systems must adapt to people's needs, cognitive limitations and contexts of use. Within this framework, usability and aesthetics are presented not as ornamental or independent attributes but as dimensions to be integrated. The chapter treats hardware and software as a single sociotechnical system: hardware provides the material canvas in which aesthetics first appears, while software shapes the interactive dynamics in which usability is experienced. The graphical user interface (GUI) is therefore addressed as the core of interaction, the space where functional and visual attributes converge. The approach is a conceptual, descriptive-analytical review of human-computer interaction literature, covering event-driven programming and GUI components such as icons, windows, pointing devices, menus and buttons, together with a brief historical account from Xerox PARC to the Macintosh and touchscreen devices. Drawing on this literature, the chapter states that interfaces based on visual metaphors and icons reduce the learning curve and cognitive load, and that an imbalance between hardware and software quickly undermines both aesthetics and actual usability. It concludes that a holistic, interactive approach grounded in user needs is required for products to be competitive, with user-centred design proposed as the framework for integrating usability and aesthetics in organizational settings.

Keywords: Cognitive load; Digital ergonomics; Visual metaphors; Sociotechnical system

RESUMEN

El capítulo estudia la interfaz tecnológica desde una perspectiva sociotécnica e interdisciplinaria. A medida que avanza el software empresarial, la industria deja atrás el enfoque funcionalista, centrado en la potencia del back-end de los equipos, para transitar hacia el Diseño Centrado en el Usuario. Este horizonte implica aceptar que hardware y software funcionan como un único sistema; por ello, el foco se desplaza hacia la interfaz gráfica de usuario (graphical user interface, GUI), espacio en el que conviven la usabilidad y la belleza. El objetivo es analizar la transición epistémica del diseño tecnológico a partir de la articulación entre la arquitectura física, las funciones lógicas y los componentes de la interfaz gráfica, así como los elementos que optimizan la eficiencia interactiva en el entorno organizacional. En cuanto al método, se declara un análisis conceptual y descriptivo-analítico basado en la revisión de la literatura sobre interacción humano-computadora, que abarca los marcos de programación orientada a eventos y los componentes de la GUI, examinados mediante una matriz analítica para valorar su impacto en la experiencia de usuario (UX). Según el texto, las interfaces basadas en metáforas visuales minimizan la curva de aprendizaje y la carga cognitiva; sin embargo, cuando existe un desbalance entre el hardware y el software, se afectan rápidamente la estética y la usabilidad real. Como conclusión, se sostiene que es necesario un enfoque holístico e interactivo basado en las necesidades del usuario para que el producto sea competitivo.

Palabras clave: Carga cognitiva; Ergonomía digital; Metáforas visuales; Sistema sociotécnico

2.1. THE PARADIGM SHIFT: FROM FUNCTIONALISM TO THE USER-CENTERED APPROACH

The design and development of interactive hardware and software products is considered not merely the result of a chronological sequence of engineering innovations. Rather, it is a fundamental shift in the epistemic structures, mental models and approaches that shape the relationship between human beings and computational systems (SHIFTA, 2025).

Historically, the development of this discipline has been structured around a central tension between two major theoretical paradigms: the functionalist paradigm and the user-centredparadigm. Our starting idea has been transformed, giving rise to another. It is precisely in this shift from one concept to the other that it becomes possible to bring together usability and aesthetics, in a balanced way, as critical factors in the competitiveness of digital organisations. This is the foundation for the analytical categories used throughout the article (Admin, 2024; Canal, 2023).

The functionalist model, which predominated in the early stages of modern computing, defined the absolute value of a product in terms of algorithm functioning and performance, electronic stability, operational capacity, and compliance with the technical requirements themselves (Admin, 2024). From this perspective, technology was regarded as the goal of action.

Engineers focused their efforts on optimizing the backend and meeting the rigid technical requirements of devices. Comfort, usability, and user experience became irrelevant, secondary, or simply auxiliary concerns. From this perspective, interaction was seen as something imposed: since the first computer was designed only for technicians, the person using it had to undergo lengthy training and was forced to adapt their mental schemas to the complex, already operational demands of the machine (SHIFTA, 2025).

This approach proved feasible as long as computing was confined to specialized environments, but the diversification of interactive profiles brought about a conceptual shift in the field that would mark a turning point. Through the work of interaction designers, it gradually became evident that technology cannot be regarded as an autonomous entity but rather has a purpose; more precisely, it is a means intended to enhance human activity and boost human performance (Patel, 2024).

Therefore, this premise, which stems fundamentally from the field of Human-Computer Interaction, radically inverts the previous functionalist thesis to formulate User-Centered Design (UCD). Methodologically, UCD holds that it is the interactive system that must adapt flexibly to people's real needs, biological capacities, cognitive limitations, and specific contexts of use (Canal, 2023; Patel, 2024).

The advent of user-centered design made it possible to dispel the myth that usability and visual aesthetics were merely ornamental attributes, or that they were independent of each other in the development life cycle. Once digital products moved beyond the exclusive domain of technical experts and took their place within production structures worldwide, the quality of the user experience became a key element.

Usability and aesthetic design are no longer regarded as competing engineering priorities; instead, they are conceived as an inseparable whole. In this book, user-centered design is presented as the methodological framework that ties these elements together and through which organizations can realize this symmetry, moving from purely instrumental engineering toward the creation of interactive ecosystems with high added value and strong competitive impact.

2.2. HARDWARE AND SOFTWARE INTERACTION AS AN INTEGRATED SOCIOTECHNICAL SYSTEM

For a holistic understanding of the balance between usability and visual appearance from a user-centered standpoint, it is necessary to move beyond the atomistic study of computer components and view hardware and software as a sociotechnical system. In the literature on human–computer interaction, the operator does not perceive the attributes of a digital product as separate elements but experiences the technological solution as a unified whole, in which the material and logical dimensions continuously co-determine each other to shape the user experience (GeeksforGeeks, 2025).

From an analytical and formal perspective, hardware is understood as a set of electronic, physical and mechanical components that make up the structure of a device. Within the organizational ecosystem, hardware is the element that, as its name suggests, is responsible for

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making the abstract processing carried out by applications and program instructions visible to the human operator.

Its structural components are organized into central processing units (CPUs), which determine processing speed; storage systems (memory units, USB devices); and input/output peripherals such as the screen and keyboard. First, hardware design establishes the initial physical constraints of the product (the material canvas, the screen size, or the input modalities), which form the basis on which aesthetics (form, texture, and materials) first manifests physically to the user. Software is the abstract and logical component of the system. In theoretical terms, it is defined as the set of programs, rules, or structured instructions that tell a computer's architecture how to execute a specific operational task.

In the business environment, software is sharply divided into system software, which comprises operating systems and drivers for the computer's resources, and application software, which addresses business needs, such as word processors, spreadsheets, browsers or analytical tools. In a design, the software algorithmically regulates the navigation flow, response to commands and visual feedback, and defines the product's dynamic interaction possibilities. It is, essentially, the dimension in which dynamic interaction and operational usability are experienced.

The proper integration of both components gives meaning and viability to the digital solution, since the correct functioning of a device depends on the proper combination of hardware and software (UNIR, 2026). Cutting-edge studies warn of the effects of a technological solution's failure when that failure is associated with a severe imbalance between the two dimensions: for example, powerful hardware coupled with poorly designed software (or vice versa) immediately disrupts the perceived usability and the overall visual assessment of the solution.

For the purposes of this research, hardware constitutes the material canvas on which aesthetics are manifested, whereas software formulates the interactive dynamics within which usability takes place. Accordingly, the strategic design balance demanded by the contemporary market is achieved only when hardware and software are conceived not as layers but as an integrated, interacting whole.

2.3. THE GRAPHICAL USER INTERFACE (GUI) AS THE CORE OF INTERACTION

In the field of human-computer interaction (HCI), the graphical user interface (GUI) is both the physical symbolic space and the interactive space that simultaneously displays usability and aesthetics, that is, the functional dimensions and the visual attributes, respectively (IONOS, 2021). Far from being merely a decorative element or an ornamental finish, a GUI theoretically represents the mediating space whose function is to translate the abstract back-end code of a computing machine as clearly as possible for the user, while also making the user's everyday tasks within the organization easier.

GUIs have changed how people communicate with computers through visual metaphors, icons and other graphical representations, so that a diverse range of [users] can understand what needs to be done without having to develop complex manual CDs or use abstract instructions. Without a GUI, the operator would be forced to rely on tedious and highly complex command sequences to run programs.

The structured design of a modern GUI effectively combines the aesthetic design of typographic and chromatic elements with the functions of programming logic. It consists of an operational surface made up of buttons, drop-down menus, navigation fields, title blocks, search fields, windows, canvases, frames, and icons. Each of these elements of analysis is causally related to the methodological categories of usability and aesthetics that we have developed.

Icons and symbols eliminate the user's cognitive load through immediate visual recognition. They act jointly on aesthetics (visual legibility of the interface) and on usability (speed of identifying the action). Windows are spatial structures that facilitate multitasking and visual organization. They directly affect usability, which enables efficient switching between organizational workflows.

Pointing devices and gestures enable direct manipulation of computer objects on the screen via the mouse or touch. According to Ionos (2021), these criteria ensure that the interaction experience is natural and fluid. Menus and buttons formally organize the actions that the user can execute. They require a careful balance between clarity in the visual design of interfaces (aesthetics) and ease of quick access to functions (usability).

Historically, the earliest principles of the graphical user interface emerged in the 70s at the Xerox PARC laboratories. These early concepts led to the creation of the Xerox Alto, at that time the first computer to have a graphical environment. Apple later popularized the concept

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on a mass scale in the 80s with the introduction of the Macintosh personal computer. With the emergence of smartphones and tablets at the beginning of the twenty-first century, the GUI paradigm underwent a radical shift with the arrival of touchscreens, which are controlled directly through intuitive gestures and finger movements.

The theoretical literature on interface engineering establishes that a well-structured graphical user interface significantly reduces the system's learning curve, thereby making it easier for users without advanced technical knowledge to access complex functional and operational applications. GUIs cannot be programmed in a strictly linear manner, since human actions and decisions are unpredictable. Therefore, event-driven programming is the engineering foundation that ensures a dynamic, interactive response.

Today, user interfaces (UIs), or interfaces in software applications, offer highly useful strategic advantages to companies. For example, they are simple, easy to use, and visually appealing. Moreover, they allow users with less computer expertise to use the digital application autonomously.

They also make documents and information quick and easy to locate. Finally, they respond to the organizational order through images, which were the easiest to understand and follow. As a result, the graphical user interface (GUI) emerges as the integrating surface of user-centered design, combining the functional effectiveness of usability with the cognitive delight of aesthetics.

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Chapter 3 / Capítulo 3

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Dimensions of usability and international standards

Dimensiones de la usabilidad y estándares internacionales

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ABSTRACT

Context: As digital technologies advance rapidly, organizations require analytical frameworks that move beyond subjective intuition and interpret ease of use as a sociotechnical property that regulates business efficiency. Objective: The chapter analyzes the functional dimension of interactive design through the formalization of usability within the corporate environment of organizations. Method: An analytical-conceptual, descriptive and foundational approach was used, based on a systematic review of standards in computer ergonomics and in human-computer interaction (HCI) and on the operationalization of the construct into performance variables and indicators. The chapter examines the definition of usability provided by the ISO 9241-11 standard, its articulation with the ISO 9241-210 standard, Jakob Nielsen's five-attribute model, the conceptual distinction between usability and user experience (UX), and the operational principles of usable design in organizations. Results: According to the analysis, the systematic measurement of effectiveness, efficiency and satisfaction optimizes workflows and limits cognitive load, and these dimensions constitute the basis for the quantitative diagnosis of interaction. However, challenges remain, such as the terminological confusion between usability and UX and the difficulty of achieving operational consistency and reversibility. Conclusions: Usability is a necessary, though not sufficient, component of a competitive UX. The formal adoption of the ISO 9241-11 standard is suggested in order to reduce technical support costs, shorten users' learning curves and maximize the perceived value of the product.

Keywords: Cognitive load; User experience (UX); Performance metrics; Usability

RESUMEN

Contexto: A medida que las tecnologías digitales avanzan con rapidez, las organizaciones requieren marcos analíticos que superen la intuición subjetiva e interpreten la facilidad de uso como una propiedad sociotécnica que regula la eficiencia del negocio. Objetivo: Se analiza la dimensión funcional del diseño interactivo mediante la formalización de la usabilidad en el entorno corporativo. Método: Se utilizó un enfoque analítico-conceptual, descriptivo y de fundamentación, basado en una revisión sistemática de estándares de ergonomía computacional y de interacción humano-computadora (HCI), y en la operacionalización del constructo en variables e indicadores de rendimiento. Resultados: Según el análisis, la medición sistemática de la eficacia, la eficiencia y la satisfacción optimiza los flujos de trabajo y limita la carga cognitiva. Sin embargo, persisten retos como la confusión terminológica entre usabilidad y UX o la dificultad de lograr consistencia y reversibilidad operativas. Conclusiones: La usabilidad es una funcionalidad esencial para tener una UX competitiva. Se sugiere adoptar formalmente la norma ISO 9241-11 para disminuir los costos de soporte técnico, acortar las curvas de aprendizaje de los usuarios y maximizar el valor percibido del producto.

Palabras clave: Carga cognitiva; Experiencia de usuario (UX); Métricas de rendimiento; Usabilidad

3.1. THEORETICAL AND OPERATIONAL DEFINITION OF USABILITY

In the field of Human-Computer Interaction (HCI), usability has evolved from an intuitive notion of "ease of use" into a multidimensional construct with a rigorous theoretical and methodological foundation. From this perspective, usability is not a static, intrinsic property of the hardware or software but a property that emerges from the dynamic interaction between the user, the interactive tool, and the environment in which the task is performed.

The theoretical definition most widely accepted internationally and adopted by the scientific community is formalized in the ISO 9241-11:2018 standard. According to that standard, usability is the extent to which a given system, product or service can be used by specified users to achieve specified goals (effectiveness) in a specified context of use and with efficiency and satisfaction.

This theoretical analysis delimits three contextual elements.

- Specifying for whom the products of a design are intended ensures that their usability is treated as relative, since a system that is usable from the perspective of the specialized technical operator need not be usable from that of the novice administrative user.
- The specified goals, which relate to achieving concrete targets within the organization's workflows, are inseparable.
- Specified context of use: This comprises the physical, social, organizational and technological environment in which the interface is used and which directly shapes performance.

The Institute of Electrical and Electronics Engineers (IEEE) also contributes to the conceptual debate with an emphasis on usability, which should be evaluated on the basis of clarity of input interaction (actions required of the operator to run the machine), legibility of outputs (ease with which the user can correctly interpret the results and information provided by the system), and speed of skill acquisition, or learning curve.

For the theoretical construct of usability to be of scientific and business value, it must be operationalized through observable and measurable empirical metrics. The ISO 9241-11 standard breaks usability down into three fundamental operational dimensions, which form the basis of any quantitative diagnosis of interaction:

Table 1. Fundamental operational dimensions

Operational Dimension	Operational Definition	Suggested Indicators and Metrics
Effectiveness	Degree of accuracy and completeness with which users achieve their specific goals.	Task completion success rate. Number of errors made per session. Frequency of use of the built-in help.
Efficiency	Relationship between the level of effectiveness achieved and the amount of resources (time, mental effort) expended.	Time required to complete a task. Number of clicks or steps in the navigation flow. Cognitive load perceived by the user.
Satisfaction	Positive attitude, subjective comfort and acceptability shown by the user during and after the interaction.	Scores on standardized scales (e.g., SUS, QUIS). Product retention and recommendation rate. Level of expressed frustration.

Operationalizing these variables allows development engineers and researchers to move beyond subjective design evaluations. When the number of errors an operator makes (effectiveness), the time taken to complete a business-critical process (efficiency), and the level of psychological comfort elicited by using the graphical interface (satisfaction) are measured on an ongoing basis, technological development can be guided by repeatable scientific and methodological parameters. The role of the empirical pillar is to analyze the evidence that usability, specifically, operates as a direct mediator between user experience and, therefore, the competitiveness of contemporary technology organizations.

3.2. JAKOB NIELSEN'S FIVE-ATTRIBUTE MODEL

The most widely used and currently most relevant model for evaluating and diagnosing usability in human-computer interaction is the one proposed by Jakob Nielsen (1993, 1994). Unlike abstract or purely subjective approaches, Nielsen breaks usability down into an operational construct made up of five quality attributes that are observable, measurable and directly applicable to the design of hardware and software interfaces in the business environment (Ermete, 2024; Moran, 2024). These five attributes help developers pinpoint a system's shortcomings and guide redesign according to scientific criteria.

Learnability is operationally defined as the speed and ease with which a new user, using an interface for the first time, can reach a basic operational level to perform elementary tasks.

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In contemporary organizations, this attribute has a direct impact on the cost structure: a highly learnable interface ensures that spending on employee onboarding and training programs is contained, so workers become productive sooner.

The initial learning curve is complete once the user has internalized the mental model of the system. From then on, the user should be productive. What is relevant at this stage are the actions performed in a timely manner in the interface or the results obtained. The time needed to correct errors and continue with the activity is also important. In technical markets that are already well served, highly efficient core software minimizes downtime and optimizes the internal process, acting as a direct driver of competitiveness.

This attribute indicates that the system can be remembered effortlessly by novice or intermittent users. In particular, it assesses how easily a user regains their former proficiency and performs tasks after a long period of inactivity without having to restart the learning curve. Memorability is ensured by graphical consistency and by the rigorous use of familiar appearance conventions.

Nielsen's model holds that a usable system must not only quantitatively minimize the number of errors users make during interaction but also qualitatively minimize the severity of those errors. When an unintentional error occurs, the system must allow rapid recovery through clear, predictable and reversible elements, so that the user does not reach catastrophic states of frustration that lead to abandoning the product.

Subjective satisfaction examines the affective and perceptual component of the interaction. It determines how pleasant and enjoyable the interface is to use, from the operator's qualitative perspective. Creating a system that promotes a positive attitude reduces corporate technostress and increases customer engagement. This attribute would interact closely with the dimensions of emotional design.

Jakob Nielsen's five-attribute model is an analytical and instrumental reference that complements formal standards such as ISO 9241-11 (Escalante, 2021; Martínez et al., 2022). During the prototyping and validation phases of software and hardware, organizations that break down the user's functional experience into measurable variables, such as task time (effectiveness), the number of erroneous clicks (errors), and comfort scores (satisfaction), can set aside subjective, intuitive assumptions and replace them with rigorous empirical evaluations. This systematic process helps ensure that the final interactive product maximizes its perceived value in today's global market.

3.3. REFERENCE STANDARDS: THE ISO 9241-11 STANDARD

Technical standardization turns design assessments that may be subjective into qualities, attributes or quality requirements. It also ensures that such requirements are verifiable and accepted internationally. The ISO 9241 standard was developed by the International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC). It is the most authoritative regulatory and methodological reference worldwide on the ergonomics and usability of interactive systems (Webmaster, 2023). According to Supfab (2025) and Martínez et al. (2022), ISO 9241-11 is the reference framework for determining, evaluating and ensuring the usability of hardware and software technology goods in business settings.

The ISO 9241-11 standard was originally titled Ergonomic requirements for office work with visual display terminals (VDTs) – Part 11: Guidance on usability, and was substantially revised as ISO 9241-11:2018 (Usability: Definitions and concepts). It provides organizations with an operational definition that unifies the technical language of engineers, designers and managers.

Its theoretical and industrial importance lies in the fact that it does not prescribe specific graphical guidelines and therefore does not function as a closed design manual; rather, it precisely establishes the set of empirical requirements an interface must meet to be formally classified as usable.

The standard states that usability must always be conceived and evaluated in terms of the three-dimensional metric of effectiveness, efficiency and satisfaction within a specified context of use.

Effectiveness is operationally defined as the accuracy and completeness with which users achieve their specific work goals. It refers to the logical relationship between the level of effectiveness achieved by the operator and the amount of resources consumed in doing so, that is, the time spent, the physical effort exerted, and the cognitive load entailed by the cognitive flow. Satisfaction is defined as the acceptability, comfort, and positive subjective attitude toward

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the user of the product, during and after active use.

Adopting the ISO 9241-11 standard helps organizations move from decisions based on intuition or visual trends to systematic design processes grounded in data and empirical testing. ISO 9241-11 is commonly used in the technology sector as a legal and industrial principle for software validation in tenders and high-level simulations that allow technical auditing, by formalizing definitions that would otherwise be highly subjective.

Furthermore, the standard does not operate in isolation; rather, it is closely linked to other complementary standards in the series, most notably ISO 9241-210:2019. This standard formalizes the characteristics and methodological phases of User-Centered Design (UCD) applied holistically to interactive systems. Accordingly, ISO 9241-210 provides the means to achieve these objectives iteratively. In other words, it supplies the methodology for the "how."

Although the high acquisition cost and technical length of these standards sometimes prevent development teams from reading them in full, in this case it constitutes an improvement in automated management. This positions it as a strategic reference framework for gaining a decisive competitive advantage, since it makes it possible to ensure standard quality, which increases the product's value in globalized markets.

3.4. CONCEPTUAL DIFFERENTIATION BETWEEN USABILITY AND USER EXPERIENCE (UX)

In interactive system design, software engineering and product strategy, the concepts of "usability" and "user experience" (UX) are often used interchangeably, which creates recurring terminological confusion (Simó et al., 2024). However, the specialized scientific literature and the field of human-computer interaction (HCI) draw a precise conceptual and analytical distinction between the two terms, one of considerable operational relevance to the strategic success of interactive products in the corporate market.

Usability is defined operationally and narrowly as user performance when carrying out specific tasks within a given context of use (Simó et al., 2024). Its approach is instrumental and pragmatic: it focuses mainly on evaluating learnability, efficiency, memorability and error prevention during a specific interaction session. Usability metrics are predominantly objective and behavioral, such as the average time required to complete an action (efficiency), the percentage of tasks completed successfully (effectiveness) or the number of erroneous clicks recorded in the navigation flow.

In contrast, user experience (UX) is a multidimensional and holistic construct that encompasses the functional perspective of ease of use as well as the perceptions, emotions, affective responses, attitudes and subjective appraisals that a person has before, during and after interacting with a product, service or system. Usability is restricted to, and is usually evaluated within, the temporal boundaries of the active interaction session with the GUI, whereas UX integrates the entire life cycle of the interactive product, as well as factors that go beyond purely instrumental performance.

Drawing on the specialized literature, this analytical distinction can be summarized in the following contrast matrix.

Table 2. Contrast Matrix: Usability and UX

Variable of Analysis	Usability	User Experience (UX)
Main Focus	User performance and efficiency in completing specific tasks	Overall perceptions, emotions and subjective responses of the user.
Temporal Scope	Limited to the duration of the direct interaction session.	Entire product life cycle (pre-use, in-use and post-use phases).
Predominant Metrics	Objective and behavioral (response times, success rates, number of errors)	Subjective and affective (positive emotions, pleasure, credibility, perceived value).
Evaluation Attributes	Ease of use, operational efficiency, memorability.	Usefulness, accessibility, desirability, trust, visual aesthetics.

From a methodological standpoint, usability must be understood, at the very least, as a necessary but not sufficient component for user experience to exist. A business software application may be highly usable (for example, enabling an operator to process data quickly and without errors), but if its visual interface is unpleasant, generates distrust or projects an outdated corporate identity, its overall user experience will be rated as unsatisfactory. Conversely, an attractive interface that immediately elicits a positive visceral response will result in frustration and abandonment if its interaction architecture does not support genuine usability (Grigoryan,

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2024; Moran, 2024).

UX does not only assess usability, that is, whether something is useful and can be used; it also examines other factors, such as how desirable it is to own that hardware or software, the credibility of, or trust in, digital processes, the emotions elicited by the interaction, and the sensory pleasure or delight produced by everyday use.

For today's technology organizations, it is critical to understand that UX is no longer just usability but reflects how the concept of usability has evolved. Leading companies are concerned not only with determining whether the user will be able to use the product (usability) but also with mapping how the user feels while using it and whether this experience builds trust in the brand.

This conceptual distinction is the foundation of this book's strategic balance model. It demonstrates that only by systemically interrelating the pragmatic functionality of usability and the emotional delight of aesthetics is it possible to design a user experience that translates into a solid competitive advantage based on differentiation in saturated global markets.

3.5. OPERATIONAL PRINCIPLES OF USABLE DESIGN IN ORGANIZATIONS

For theoretical usability standards and user experience models to become more than abstract concepts and be successfully integrated into the software and hardware development culture, organizations need to implement a set of functional interaction guidelines.

The specialized literature on Human-Computer Interaction (HCI) has identified five guiding operational principles that should inform the design of interactive products intended for corporate environments. These principles are fundamental technical requirements derived from analyzing human behavior with digital systems, so that technology eases cognitive load and fits smoothly into institutional workflows.

According to empirical research and best-practice frameworks in interactive development, a usable product should be structured around the following operational guidelines. This characteristic means that the product must be graphically and interactively uniform across all its states, screens or logical modules.

It is characterized by the repeated use of the same color codes, the same conceptual terminology and a predictably identical layout of the primary control buttons. Consistency reduces learning effort and prevents over-execution.

Organizational users must manage and complete interaction objects in such a way that they can predict the outcome of what they are about to do on screen. Likewise, it must be possible to perform system operations freely, and there must be mechanisms that allow previous actions to be undone or redone clearly. Virtual emergency exits will also be provided in the event of unintentional errors, so that business data integrity is not compromised (Nielsen, 1994; Simó et al., 2024).

Constant feedback and visibility of system status refers to the requirement that the interactive system be technically capable of communicating with the user clearly and without delay about the status of the computational processes running in the backend. This is achieved through visual confirmations, clear contextual alerts, animated progress bars or loading icons that prevent the user from being left unsure whether the software has correctly processed their instruction.

Regarding user control and flexibility, users should not be forced to follow rigid or unalterable operating workflows. A usable design allows users to customize key features of their work environment (main menu tree, matching and size of typefaces, accessible placement of shortcuts, among others), thereby adapting to the visual and cognitive capabilities of different company operator profiles.

An inclusive, better-performing design should provide more than one path to complete the same task successfully. Multiple interaction options and channels. Including keyboard shortcuts for experts alongside guided menus or visual assistants for novice operators makes the software flexible and allows it to maintain high productivity regardless of the user's level of technical expertise.

The one that works with at least 50 people, with or without the consent of the person concerned in the registry. Within current organizational structures, hardware and software are not designed to replace human beings but to enhance their analytical and strategic capabilities (Ermete, 2024).

Rigid, imposed automation should be limited to repetitive, automated and low-value-

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added tasks. Decisions that require critical judgment and adaptation to unforeseen situations, by contrast, should be left to human operators (Esquiavetto et al. 2024).

Operational usability is becoming increasingly important in the development of new technologies. This means that human beings must be regarded as the main and irreplaceable element in company processes. When an interactive design supports interaction based on these five functional guidelines, it has a direct, positive impact on various organizational performance indicators (ROI).

The first benefit is the reduction in technical support costs. By this we mean that the number of incidents, queries and corrective assistance requests reported to information technology departments decreases drastically. These requests stem from comprehension errors or unclear interfaces.

Regarding Training Time Optimization, the workforce's competency-acquisition curves are drastically shortened, which saves money on training.

Regarding the Mitigation of Work Stress and Operational Errors, it seeks to establish a digital ergonomic environment that prevents worker frustration and mental fatigue, with the aim of raising business productivity levels and fostering greater well-being in the corporate work climate.

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Chapter 4 / Capítulo 4

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Sustainable balance between usability and aesthetics in hardware and software design within the organizational context
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Aesthetics, visual design and emotional responses

Estética, diseño visual y respuestas emocionales

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ABSTRACT

Context: The aesthetic dimension of interactive design in hardware and software used to be conceived as a decorative element. As human-computer interaction advances, the formal properties of the graphical interface become an epistemological scaffolding that coordinates selective attention, guides the cognition of the corporate operator and alleviates the discomfort that technology may cause. Objective: The epistemology underlying technological aesthetics is analyzed in terms of the Gestalt laws, the three levels of Donald Norman's emotional design (visceral, behavioral and reflective) and the neuropsychological evidence underpinning consumer behavior. Method: A theoretical-descriptive and systematic review of frontier literature in neuroaesthetics, perceptual psychology and neuromarketing was carried out, through the structuring of qualitative matrices of biological responses and perceptual attribution biases. Results: According to the reviewed literature, harmonious visual stimuli reduce cognitive load and activate dopaminergic reward areas, and users tend to rate the system with the better visual appearance as easier to use. On the other hand, the difficulty of balancing the visceral effect with actual usability is identified, so that apparent usability does not conceal logical flaws in the system. Conclusions: Visual aesthetic perception influences the formation of perceived value and purchase intention. It is proposed that incorporating Gestalt laws and spatial balance into the design of interactive environments and equipment mitigates work fatigue and strengthens the competitive advantage of the organization.

Keywords: Consumer behavior; Visual aesthetics; Gestalt laws; Perceived value

RESUMEN

Contexto: La dimensión estética del diseño interactivo en hardware y software solía concebirse como un elemento decorativo. Conforme avanza la interacción humano-computadora, las propiedades formales de la interfaz gráfica se constituyen como un andamiaje epistemológico que coordina la atención selectiva, orienta la cognición del operador corporativo y alivia el malestar que la tecnología puede provocarle. Objetivo: Se analiza la epistemología subyacente a la estética tecnológica en función de las leyes de la Gestalt, los niveles del diseño emocional de Donald Norman y la evidencia neuropsicológica que fundamenta el comportamiento del consumidor. Método: Se realizó una revisión teórico-descriptiva y sistemática de la literatura de frontera en neuroestética, psicología de la percepción y neuromarketing, mediante la estructuración de matrices cualitativas de respuestas biológicas y sesgos de atribución perceptual. Resultados: Según la literatura revisada, los estímulos visuales armoniosos disminuyen la carga cognitiva y activan áreas de recompensa dopaminérgicas. Por otro lado, se identifica la dificultad de equilibrar el efecto visceral con la usabilidad real, de modo que la usabilidad aparente no oculte fallas lógicas del sistema. Conclusiones: La percepción estética visual incide en la formación del valor percibido y de la intención de compra. Se plantea que la incorporación de las leyes gestálticas y del equilibrio espacial en el diseño de entornos y equipos interactivos mitiga la fatiga laboral y refuerza la ventaja competitiva de la organización.

Palabras clave: Comportamiento del consumidor; Estética visual; Leyes de la Gestalt; Valor percibido

4.1. EPISTEMOLOGY OF AESTHETICS IN THE TECHNOLOGICAL ENVIRONMENT

Based on the literature review, an epistemological foundation is needed for studying the impact of visual aesthetics on the design of hardware and software interfaces. Throughout the history of engineering and computer science, aesthetics has been regarded as something merely ornamental, cosmetic or secondary, with its technical function rigidly subordinated to the rationalist maxim: form follows function (Norman, 2004; Sutil, 2023).

However, theories of Human-Computer Interaction (HCI) have shown that the aesthetic dimension of a technological artifact is not a mere accessory but an epistemic mediating factor that regulates intelligibility, appropriation of the tool, and the construction of human knowledge.

From a classical philosophical perspective, aesthetics can be defined as the branch of philosophy that studies the nature of beauty, sensory perception and the judgment of taste. However, if this construct is transferred to another domain, aesthetics can begin to be seen as an operational, pragmatic and instrumental element.

Aesthetics in technology does not refer to a picture to be looked at; rather, it designates the formal qualities of design (color mixing, typeface grid, spatial symmetry, and the combination of graphic elements) that make the computer system easier to use and understand. It is grounded in the phenomenology of perception, as argued by Sutil in 2023.

Users have no direct contact with the abstract backend code or the hardware microprocessor; their contact is instead with the visual and formal representation that the interface projects (IONOS, 2021). Therefore, based on their experience, workers refer to a graphical user interface to attribute meaning to the operational technology.

This component refers to the creation of works of art in relation to something else.

•Visceral Level (Immediate Perception): This is the instantaneous biological and affective reaction to the product's appearance. A harmonious and intuitive visual design generates positive emotional responses that predispose the user favorably toward using it, thereby avoiding technological anxiety and situational stress.

•Behavioral (aesthetic usability). This dimension concerns how aesthetic cues are interpreted as clear guidelines for use. A design that seeks balanced spatial distribution, typographic contrast and a correct hierarchy of navigation elements is highly appealing to the eye and also shows the operator how to perform the task, so that the task is carried out predictably and without the use of text.

• Según Norman y Shi et al, (2021), in the case of hardware or software products, long-term subjective satisfaction has significant effects on perceived value. In this regard, aesthetics blends with corporate identity and is tied to brand reputation, which ensures user trust and loyalty in highly competitive markets.

Aesthetics has scientific importance because we humans process information holistically and in an embodied way. Cutting-edge research in cognitive neuroscience applied to digital design has moved beyond the traditional dichotomy between cognition and emotion, indicating that the two systems interact constantly during decision-making.

According to research by Norman (2004), an attractive work environment can increase the operator's cognitive flexibility. This positive emotional state induces more creative thinking, greater tolerance of minor software glitches, and the resolution of complex system problems.

In today's technology business environment, aesthetics has ceased to be an "embellishment" added after engineering and has become a "high-order design requirement." The mental processing load required of users to decipher an interface is drastically reduced when it is designed according to principles of symmetry, brand consistency and visual simplicity. Users can then devote more attentional resources to the organization's productive tasks. It follows that visual aesthetics is the necessary epistemic core in which form and function are integrated to ensure the viability and competitiveness of technology.

4.2. UNIVERSAL AESTHETIC PRINCIPLES AND APPLIED GESTALT LAWS

If the visual aesthetics of a graphical user interface (GUI) are no longer to be regarded as a purely subjective or artistic exercise in appreciation, contemporary hardware and software design must be grounded in universal aesthetic principles and psychophysical laws of perception. Within this theoretical framework, Gestalt psychology (a German school of thought from the early twentieth century focused on the study of visual perception) provides the ideal scientific foundation for understanding how the human brain organizes, groups and decodes the complex

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visual stimuli projected onto the screens of technological devices (Interaction Design Foundation [IxDF], 2021; Jvarela, 2025).

The ontological idea of Gestalt, which holds that "the whole is different from the sum of its parts," clearly explains how the overall design of a user interface significantly modifies its perceived usability and aesthetics. By designing logical and physical products according to structural principles that match the brain's cognitive biases and shortcuts, organizations are able to create smoother user experiences and reduce operators' attentional fatigue.

Applying Gestalt laws to the design of human–computer interaction (HCI) makes it possible to provide a scientific rationale for the placement of each GUI element. The laws most relevant to organizational workflows and interfaces are outlined below:

- Law of Proximity. Elements that are spatially closer to one another tend to be perceived as part of the same group or as sharing a common function. In enterprise software design, this law governs the grouping of input fields in data-entry forms and the physical proximity between an action button and its corresponding text label, thereby reducing visual scanning time.
- Law of Similarity. The brain automatically groups objects that share visual characteristics, such as shape, color, size, or typeface. This principle governs color coding in interface design; for example, specifying that all primary command buttons (such as "OK" or "Save") have the same color and identically rounded borders allows users to instantly identify clickable elements.
- Law of Common Region. Perceptual grouping is strengthened when a group of elements is enclosed within a visual boundary, such as a small card or an interface box. In enterprise dashboards that handle large volumes of data, this makes it possible to clearly separate sections assessing the financial dimension from operational variables without filling the screen with dividing lines.
- Law of Continuity When we scan an interface with our eyes, we prefer to follow the simplest, most continuous and fluid visual path rather than jump abruptly between unconnected elements. Structuring navigation flows and aligning data columns according to this law allows fast reading and prevents task interruption.
- Law of Figure and Ground. The cognitive system naturally separates the object of interest (figure) from the rest of the surface (ground). In current digital systems, using subtle shadows to overlay pop-up windows, confirmation errors or drop-down navigation menus on the content, with a blur effect, immediately focuses the mechanic's attention.

As with the Gestalt laws, the design of high-performance hardware and software requires universal aesthetic principles, namely symmetry, the golden ratio, the use of white space, and compositional simplicity. The distribution of visual weight, that is, the portion of the screen an object occupies, has a striking immediate effect. Symmetry and balance on screens thus create a sense of order, stability, and institutional professionalism that enhances the credibility of the technology brand.

In turn, the strategic use of white space (or negative space) is one of the most powerful aesthetic mechanisms for managing cognitive load. Contrary to the functionalist view that regards empty areas of the screen as a "waste of material space," the psychology of interaction shows that free space acts as a visual lung that enables the brain to structure information, identify hierarchies and mitigate data overload during complex tasks (IONOS, 2021; Norman, 2004).

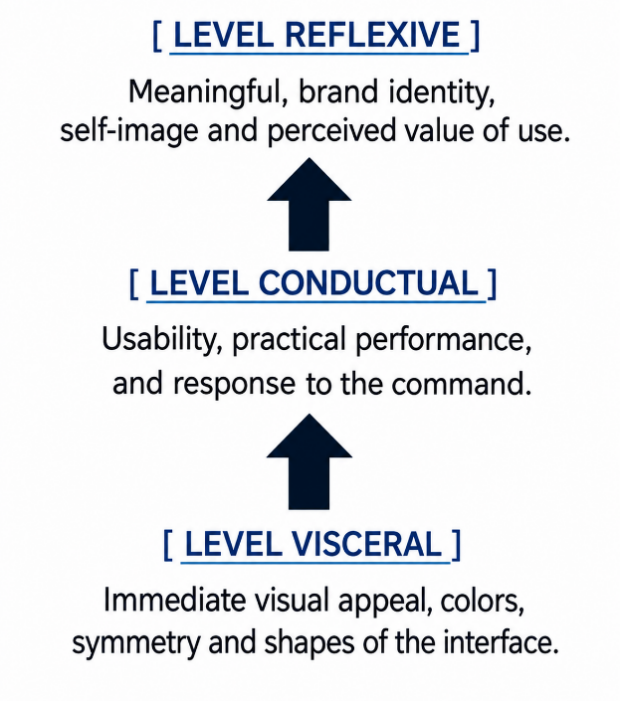
When an interactive product combines the perceptual delight of the Gestalt laws with principles of structural simplicity, aesthetics ceases to be a decorative add-on and establishes itself as an indispensable enabler of performance and usability in corporate technology (Nielsen, 2020; Sutil, 2023).

4.3. EMOTIONAL DESIGN AND DON NORMAN'S THREE LEVELS OF CONNECTION

To understand why visual aesthetics is not merely a superficial attribute but should instead be conceived as a first-order interactive pillar, the scientific literature on Human-Computer Interaction (HCI) draws primarily on Donald Norman's (2004) theory of emotional design.

In his foundational book Emotional Design: Why We Love (or Hate) Everyday Things, Norman upends technological design by showing that the mind operates on interactive objects and systems through three interconnected visceral levels: the visceral, the behavioral, and the reflective. Each of these levels of connection shapes, in its own way, the perception, usability, adoption, and competitive success of hardware and software developments in the corporate environment (Grigoryan, 2024; Moran, 2024).

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The visceral level is the most basic, biological and immediate level in humans. The system is triggered automatically, within milliseconds, at the first perceptual contact with the product, whether physical or digital. It responds to formal design features such as symmetry, color palette, typography and the harmony of visual proportions (Grigoryan, 2024).

This level is pre-competential and pre-linguistic: the user does not think about the system but reacts instinctively upon experiencing immediate sensations of attraction, liking, rejection or distrust.

In developing software interfaces or designing hardware exteriors, a viscerally deficient design (for example, an interface with saturated colors and visual clutter, or hardware made of plastic that feels flimsy to the touch) can trigger an instant negative response that predisposes the user to reject the system.

Conversely, a visually neat, clean and harmonious environment elicits a positive visceral response that stimulates the release of neurotransmitters associated with pleasure and comfort. This neurochemical activation reduces attentional anxiety, predisposes the user favourably and makes them more tolerant of minor performance failures or logical difficulties during subsequent navigation.

The behavioral level focuses exclusively on operational performance, efficiency, ease of use, and the effectiveness with which the hardware or software executes the required task. Unlike the visceral level, which is purely perceptual, the behavioral level is fundamentally interactive and practical. At this level, the operator's positive emotions stem from the sense of control, immediate feedback, success in completing a business transaction, and the absence of technical frustration during the workflow.

A system that is highly functional and usable but viscerally unpleasant may achieve its objective at the behavioral level, yet it will produce an arid work experience and low voluntary retention of the system. Best practices in technology take both the behavioral and the visceral aspects into account; that is, the metaphors used in visual design are also aesthetic indicators of the operational action. This makes it possible to reduce the cognitive load the user perceives.

The reflective level is the highest on Norman's (2004) scale and is associated with higher-order conscious thought, long-term memory, self-image and cultural values, as well as pride of ownership. At this stage, the user analytically processes the interaction after it has ended, evaluating the meaning that the software or hardware has in their personal or professional life and the cost–benefit ratio of its use.

In the technology business, the reflective level is where customer loyalty and brand recognition are won. Industry leaders such as Apple have mastered this level: their users do not buy their products because they work well (behavioral) or because they look good (visceral), but because they feel that owning and using the device gives them a reflective sense of status,

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professionalism, belonging, and creative sophistication.

Technology organizations seeking to compete in high-value global markets face a major strategic challenge: achieving a design that satisfies all three levels of emotional design harmoniously and at the same time. A recurring imbalance is the failure to design systems that adequately address the visceral and reflective levels, even when the behavioral level is optimally resolved (Moran, 2024).

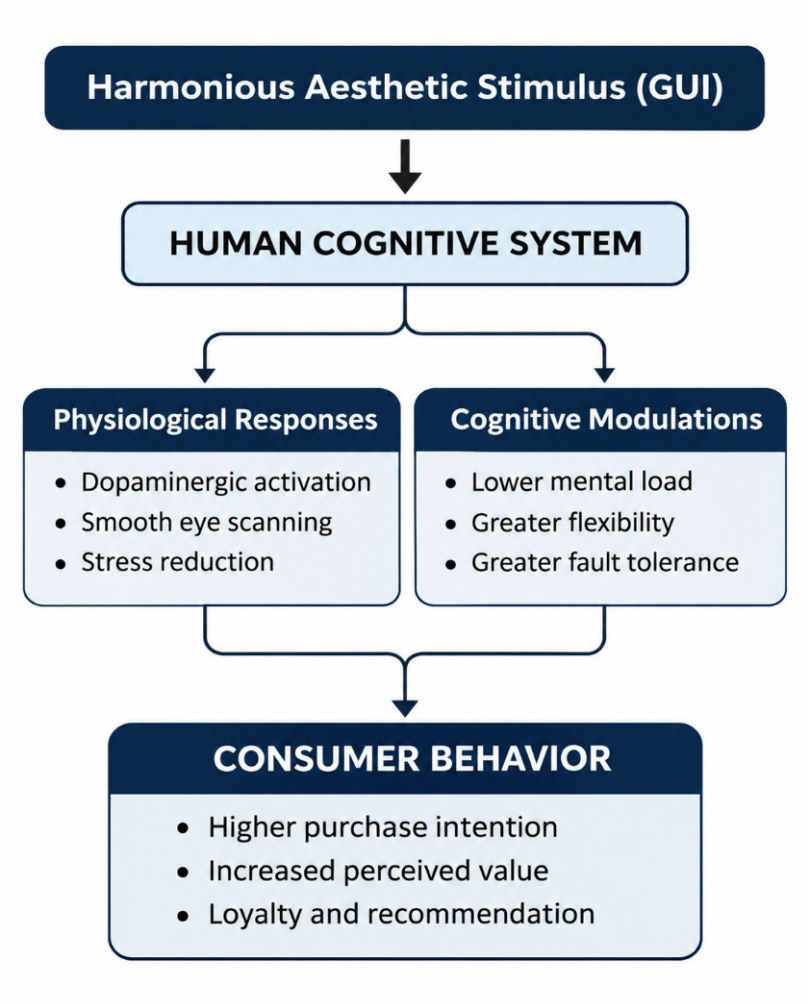
Norman's theory demonstrates that emotions and affect are not decorative elements that hinder the user's capacity to reason, but rather adaptive processing systems that guide the individual's decisions about purchasing, technology adoption and social recommendation.

By incorporating, first, visceral aesthetics and design and, second, a robust behavioral usability system together with a reflective proposition about what is to be communicated, organizations can move beyond the instrumental and functional use of conventional engineering. They can then offer genuine experience ecosystems that safeguard their value proposition in today's market.

4.4. NEUROPSYCHOLOGICAL AND EMPIRICAL EVIDENCE OF VISUAL APPEAL IN CONSUMERS

Consolidating visual aesthetics as a first-order variable in hardware and software design requires going well beyond the now-classic perceptual theories and grounding this effort in the body of empirical evidence provided by neuromarketing, cognitive neuroscience, and neuroaesthetics.

The most recent studies demonstrate, through direct physiological measurements, that the visual appeal of an interface is not a secondary matter of opinion but a powerful biological stimulus that modifies neural reward networks, selective attention processes and consumer decisions about technology products.



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According to studies using functional magnetic resonance imaging (fMRI) and electroencephalography (EEG), the medial orbitofrontal cortex and the striatum, neuroanatomical structures involved in the brain's reward system and in dopamine release, are activated immediately upon exposure to interfaces and products with high visual appeal (García-Madariaga et al, 2021).

The dopaminergic response produces a state of biological pleasure that not only shapes the affective appraisal of the product but also, as dopamine acts on the amygdala, does not trigger the frustration that certain technical frictions provoked in the user.

Eye-tracking studies have also provided valuable evidence on how aesthetic structure and visual balance coordinate selective attention. Visual stimuli organized according to principles of symmetry, clear hierarchy and a good balance of empty space facilitate more fluid and orderly visual scanning. They prevent uncontrolled eye fixations and optimize the operator's use of cognitive resources when performing a highly critical corporate task.

The first step in a project of this nature concerns the intellectual property of the works generated by this initiative, for which a licensing-based arrangement should prevail.

Consumers often subconsciously transfer the aesthetic value they see in a product to its internal effectiveness. This is a heuristic phenomenon whereby hardware made with premium materials or software with an elegant, modern graphical user interface (GUI) is systematically perceived as more reliable, more powerful and more professional before any active evaluation of its mechanical or algorithmic components takes place.

This shift in positive perception is complemented by the attribution of apparent usability (Kurosu and Kashimura, 1995; Moran, 2024). Controlled experiments have shown that when two systems have similar technical capabilities, users tend to rate the better-looking alternative as "easier to use."

In the current corporate context, aesthetic factors do not compete with usability; rather, they are a "layer of neuropsychological induction that increases user acceptability and consolidates the product's commercial positioning in the global market" (García-Madariaga et al., 2021; Shi et al., 2021).

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Chapter 5 / Capítulo 5

Check for updates

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The aesthetic-usability effect and strategic balance

El efecto estética-usabilidad y el equilibrio estratégico

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ABSTRACT

Context: This chapter studies the strategic convergence between functional usability and aesthetic standards in hardware and software interfaces. The aesthetic-usability effect occurs when it is mistakenly assumed that a more attractive object will be easier to operate, and it is presented as a cognitive phenomenon in human-computer interaction (HCI). Objective: The chapter examines the historical and methodological framework of the aesthetic-usability effect, the role of cognitive tolerance mechanisms in response to minor errors and their limits, as well as the integration model based on the five planes proposed by Jesse James Garrett. Method: A theoretical-descriptive documentary review was conducted, based on the analysis of classic experimental studies and contemporary analytical frameworks from information architecture and neuropsychology, insofar as they apply to corporate technology design.Results: The reviewed literature confirms that harmonious interfaces elicit a halo effect and a positive affective response that favor cognitive flexibility and user persistence. However, the chapter concludes that this benefit weakens in the face of catastrophic failures or prolonged interactions, in which the risk of an aesthetic trap emerges if deficient engineering is disguised. Conclusions: The aesthetics of the surface should be structurally linked to the underlying strategic and functional planes of technical development. The chapter suggests that the visual layer should act as a channel for the ease of use present in the object or service, with the aim of building organizational competitiveness.

Keywords: Information architecture; Aesthetic-usability effect; Halo effect; Cognitive flexibility; Leniency bias

RESUMEN

Contexto: En este capítulo se estudia la convergencia estratégica entre la usabilidad funcional y el estándar estético en las interfaces de hardware y software. El efecto estética-usabilidad (Aesthetic-Usability Effect) se produce cuando se asume erróneamente que un objeto más atractivo será más fácil de operar, y se presenta como un fenómeno cognitivo de la interacción humano-computadora (HCI). Objetivo: Se examinan el marco histórico y metodológico del efecto estética-usabilidad, el papel de los mecanismos de tolerancia cognitiva ante errores menores y sus límites, así como el modelo de integración de los cinco planos de Jesse James Garrett. Método: Se llevó a cabo una revisión teórico-descriptiva y documental, basada en el análisis de estudios experimentales clásicos y de marcos analíticos contemporáneos de arquitectura de la información y de neuropsicología, en su aplicación al diseño tecnológico corporativo. Resultados: Se confirma que las interfaces armónicas provocan un efecto halo y una respuesta afectiva positiva que favorecen la flexibilidad cognitiva y la persistencia del usuario. Sin embargo, se concluye que este beneficio se atenúa ante fallas catastróficas o interacciones prolongadas, en las que emerge el riesgo de una trampa estética si se disfraza una ingeniería deficiente. Conclusiones: La estética de la superficie debe estar ligada estructuralmente a los planos estratégicos y funcionales inferiores del desarrollo técnico. Se sugiere que lo visual funcione como canalizador de la facilidad de uso presente en el objeto o servicio, con el fin de construir competitividad organizacional.

Palabras clave: Arquitectura de la información; Efecto estética-usabilidad; Efecto halo; Flexibilidad cognitiva; Sesgo de indulgencia

5.1. THE AESTHETIC-USABILITY EFFECT PHENOMENON: HISTORICAL FRAMEWORK

The aesthetic-usability effect apparently lies at the core of HCI. This concept refers to the relationship between the visual and functional aspects of the same object or phenomenon. However, this so-called effect is not just any effect: it is regarded as one of the best concepts in the field of more human-centered design and, to some extent, in HCI.

This phenomenon describes a cognitive tendency that appears to be very widespread among users: they tend to believe that a visually attractive interface is, for that reason, more usable, efficient and easy to operate than an equivalent alternative that lacks a harmonious formal design. This holds true even when both technical solutions have an identical logical and programming architecture.

The conceptual framework of this effect formally emerged in 1995 with the publication of the first experimental study, conducted by the Japanese researchers Masaaki Kurosu and Kaori Kashimura at design and computer science laboratories in Tokyo. Until the mid-1990s, the mainstream in usability engineering, led by pragmatic and rationalist approaches, assumed that a user's aesthetic judgment was an independent variable that did not interfere with the objective measurement of the system's technical performance.

Experimental Methodologies in Human-Computer Interaction Kurosu and Kashimura (1995) challenged this paradigm methodologically by using the interaction panel of an ATM as their sample. The 26 interface variations systematically altered the aesthetic attributes of the graphical interface design, while the logical characteristics of the operation, such as backend response times and the operational input and output functions, were strictly held constant. The changes affected the symmetrical balance, the color palette, the typography of the buttons, and the geometric layout of the navigation functions.

The trial participants were instructed to evaluate each prototype along two different categorical dimensions: apparent usability (ease of use perceived before extensive manipulation) and inherent usability attributes (ease of use experienced during and after manipulation).

Statistical analysis of the usage data yielded a surprising finding: an extremely high and statistically significant correlation coefficient between the visual aesthetics of the panel and the apparent usability rated by the subjects. What stands out even more in the study is that the initial aesthetic perception distorts reasoning. Thus, users continue to state that the most beautiful interface is "easier to use," even after following flawed logic or making an operating error.

Because the original study was conducted solely in Japan, various parts of the Western scientific community skeptically suggested that the Aesthetic-Usability Effect may be a cultural bias specific to Japanese society, which has historically held a strong traditional appreciation for harmony and Zen minimalism in everyday objects.

To test whether the phenomenon was universal, the Israeli researcher Noam Tractinsky led a rigorous cross-cultural replication study in the late 90s, whose results were officially published in 2000 in the landmark article What is beautiful is usable.

Kurosu and his team replicated the design variables used by Kurosu and Kashimura, but under stricter experimental conditions, testing them with users in Western-style settings and controlling for additional fatigue or stress variables (Tractinsky et al., 2000).

The results not only confirmed the Japanese researchers' conclusions but also indicated that the effect was stronger and more robust than originally thought. The quantitative metrics reaffirmed that the user's visual aesthetic assessment was not diminished by practical use of the system. On the contrary, the initial aesthetic experience formed a strong cognitive frame of reference that determined overall post-use satisfaction per interactive session.

Through his research, Malinowski transformed the historical foundation of Human-Computer Interaction and usability engineering. Norman and authors working within the cognitive field, such as Antonio Damasio, have taken up the work of Kurosu, Kashimura and Tractinsky to establish the neuropsychology of emotional design. This approach provides scientific support for the view that positive emotions elicited by an attractive visceral environment make human thought patterns more flexible and optimize the capacity to solve technical problems.

In contemporary technology organizations, the Aesthetic-Usability Effect provides the empirical justification on which modern corporate product differentiation strategies are founded. Funding allocated to interface development is not mere "decoration"; rather, it is a strategic engineering requirement needed to improve the system's acceptance rate, reduce resistance to implementing new technological change within the company, and increase the perceived value of hardware and software in highly competitive markets (Moran, 2024; Shi et al., 2021).

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5.2. THE FOUNDATIONAL STUDY BY KUROSU AND KASHIMURA (1995)

A detailed examination of the methodological design, study variables and results of Masaaki Kurosu and Kaori Kashimura's 1995 study, the experiment that revolutionized modern usability engineering, is key to explaining scientifically the reason for the balance between functionality and visual appeal. Until then, the orthodox HCI (human-computer interaction) approach operated from a purely and exclusively functionalist perspective: it assumed that visual design components were independent of performance and endorsed a view of users as evaluating interfaces through strictly rational judgments of efficiency.

The study was designed to verify how the visual aesthetic configuration of a user interface influences users' perceptions of its ease of use before any interaction with the system takes place. Kurosu and Kashimura (1995) chose the control interface of the automated teller machine (ATM) as the object of study to eliminate biases arising from experience with complex systems. The ATM is an everyday artifact whose operational purposes are universal and predictable (withdrawing money, checking one's balance).

The experts devised a robust experimental design with 26 variations of the user interface. In fact, the same software was used in all three scenarios. For the experiment, the software is therefore considered to operate identically in all three scenarios.

The controlled logistical factors of the software are backend delay, the logical number of menus, and the sign accuracy rate.

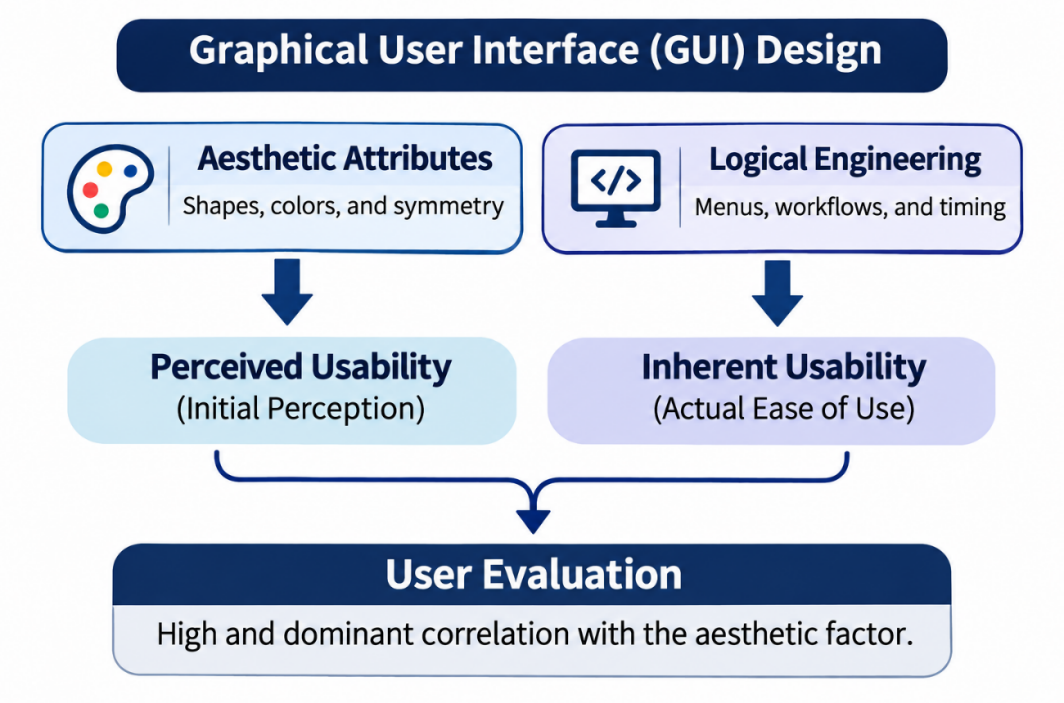
The alterations focused exclusively on the systematic manipulation of the visual and design properties of the Graphical User Interface (GUI) and modified the following formal analytical categories:

- Spatial symmetry and geometric balance in the distribution of the components.
- The typography used in the header blocks and text labels.
- The color palette, contrast levels, and the presence of visual guides.
- The aesthetic design of buttons, icons and typographic forms.

The test was administered to a controlled sample of participants, who were asked to rate the 26 prototypes to which they were exposed quantitatively, using interval rating scales. The methodological framework adopted broke usability down into two broad operational variables to isolate perceptual bias.

1.Apparent usability is the degree of ease of use that the user assumes or predicts the interface will have, based solely on its initial visual appearance, that is, before any prolonged physical interaction with it.

2. La usabilidad inherente es la facilidad de uso real, estructural y objetiva del sistema, determinado por la simplicidad de la arquitectura de información del sistema, la ingeniería de software, así como la inexistencia de errores lógico en el flujo.



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At the same time, a panel of independent professional designers evaluated the prototypes and gave each an objective "aesthetic appeal" score, which was then compared with the users' judgments. Kurosu and Kashimura (1995)analysed the data using statistical correlation and regression, and one of their findings challenges the more traditional software engineering theses: there was an extremely high, positive and statistically significant linear correlation between visual aesthetics and the apparent usability of the system (exceeding r=0.6 and 0.7 in several tests). Thus, the relationship between apparent usability and inherent usability, that is, engineering-based ease of use, was markedly weaker.

The results described above showed that the aesthetic appearance of an interface strongly influences users' judgments of its functionality and technical performance. The study concluded that apparent usability is governed almost exclusively by the visual aesthetics of the graphical interface. This is because visual aesthetics acts as such a powerful cognitive bias that it allows users to extend the beauty of the system's outer layer to the effectiveness of its internal functioning.

This initial experiment was a landmark in the history of the scientific literature on Human-Computer Interaction, as it demonstrated empirically that aesthetics is not an ornamental property, not something that merely serves to give "form" to what is "pretty," but rather an essential variable that governs mental models and initial acceptance (Norman, 2004; Tractinsky et al., 2000).

5.3. COGNITIVE TOLERANCE MECHANISMS FOR MINOR ERRORS

To understand the aesthetic-usability effect on users' performance and everyday interaction, this effect must be regarded as mediated by neuropsychological processes linked to visual perception and problem solving.

HCI research shows that a user interface that looks aesthetically pleasing and is harmoniously organized is not only perceived as easier to use but also acts as a buffer against the operator's frustration with minor algorithmic or design failures (Ben-Bassat et al., 2021; Norman, 2004). This phenomenon manifests through mechanisms of cognitive tolerance and leniency biases grounded in the neurobiology of positive affect.

The defense of the attractive interface. The main psychophysical substrate that explains user tolerance of the technical shortcomings of an attractive interface lies in the theory of positive affect formulated by the cognitive sciences (Norman, 2004). When the operator interacts with a digital or physical environment that adheres to the norms of symmetry, chromatic balance and typographic legibility, their nervous system is viscerally stimulated, pleasurably and automatically, and medial orbitofrontal cortical mediation gives rise to the presence of neurotransmitters such as dopamine (García-Madariaga et al., 2021; Norman, 2004).

Cutting-edge research indicates that a positive emotional shift immediately broadens the brain's processing resources; that is, it increases cognitive flexibility. A user in a state of psychological comfort derived from aesthetic delight tends to abandon the rigid, tunnel-vision thinking patterns characteristic of technology-related stress and anxiety and instead approaches system inconsistencies through creative exploration and problem-solving.

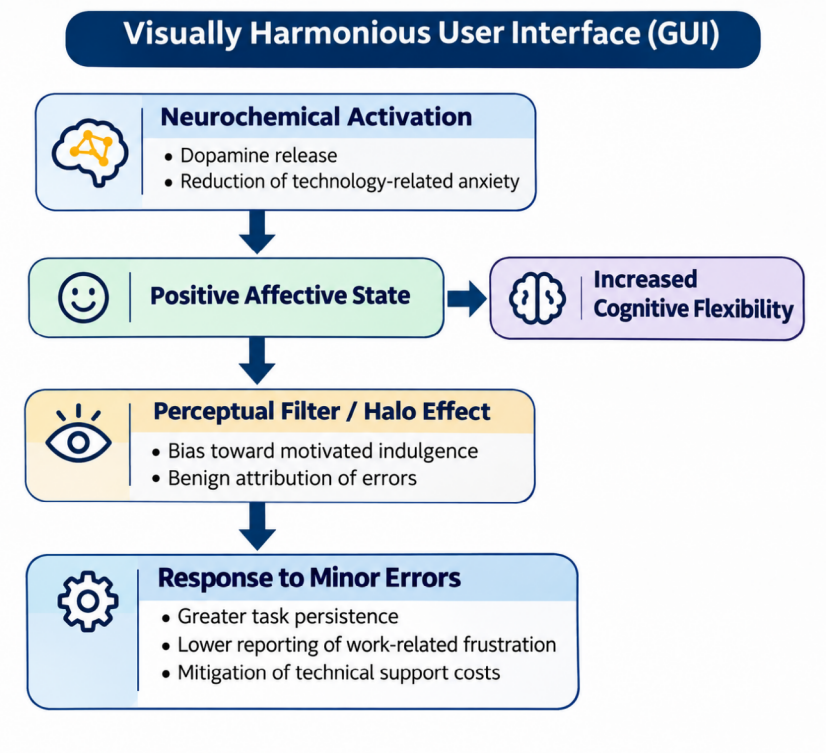
Consequently, a slight delay in data processing or an ambiguous navigation menu in corporate software would lead the operator with greater cognitive flexibility to persist voluntarily with the task, find alternative interaction paths and resolve the problem autonomously, interpreting the anomaly as minor rather than attributing it to a failure of the digital tool.

From a perceptual standpoint, the apparent usability determined by the visual design of the graphical user interface (GUI) creates a "halo effect" that strongly biases the evaluation of system performance. Within the space an organization occupies, human beings tend to unconsciously transfer positive characteristics from a dimension we know to other dimensions that we do not know or that we find complex. For reasons that go beyond what is natural or foreseeable, every form of life is called to contemplate its own nature and becoming, as well as the ends it must fulfil.

The culpability of actions is equivalent to the magnitude of their consequences. When an operator makes an error on a visually neglected or disorganized interface, they usually attribute the failure automatically to the system's ineffectiveness, which raises indicators of dissatisfaction and resistance to technological change (Ermete, 2024; Moran, 2024). By contrast, if the same inconsistency occurs in a GUI with a formally superior design, the user activates an attentional benevolence filter: they assume the system is robust.

Users also tend to blame themselves for the command error, or they classify the operational friction as an accidental and transient event (Moran, 2024; Tractinsky et al., 2000).

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For strategic discussions on information technology in companies, it is useful to understand information management technologies and their financial behavior (Ermete, 2024). Interfaces that combine instrumental usability with aesthetic standards in a symbiotic approach make it possible to eliminate a high percentage of low-level corrective technical support incidents and tickets in IT departments. This is because users naturally absorb the small everyday frictions of interaction, thanks to the buffering effect of the design.

Likewise, visual aesthetics prevent heavy attentional load and the build-up of technostress-related frustration peaks, and so bring the design closer to cognitive ergonomics. This, in turn, safeguards the organization's productivity indices while contributing to staff well-being.

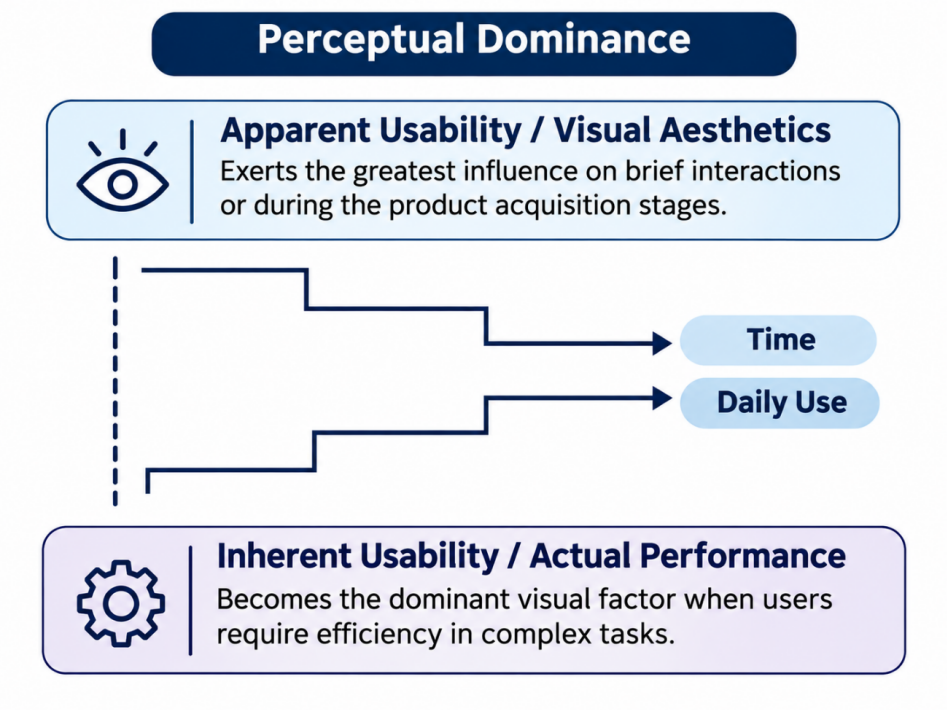
5.4. BOUNDARIES AND LIMITATIONS OF THE AESTHETIC-USABILITY EFFECT

Although the Aesthetic-Usability Effect is one of the most robust empirical pillars in HCI, current scientific literature cautions that it is neither an absolute nor an unlimited phenomenon. As hardware and software systems integrate the operating structures of organizations in increasingly complex ways, methodological and cognitive limits emerge at which the protective effect of visual appeal weakens, breaks down or, in the worst case, has adverse effects on the user experience. Understanding these limitations is key to preventing researchers and designers from falling into a bias toward over-designed interfaces that focus on visual enjoyment, thereby neglecting the technical and operational viability of the business Ben-Bassat et al., 2021.

The first critical boundary of the phenomenon is directly related to the time and frequency of use. Across the various controlled longitudinal studies, the aesthetic-usability effect is strongest in the initial phases of interaction, in short usability tests, or during the phases in which a novice user freely explores the product. At this first point of contact, the visceral emotion described by Donald Norman (2004) entirely shapes the operator's mode of judgment, masking system failures.

However, the initial cognitive bias gradually dissolves as the user engages in repeated interactions over the course of the workday. The chaos lies in the design. For required corporate tasks that demand concentration, production and high-speed processing, a software application that is initially visually striking is severely unusable by default owing to redundancies in navigation flows, delays in data loading or a lack of something. Empirical evidence shows that, in the long run, actual usability and actual performance completely displace apparent usability in visual design and are the sole determinants of the user's final satisfaction and voluntary acceptance.

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Tractinsky (2018) notes that one of the most fundamental limitations on the system's capabilities relates to the severity and nature of errors. The positive impact of aesthetics on usability acts as an effective buffer for low-intensity errors. With minor operational mismatches, typographic design ambiguities, or small synchronization delays, the user's mind shows greater cognitive flexibility and, when the aesthetic design is successful, a benevolence bias.

When the interactive product becomes inoperative or suffers critical blocking failures that prevent the business objective from being achieved (which could involve the loss of information in the database, the application closing unexpectedly, or the hardware failing to respond to basic physical commands), aesthetics no longer mediates or protects.

Under high work-related stress, where the technological tool blocks the productive workflow, an excessively ornate visual aesthetic may even heighten the sense of frustration, to the point that the operator, upon reflection, judges it to be a cosmetic layer that attempts to conceal deficient or poor-quality software engineering.

The most methodologically significant limitation is known in the specialized Human-Computer Interaction literature as the "aesthetic trap" or usability masking bias. Given the strength of the apparent usability effect documented by Kurosu and Kashimura, a high risk is observed in QC and in corporate prototype evaluation practices.

Software development teams may be dazzled by highly positive feedback from project clients and assume that the system they are developing already works and is ready for production, merely because of the favorable visual impression of external evaluators (Ben-Bassat et al., 2021; Moran, 2024).

This is dangerous if designers neglect quantitative performance testing or stop measuring objective indicators of actual usability, such as the task completion success rate (effectiveness) or a strict count of the time required to carry out organizational processes (efficiency) (ISO, 2018; Martínez et al., 2022).

Thus, the Aesthetic-Usability Effect can mask key architectural flaws that resurface once the product is put into production, released to the market or deployed at the organization's operational workstations. The result is high corrective maintenance costs after production and deployment. Consequently, aesthetics must act as an accelerator of use, never as a substitute for or a cosmetic cover-up of functional engineering.

5.5. INTEGRATION MODELS: JESSE JAMES GARRETT'S FIVE PLANES

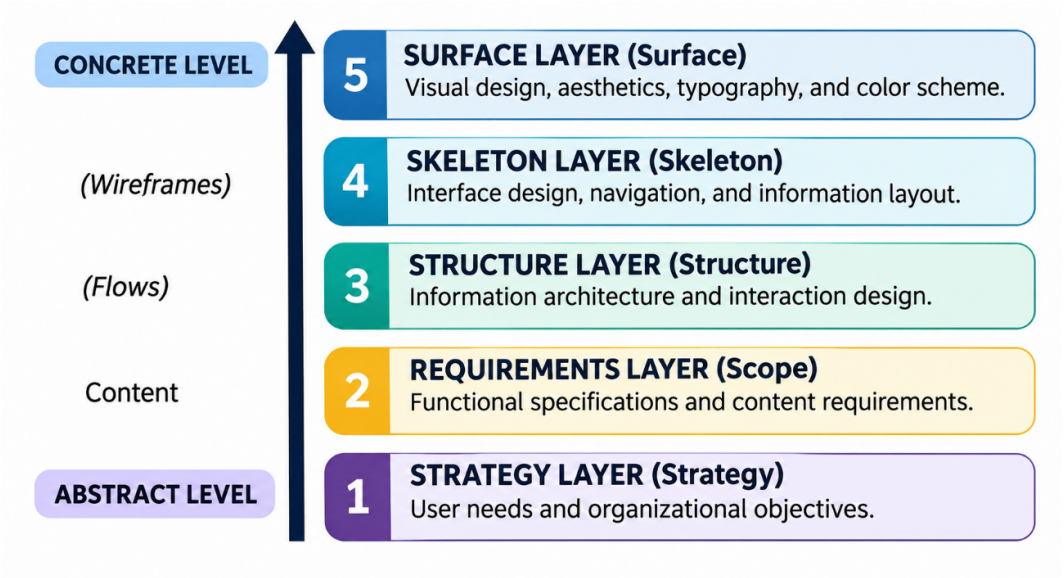
For functional usability and the visual aesthetic standard to be integrated systematically, it is very important that organizations have methodological architecture frameworks to work

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within, so that the design process starts at the strategic level of abstraction and proceeds to the graphical user interface (GUI).

One of the most effective, validated and widely used reference models worldwide in software engineering and human-computer interaction (HCI) design is Jesse James Garrett's (2011) five-plane model, presented in his acclaimed book The Elements of User Experience: User-Centered Design for the Web and Beyond.

This conceptual model divides the process of sociotechnical development and integration into five interconnected strata that function dependently and incrementally. Decisions made at the lowest, most intuitive (abstract) levels directly constrain the options available at the highest (concrete) levels. The model thus provides guidelines for keeping the surface finish consistent with usability and business performance (Garrett, 2011; Simó et al., 2024).



It forms the abstract foundation of Garrett's (2011) model. At this first design level, the organization concerned explicitly establishes which strategic objectives the technological product must meet with respect to the organization, and what the actual needs, expectations and constraints of the target end-user profile are. Within the balanced integrity of this work, this level is where the first analytical categories of usability and overall experience (user experience, UX) take shape, determining the specific context of use according to the parameters established by the ISO 9241- 11 standard.

Once the strategic objectives have been defined, the process moves on to the second plane, in which the strategy is translated into technical requirements. It breaks down into two operational dimensions, namely functional specifications (the detailed description of what the software or interactive system must do, that is, its algorithmic and programming features) and content requirements (the informational elements that must be included in the application). This plane delimits the functional scope of the system to avoid unnecessary overdesign of logical tools.

The third level defines the model that will govern the system's behavior and how the different logical modules relate to one another. It naturally integrates interaction design, which maps how the software responds to the operator's command, click or gesture, and information architecture, which controls the schemes for organizing, labeling and categorizing the company's information (Garrett,2011).

This level directly shapes Jakob Nielsen's (1993) attributes of operational efficiency and error prevention, which ensure that navigation flows fluidly reflect the user's mental model.

The skeleton plane makes it possible to represent on screen, by means of low-fidelity sketches or wireframes, the implementation of an abstract structure within a specific spatial arrangement. This level integrates three HCI disciplines. The first is graphical interface design, which is responsible for the "precise placement" of buttons, menus, search fields and forms. The second is navigation design, which establishes the visual paths the operator must follow to move from one section to another. Finally, information design seeks to make data easier to read through the way they are presented. This plane makes judicious use of psychophysical laws of perception, such as the Gestalt principles of proximity and common region, which optimize initial apparent usability.

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The GUI is what experts call a “Gloss Interface,” which refers to its “glossy” quality compared with a conventional 3D applied-icon model. In this final layer, the development team’s design work is carried out only on the corporate components: defining the institutional color palette, the typeface to be used along with the treatment of the images, and the application of texture or elevation shadow.

One epistemological contribution that can be discerned in the model of Garrett (2011) is that surface aesthetics cannot operate in isolation or on their own. A GUI that is clearly attractive on the surface plane will prove sterile and cause frustration if the skeleton lacks a clear hierarchy, if the information structure is anarchic, or if the business strategy does not take user needs into account.

When organizations assimilate the five planes bidirectionally and sequentially, they manage to safeguard the coherence of their technological developments. The visual aesthetics of the surface then act as the appropriate channel and translator of the inherent usability performance structured in the lower planes, thereby scientifically ensuring the creation of a competitive advantage through differentiation in saturated global markets.

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Chapter 6 / Capítulo 6

Check for updates

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.

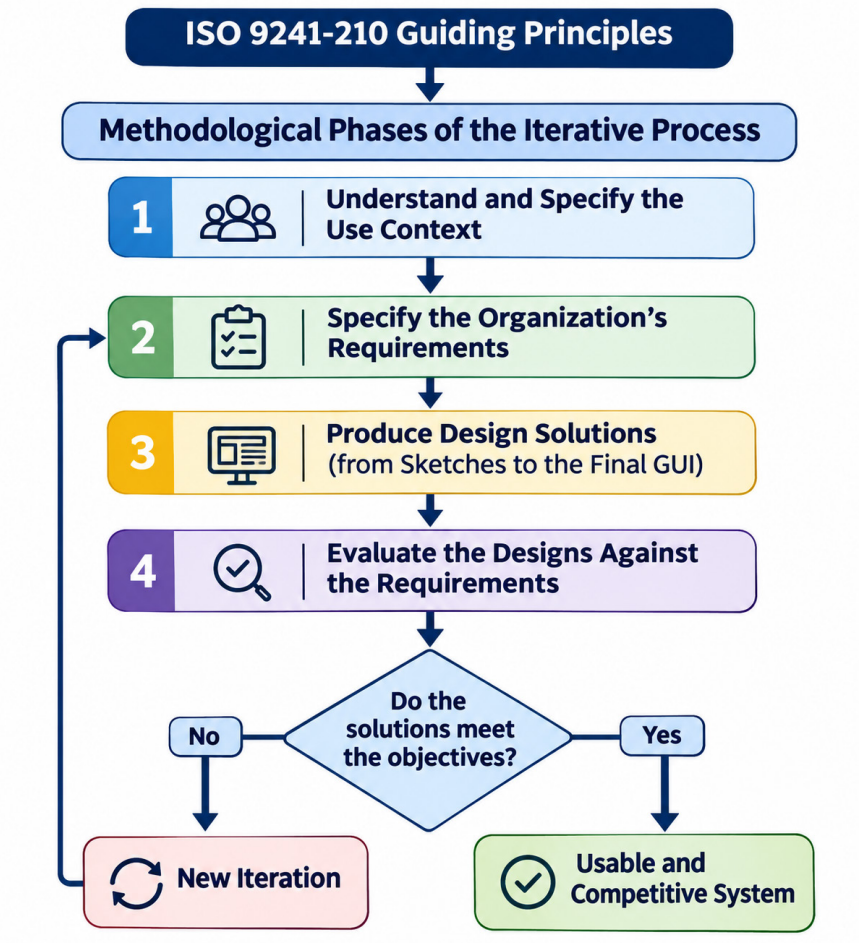
- Fase uno: comprender y concretar el contexto de uso. Implica la recolección exhaustiva de datos sobre quién utilizará la tecnología, para qué actividades del negocio y bajo qué condiciones físicas y ambientales.

•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.

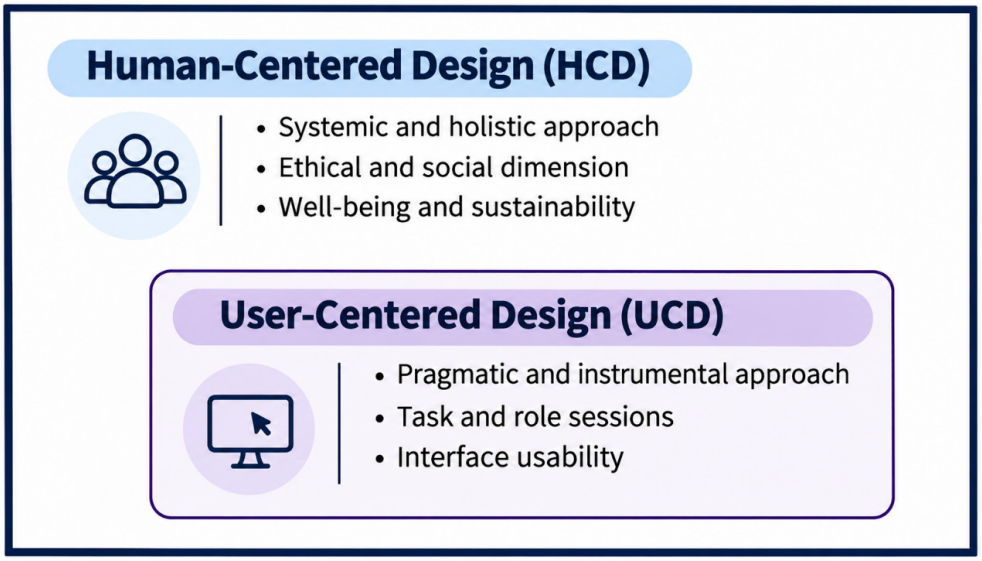
• La Reiteración Estructurada. Se presume con enfoque metodológicos que la optimización de algún producto interactivo requiere de un ciclo continuo de diseño, evaluación, feedback and empirical refinement.

•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).

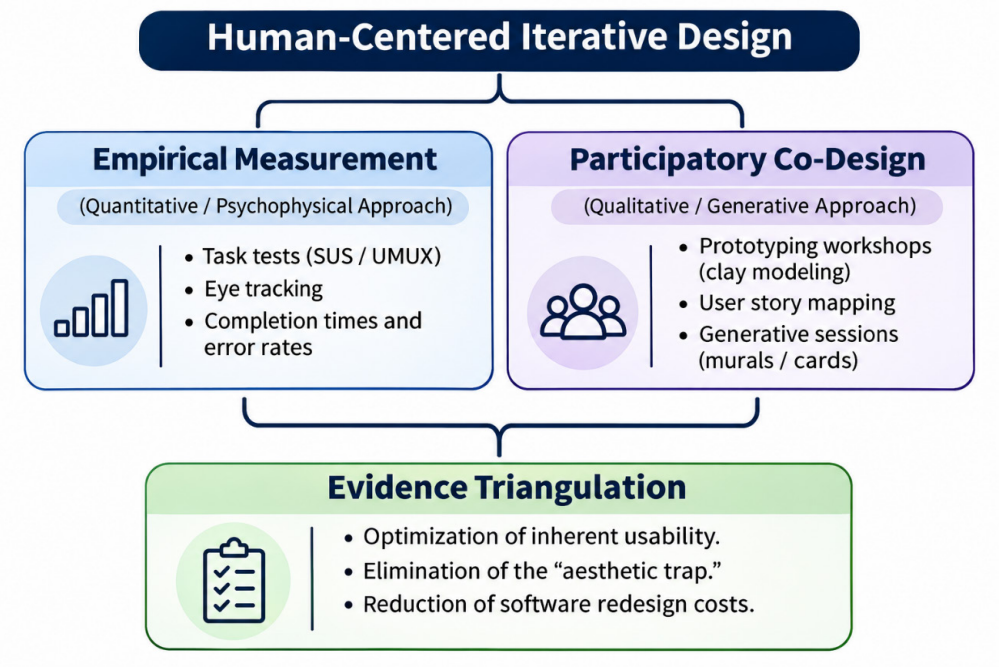
Control theory is based on empirical measurement or on a solution that is already tangible, which means the project team can control the extent to which its citizens are integrated into participatory co-design. In this generative paradigm, operators are not merely passive test subjects: they know their 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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Chapter 7 / Capítulo 7

Sustainable balance between usability and aesthetics in hardware and software design within the organizational context
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Impact of technological design on business competitiveness

Impacto del diseño tecnológico en la competitividad empresarial

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ABSTRACT

Context: In this chapter, interface aesthetics and human-centred design are analysed as pillars of corporate governance. In highly saturated and competitive markets, the visual and functional properties of graphical user interfaces (GUIs) become assets of strategic value for decision-making by senior management. Objective: To substantiate the impact of user experience (UX) on business economics through Michael Porter's generic strategies, the mechanisms of horizontal and vertical differentiation, the taxonomies of technological innovation, perceived value and the calculation of return on investment (ROI). Method: A theoretical-descriptive review was conducted, grounded in microeconomic models of product differentiation, neo-Schumpeterian theories of innovation and financial profitability equations applied to the development of intangible software and hardware assets. Results: The review indicates that a harmonious GUI acts simultaneously by increasing hedonic benefits and by reducing cognitive load, which in turn favours customer perceived value (CPV). In addition, a model is put forward according to which the ROI of UX influences both the reduction of internal operating expenses (OPEX) and external commercial traction, including the capture of premium prices. Conclusions: Investment in interaction design is presented as a cross-cutting strategic imperative that contributes to the financial sustainability of the business. The chapter recommends institutionalising empirical metrics in order to predict technology adoption and to mitigate the extra costs arising from subsequent corrective redesign, with the aim of sustaining competitive advantage.

Keywords: Operating expenses (OPEX); Vertical and horizontal differentiation; Cognitive ergonomics; Differentiation strategy

RESUMEN

Contexto: En este capítulo se analizan la estética interfacial y el diseño centrado en el ser humano como pilares de la gobernanza corporativa. Ante mercados altamente saturados y competitivos, las propiedades visuales y funcionales de las interfaces gráficas de usuario (GUI) se consolidan como activos de valor estratégico para la toma de decisiones en la alta dirección. Objetivo: Justificar el impacto de la experiencia de usuario (UX) en la economía empresarial a través de las estrategias genéricas de Michael Porter, los mecanismos de diferenciación horizontal y vertical, las taxonomías de innovación tecnológica, el valor percibido y el cálculo del retorno de la inversión (ROI). Método: Se desarrolló una revisión teórico-descriptiva fundamentada en modelos microeconómicos de diferenciación de producto, teorías neoschumpeterianas de innovación y ecuaciones financieras de rentabilidad aplicadas al desarrollo de activos intangibles de software y hardware. Resultados: La revisión indica que una GUI armónica actúa simultáneamente elevando los beneficios hedónicos y reduciendo la carga cognitiva, lo que favorece el valor percibido por el cliente (CPV). Asimismo, se plantea un modelo según el cual el ROI en UX incide tanto en la reducción de los costes operativos internos (OPEX) como en la tracción comercial y la captura de precios premium externos. Conclusiones: La inversión en diseño interactivo se presenta como un imperativo estratégico transversal que contribuye a la sostenibilidad financiera del negocio. Se recomienda institucionalizar métricas empíricas para predecir la adopción tecnológica y mitigar los sobrecostes por rediseño correctivo posterior, con el fin de sostener la ventaja competitiva.

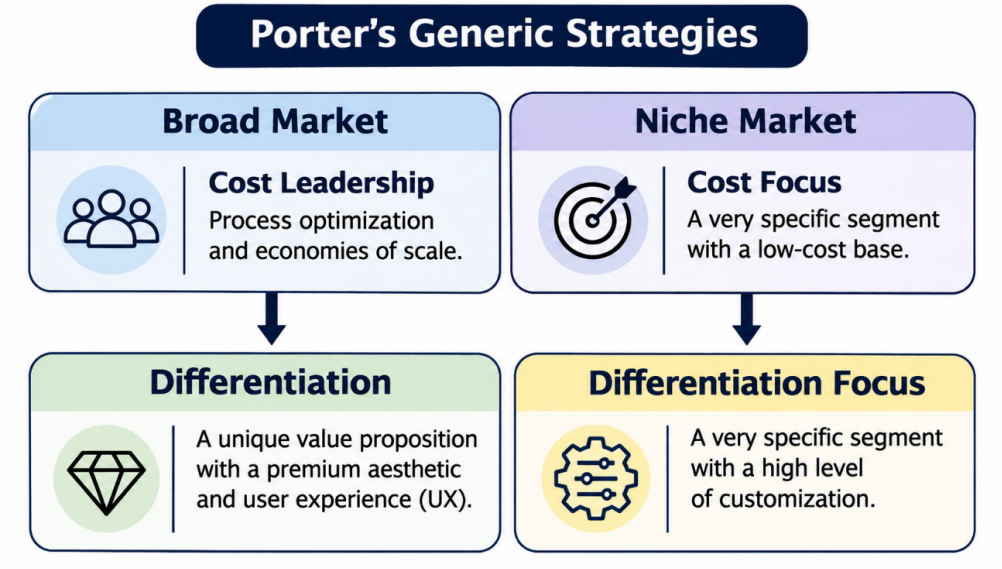
Palabras clave: Costes operativos (OPEX); Diferenciación vertical y horizontal; Ergonomía cognitiva; Estrategia de diferenciación

7.1. MICHAEL PORTER'S COMPETITIVE ADVANTAGE AND GENERIC STRATEGIES

For hardware and software to cease to be interpreted as an isolated technical-operational variable, in which the digital connection between usability design/architecture and the product's aesthetic designs matters only locally, it must be shown that this synergy has a powerful impact on the corporate economy.

The theory of competitive advantage developed by the economist Michael Porter (1980; 1985) is indeed particularly well suited as a theoretical justification within this analytical framework, which examines how the visual standard and the information architecture embodied in graphical user interfaces (GUIs) can determine an organization's strategic position, its long-term economic viability, and its capacity to respond to competition driven by global market forces.

As Porter (1985) emphatically states: "Competitive advantage grows fundamentally out of value a firm is able to create for its buyers that exceeds the firm's cost of creating it." The only way organizations can achieve this superior and sustainable long-term position is to choose a decisive direction and avoid strategic ambiguities such as becoming stuck in the middle. That is, they must rigorously select one of Porter's three generic strategies: cost leadership, differentiation, or focus (Porter, 1980).



The differentiation strategy directs the organization's resources toward developing products or services that target customers unanimously perceive as unique, exclusive and far more valuable. This singular value allows firms to insulate themselves from direct price-based competition, keep their customers satisfied and charge a price premium that amply covers their investments in research and development.

The formal features of the user interface have become one of the most powerful vectors for differentiating a small digital company today, and also nearly one of the hardest to replicate because of scale. If a company produces an interactive software solution or designs hardware using principles of symmetry, geometric balance and formal cleanliness (Garrett's surface plane), it immediately influences consumers at their most visceral level.

This instantaneous positive affective response produces the Aesthetic-Usability Effect: a cognitive bias whereby the customer generalizes external attractiveness to the inherent technical quality and internal usability of the system. This makes sense, because interface design acts as a market signal that helps mitigate information asymmetry and instantly increases the perceived value of your product; it now protects you from being drawn into price competition in technology.

Although aesthetic design falls largely under the differentiation strategy, it works symbiotically with functional usability (Human-Centered Design), which even plays a decisive role in cost leadership strategies. Cost leadership does not mean merely compromising the material quality of a product, but rather radically optimizing internal processes, reducing operational redundancies, and increasing individual productivity through effective use of human capital.

Enterprise corporate software (ERP, CRM system, etc.) with a universal aesthetic applied with restraint through Gestalt principles (proximity, similarity, and common region) greatly reduces command errors: it saves time in logical workflows, executes processes, and reduces technostress

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during office downtime.

This cognitive ergonomics "barrier" generates a high ROI from the perspective of operating expenses (OPEX):

· Reduction in error-related costs: it prevents financial losses associated with incorrect data entry or logic rework.

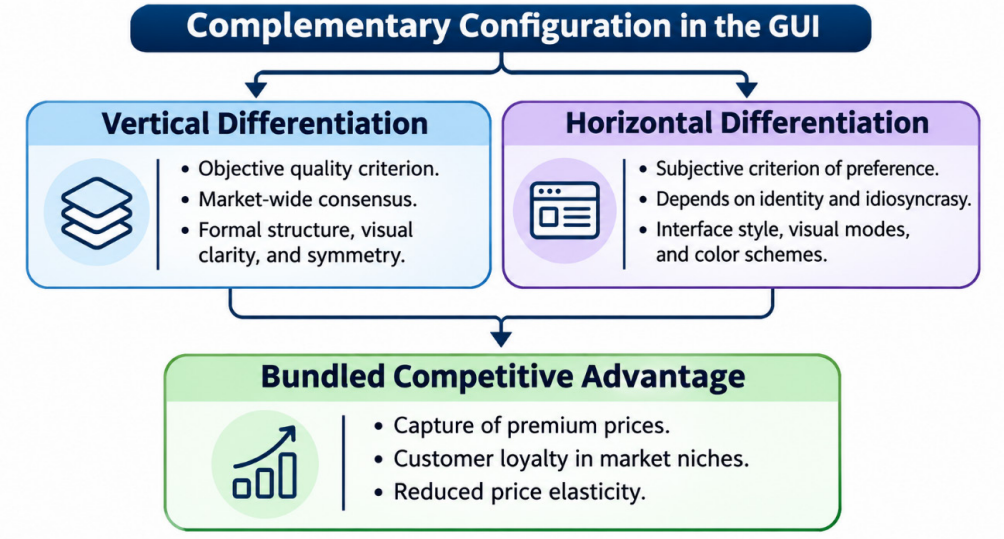
·Reduction in technical support costs: when cognitive tolerance mechanisms for minor errors are induced through aesthetic comfort, the flow of incidents to IT departments drops drastically.

·Reduced training program costs: intuitive interfaces dramatically reduce learning time and the cost incurred by the organization in the continuing education of its employees.

Therefore, interface aesthetics and user-centered design in accordance with the ISO 9241-210 standard are no longer mere design embellishments that only enhance visual appeal; rather, they encapsulate typography as a requirement of senior management. They are cross-cutting strategic tools that can maintain the uniqueness of the product offered at the end-user level (i.e., differentiation) while also protecting operating-cost efficiency within an internal organizational structure.

7.2. HORIZONTAL AND VERTICAL DIFFERENTIATION MECHANISMS IN SATURATED MARKETS

Technology management must therefore draw on microeconomic models of product differentiation in saturated markets if it is to truly understand when a visual standard for an interface gives an organization a sustainable competitive advantage. In hypercompetitive environments, where the inherent "as-is" technical capabilities of interactive systems are beginning to consolidate through programming languages and the standardization of logical hardware components, it is in the interface that a rising industry leader will prevail. In practice, organizations structure their commercial offering by describing two econometrically independent dimensions: vertical differentiation and horizontal differentiation (Tirole, 1988).



When two or more alternative products are compared on the same attribute, consumers all agree that one is objectively better than another; this is an example of vertical differentiation. In Human-Computer Interaction (HCI), vertical differentiation is constrained by how rigorously a surface plane adheres to properly articulated functional usability.

A GUI that displays impeccable white space, corporate typefaces with optimal contrast levels and perfectly uniform geometry (applying Gestalt principles) is always rated by the market as a premium product compared with a cluttered, data-laden deliverable.

This unanimous perception triggers the Aesthetic-Usability Effect and acts as a market signal, reducing information asymmetry for the consumer. Customers translate external formal beauty into a kind of confidence in the quality of the back-end engineering, even if they do so involuntarily. In microeconomic terms, vertical differentiation resolves the dilemma of pure price competition by allowing the technology company to command a higher price while extracting a

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larger share of the social surplus.

Tirole (1988) explains that horizontal differentiation arises when, at identical prices and technical specifications, consumers cannot agree on which product is preferable because the purchase does not depend on an objective quality scale. Firms, for their part, offer products whose attributes are tailored to subjective coefficients such as personal preferences, aesthetic values or lifestyle. This relates directly to the reflective level of emotional design proposed by Donald Norman (2004), which involves assessing the extent to which hardware or software reflects one's identity in our social and business context.

In the modern era of loosely focused Markovian markets, organizations use horizontal differentiation systems when developing interfaces with limited aesthetic variation that does not compromise the calibration of the core algorithms. The following are some clear illustrations of this vector:

· Alternative Visual Modes: this kind of interface, which can switch between a "dark mode" and a "light mode", responds to an operator's aesthetic preferences or to certain ergonomic conditions of use.

· Interface Design Styles: the axis running from skeuomorphic to flat design separates users horizontally according to perceived sophistication or nostalgia for interface textures.

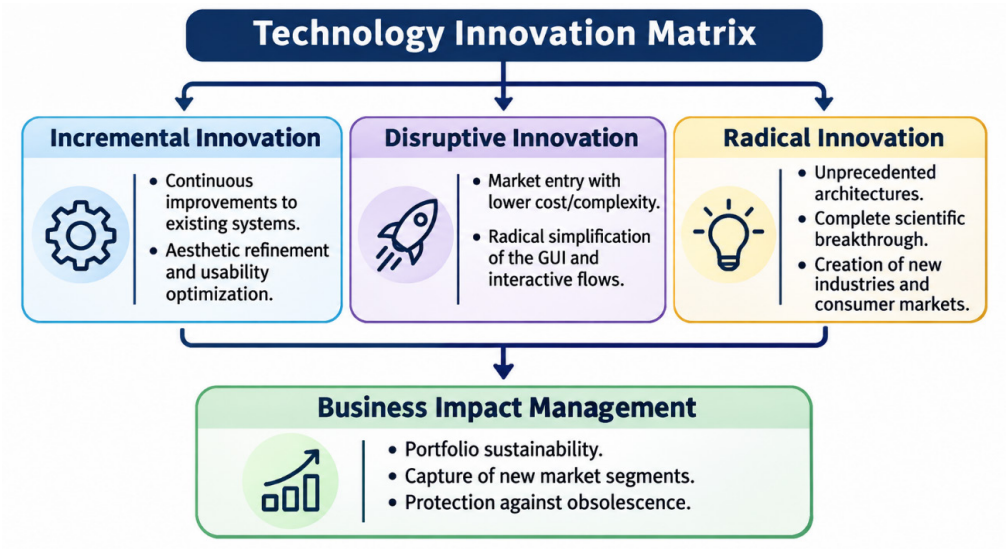
· Theme Customization: giving business operators the ability to change, for example, the color scheme of their organizational control panel (dashboard) increases levels of psychological ownership and the affective sense of belonging to an interactive work tool.

Clearly articulated horizontal (vertically) differentiation strategies allow the organization to avoid massive, undifferentiated competition and to make its way into highly lucrative market niches. By aligning seamlessly with customer subjectivity, the organization builds psychological switching barriers that increase switching costs and reduce the price elasticity of demand, while also shielding the business from competitors' commercial attacks on its market share.

7.3. TECHNOLOGICAL INNOVATION (INCREMENTAL, DISRUPTIVE AND RADICAL)

To successfully integrate interaction design and interface aesthetics into strategic planning, an organization's senior management must link these efforts to the taxonomies of technological innovation (Schumpeter, 1934).

Innovation does not manifest uniformly across hardware and software markets; rather, it can be classified according to its degree of novelty, its influence on organizational capabilities or business processes, and how it shifts market dynamics. These transformations are the focus of the classic innovation management literature, which divides them into three main types: incremental versus disruptive and radical (Christensen, 1997; Freeman and Soete, 1997).



Incremental innovation is characterized by gradual progression, involving relatively minor improvements to already established commercial products, component parts or process technologies (Freeman & Soete 1997). It does not alter the system architecture or create new markets; rather, it fine-tunes existing solutions to optimize their performance, efficiency and

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appeal so that they remain competitive (Henderson & Clark, 1990).

Incremental innovation is the dominant methodology in application design, largely driven by the iterative cycles of human-centered design (ISO 9241-210).

This type of innovation may consist of changing an application's color palette to bring it up to date with design trends, redesigning a menu's typography to improve contrast levels, or reducing the number of clicks required during a software transaction.

Through this layering of subtle aesthetic and functional refinements, the organization improves a user experience that would otherwise be superficial and lightens the cognitive load on the end user. It does so without risking economic stagnation from competitive substitutes, instead preserving the value of defensible differentiation, and without ever having to invest in risky R&D for a truly new technology.

Disruptive innovation is an existing process described by Clayton Christensen (1997) in the bestseller The Innovator's Dilemma. In this process, a product or service that appears strikingly rudimentary, with lower raw performance and much greater cost efficiency than the established solutions offered by the leading companies, typically ends up first at the bottom of a market (or, more simply, among undersupplied features). Over time, the disruptive technology improves progressively until it completely displaces the traditional competitors.

In digital corporate economics, interface design often serves a dual function as a turning point (Norman 2013). Emerging and disruptive organizations usually approach the market by simplifying technological and engineering complexity, the same complexity that saturates the interfaces of dominant companies. By somehow drastically simplifying the structure and surface described by Garrett (2011), these organizations create tools whose inherent usability minimizes the behavioral and visceral levels. This essentially means that these products can be used as they are by uninformed and non-expert consumer segments.

Simplified mobile video-editing applications, which began to appear as an alternative to complex professional post-production software, were one example of this phenomenon in action. They redefined the landscape for tens of millions of new users and shifted the boundaries between the domains of digital design and communication by simplifying work through a GUI that takes over the screen.

Radical innovation refers to a profound and discontinuous break with current knowledge and technologies, as well as with markets (Freeman & Soete 1997). Most of the time, it originates in science-based R&D projects that come to fruition, create entirely new industries and, in turn, decimate many capabilities that existing organizations had mastered under a previous technological paradigm (Henderson & Clark, 1990).

A radical innovation occurs (as when we moved from text-based command-line interfaces [CLI] to a mouse- and window-based graphical user interface that emerged at the Xerox PARC laboratories and later at Apple), and it is not only the source code or the storage hardware that changes; a new mental model / architecture of the copyright system also emerges for human beings.

All three levels of emotional design proposed by Norman (2004) must be fully implemented for radical innovation to occur:

- Visceral: It requires the creation of an entirely new aesthetic language that elicits desire and minimizes instinctive resistance to the unknown.
- At the behavioral level: it drives the invention of new ways of transferring interaction (gesture/pinch on the touchscreen to zoom) that ensure immediate, high operational efficiency.
- At the reflective level: it proposes and changes form, culturally re-signifies, and restructures consumers' subjectivity with a new, adjustable self-concept to strengthen brand value amid the fiercest global competition.

By wisely allocating their investments among incremental, disruptive and radical innovations within a balanced corporate portfolio, technology companies can not only keep the lights on in day-to-day business but also capture near-future markets and, most importantly, anticipate the paradigm shifts that determine whether an organization survives across many periods.

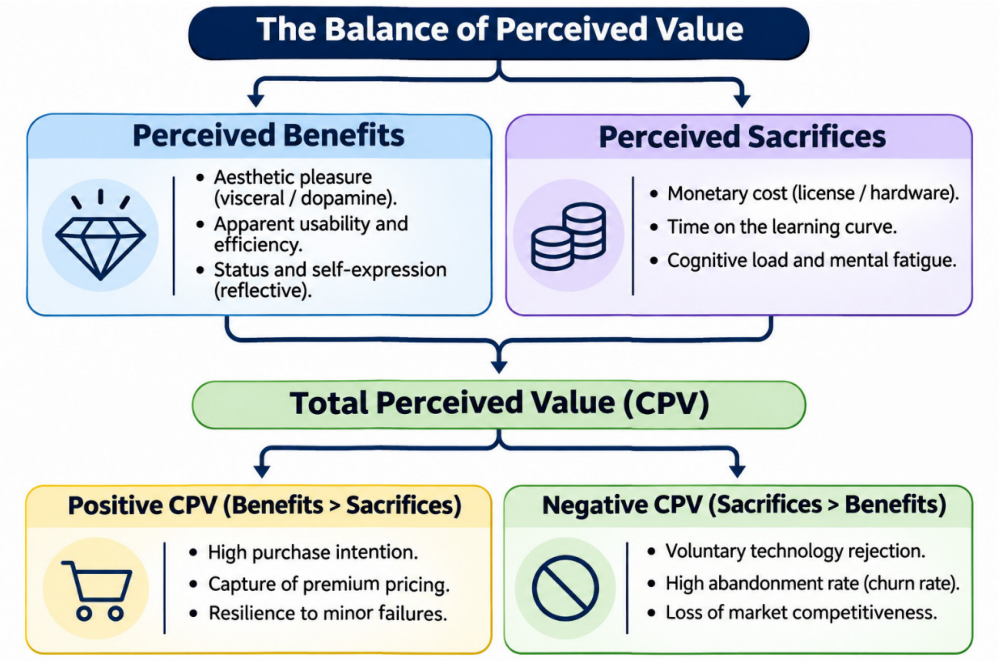
7.4. CUSTOMER PERCEIVED VALUE AS A MEDIATING VARIABLE

To elevate how interface design and investments in the aesthetic standard of hardware (and software) are conceived, moving them from a supporting component to one that drives executive-level decisions, it is important to map these correspondences between display properties and their economic impacts on an organization.

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In this regard, the scientific literature on business strategy and services marketing shows that Customer Perceived Value (CPV) is the predominant psychophysical mediating variable between the functional architecture of an interactive system and business outcomes such as brand loyalty, user retention and positive purchase intention (Zeithaml 1988).

Customer-perceived value is not governed by engineering constants or by a defined objective measure; rather, it is a cognitive and affective evaluation that is relational and subjective in nature. In a consumer's mind, it is operationalized mathematically as a heuristic balance that weighs the total of perceived benefits (including economic, functional, aesthetic, and social value) against the collateral sacrifices associated with its acquisition (monetary cost plus time investment, the cognitive effort involved in learning curves, and the risk of error when operating it).



In this calculation, the formal properties of the UI mediate between the two sides:

· In the benefits dimension: A perfectly formed and balanced surface plane activates an immediate reward mechanism in our brain and elicits visceral-level responses that amplify users' hedonic enjoyment and aesthetic appreciation. Similarly, even a more sophisticated interface reinforces the social benefit dimension and Norman's reflective level.

· Regarding sacrifices: The GUI is designed according to many Gestalt principles and with more complex ergonomic sequences that, taken together, will save a great deal in non-monetary costs, fully integrated systems. The system minimizes cognitive load, reduces work fatigue, and shortens the time needed to complete business tasks by clarifying which information is most relevant. This type of psychological sacrifice associated with depression is what the organization uses to drive the net CPV of the effect.

Formally, perceived value functions as a mediating variable by amplifying the external aesthetic stimuli of the graphical interface and converting them into stable behavioral intentions. It operates by changing how this balance is weighted; specifically, it determines how much Aesthetic play influences concrete instances of judgment relative to Usability, thereby disrupting our intuition about usability through what we see. Evidence from a series of controlled experiments indicates that an attractive GUI immediately leads the user to hypothesize high apparent usability (Kurosu & Kashimura, 1995; Moran, 2024).

This favorable heuristic disposition substantially increases the customer's readiness to accept minor sacrifices. When the software has minor processing delays or logical inconsistencies that are not catastrophically disruptive, a positive dopaminergic impact provides a protective buffer. Consequently, the consumer perceives that the balance still tips in favor of the benefits, which keeps CPV high and offsets any inclination to abandon/not use or switch from competing digital tools.

Interface design helps senior management at software development companies or hardware vendors control perceived value, one of the most profitable pricing strategies. According to Porter (1985), "The ability to charge a premium price depends critically on whether or not differentiation

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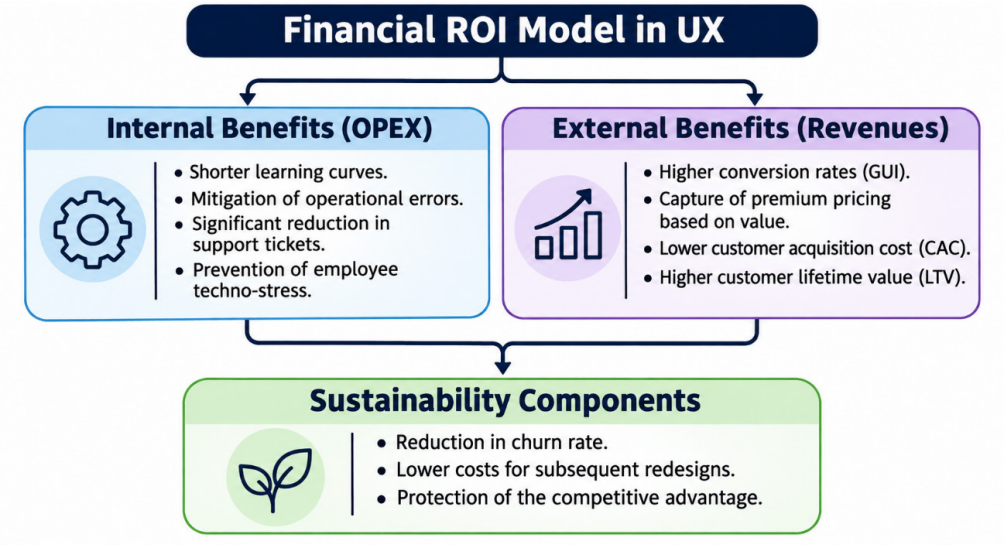
enhances buyer value."

If corporate investment succeeds only insofar as it symbiotically refines technical performance (inherent usability) together with the formal elegance of the interactive environment (apparent usability), a break occurs in the price elasticity of demand.

The customer stops comparing hardware specification sheets or system licensing costs, because the interface has now become established in their mind as a single, fully integrated productive solution for achieving maximum work efficiency and creating unique psychological experiences of positive reinforcement. When perceived value is established as the highest point of the strategy, interface aesthetics is no longer a mere decorative expense but an important part of the core of your business's sustainable competitive advantage, and this is imperative in hypersaturated economies that circulate globally every minute.

7.5. RETURN ON INVESTMENT (ROI) IN UX AND BUSINESS SUSTAINABILITY

To anchor the interfacial presence of aesthetics and Human-Centered Design in corporate governance, senior management must transform psychophysical and relational metrics into requirements for financial profitability. ROI in UX is the definitive analytical argument regarding capital expenditure (CAPEX) for interface design and development in relation to information technology management [2]—[6](Marcus 2020; Rosenberg, 2024). In hypercompetitive and saturated markets, where the focus of a product is so muddled that its very purpose cannot afford to be more than an ornamental sunk cost in the conduct of high-level scientific experimentation disguised as good engineering practice: harness nature and demonstrate that investment in the formal elegance of usability can, in fact, act like a few daisies sprouting among your business model's revenue streams.



The literature on economic usability engineering divides the quantification of UX ROI into internal and external benefits. Internal benefits center on monetary savings (i.e., time/budget) or gains in human/organizational productivity tied to processes within the company, whereas external benefits refer to the impacts that determine product performance in consumer markets.

· A. Internal benefits (optimized operating cost – OPEX)

If a corporation uses internal management software (such as an ERP or a CRM) built on rigorous Gestalt guidelines and disciplined symmetry, the non-monetary cost of its operations plummets. The internal impact on revenue (as defined by the classical formulas of usability engineering) is estimated solely from measurements of the following variables:

· Time savings: Clear, clean interfaces with well-defined hierarchies (Garrett's skeleton plane) reduce the number of seconds needed to complete each task. When multiplied by the number of annual transactions and an employee's hourly cost, this reduction translates into capital savings that a company can deploy immediately.

· Shorter learning curve: Reduced cognitive load decreases the number of days of ongoing "shadowing" training, which speeds up onboarding and lets existing operators become productive in less time.

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• Error mitigation and support: An interface that, through visual comfort alone, provides sensations that facilitate tolerance mechanisms leads to a lower volume of incidents escalated to technical support systems, thereby optimizing these systems in the relevant area.

• B. External Benefits (Commercial Traction and Revenue)

In mass-market, user-oriented interactive consumer products, a more favorable conversion balance is achieved through the graphical interface. By providing a perfectly balanced surface pattern, the floor layout gives new users an immediate sense of competence that lets them navigate each conversion funnel intuitively. As for external monetary returns: a decrease in CAC and an increase (in response to retention + repurchase triggered by the beauty of the system, positively modulated through dopaminergic inputs), with a stable LTV boost.

The Immediate Evaluation-Oriented Return (ROTI), or return, is calculated from the familiar ROI equation, adjusted for both social and technical user experience projects;

ROI = (Cost of UX investment Δ Total benefits $[Savings + Revenue] − Cost of investment) x 100

A comprehensive record of metrics and research in the technology business sector has shown that, for every dollar senior management formally invests in Human-Centered Design processes (ISO 9241-210 standards), an organization is likely to generate a return on investment somewhere between $10 and $100, with a net benefit; moreover, this is one of the most consistent rates of return on capital across all classes of goodwill intangibles.

Over time, this continuous flow of protected operational savings and revenue strengthens the sustainability of the business. If the corporation institutionalizes quantitative empirical measurement processes and participatory co-design methodologies (such as task-based testing, eye-tracking, or SUS/UMUX scales), it can become proficient at predicting user behavior with respect to technology adoption.

Scientific rigor eliminates visual improvisation at its root and eradicates the catastrophic financial cost overruns associated with corrective code reengineering in post-production stages. As a result, hardware and software are implemented as robust, ergonomic, high-efficiency tools that protect the organization’s competitive moat in globally hypercompetitive contexts.

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Chapter 8 / Capítulo 8

Check for updates

Sustainable balance between usability and aesthetics in hardware and software design within the organizational context
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Proposal for an integrative conceptual model

Propuesta de un modelo conceptual integrador

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ABSTRACT

Context: Considerations of usability and aesthetics are taken into account and incorporated into the strategic design processes of any organisation, whether it is a company or a public entity. Objective: Given the variety of meanings that have been attributed to the field of human-computer interaction (HCI) and the theoretical fragmentation of paradigms and approaches, the work seeks to unify psychophysical dimensions, emotional design and strategic management within a single framework, in order to understand the cognitive path of technology adoption in the context of organisational interactions. Method: A framework for the research strategy is outlined, based on structural equation modelling (SEM), which is triangulated with independent quantitative data through the combined use of standardised psychometric metrics and of psychophysical records obtained through eye-tracking. Propositions: According to the model, the visual aesthetics of the surface (X1) would predictively activate apparent usability (M1), which would then behave as a buffer that sustains cognitive tolerance towards the frictions of the system. However, this mediation path would lose validity and break down in the presence of catastrophic engineering failures. Conclusions: The chapter argues that the aesthetic coordination of the graphical user interface (GUI) jointly enhances both the hedonic and the functional benefits of software. The chapter also recommends that the structural model be formally validated in order to eliminate graphic improvisation and to orient interaction design towards corporate profitability.

Keywords: Cognitive tolerance buffer; Confirmatory factor analysis (CFA); Structural boundary conditions; Operationalisation of variables

RESUMEN

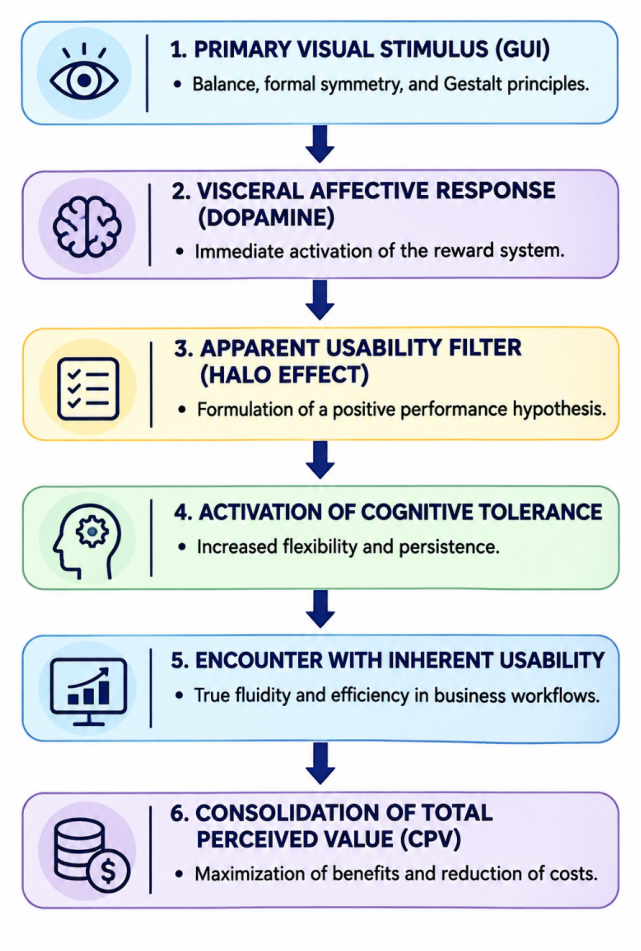
Contexto: Se toman en cuenta e incorporan consideraciones relativas a la usabilidad y la estética en los procesos de diseño estratégico destinados a cualquier organización, sea esta una empresa o una entidad pública. Objetivo: Ante la variación de sentidos de la interacción humano-computadora (HCI) y la fragmentación teórica de los paradigmas y de los enfoques, el trabajo se propone unificar, dentro de un solo marco, las dimensiones psicofísicas, el diseño emocional y la gestión estratégica, para comprender el recorrido cognitivo de la adopción de tecnología en el contexto de las interacciones organizacionales. Método: Se plantea un marco de estrategia investigativa por medio del modelado de ecuaciones estructurales (Structural Equation Modelling, SEM), en triangulación con datos cuantitativos independientes, mediante el uso combinado de métricas psicométricas estandarizadas y registros psicofísicos de seguimiento ocular (eye-tracking). Proposiciones: Según el modelo, la estética visual de la superficie (X1) activaría predictivamente la usabilidad aparente (M1), que se comportaría como un amortiguador de la tolerancia cognitiva ante las fricciones del sistema. No obstante, esta ruta de mediación perdería validez y se quebraría en presencia de fallos catastróficos de ingeniería. Conclusiones: Se sostiene que la coordinación estética de la interfaz gráfica de usuario (GUI) potencia de manera conjunta tanto los beneficios hedónicos como los funcionales del software. Se recomienda validar formalmente el modelo estructural para eliminar la improvisación gráfica y orientar el diseño interactivo hacia la rentabilidad corporativa.

Palabras clave: Amortiguador de tolerancia cognitiva; Análisis factorial confirmatorio (CFA); Condiciones de frontera estructural; Operacionalización de variables

8.1. FOUNDATIONS AND CAUSAL SEQUENCE OF THE USABILITY-AESTHETICS MODEL

To consolidate the empirical, methodological, and strategic dimensions addressed throughout this work, it is necessary to articulate a theoretical-operational framework for interface design in organizations. The MIUE is defined as a system that presents a descriptive analysis of three distinct dimensions of usability and aesthetics.

First, usability is defined as the influence that using the system has on the task for which it is intended. The MIUE formally defines the psychophysical and cognitive process that an operator experiences when interacting with a GUI, translating chromatic and spatial stimuli into economically measurable value for the business.



The MIUE rests on the scientific triangulation of three conceptual frameworks validated by the literature on Human-Computer Interaction (HCI) and business economics:

- Donald Norman's (2004) Emotional Processing Model: provides the framework for understanding the transition of the interface through the visceral level (immediate chromatic and geometric appeal), the behavioral level (efficiency and intuitiveness in task execution), and the reflective level (cultural meaning, status, and appropriation of the technological tool).

2. Se puede saber de James Garrett that in 2011, in his work "The Architecture of the Five Planes," he clarified that the operational map of layers on which graphical user interfaces (GUIs) are based is essential for building a graphical interface. Under this map, the external visual appeal, that is, the surface plane, is built on, and dependent on, logical foundations. These logical foundations are robust and comprise navigation (skeleton), interaction flows (structure), functional specifications (scope) and business objectives (strategy).

3.Valarie Zeithaml's (1988) Customer Perceived Value Equation: a financial bridge that shows how reducing cognitive sacrifices and maximizing hedonic benefits increase the product's net value, making it possible to capture premium prices and secure user retention.

The Integrative Usability-Aesthetics Model operates through a strict chronological causal sequence that determines the success or failure of technology adoption within the organization.

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This sequence unfolds through the following links or connections.

Link 1: Primary Visual Stimulation and the Visceral Response.

When the operator sees the graphical interface, the brain unconsciously processes the formal aesthetic attributes (spatial symmetry, typography, color palette, and contrasts) in less than 50 milliseconds. It has been shown that a harmonious layout, in keeping with the Gestalt laws, immediately triggers the release of dopamine in the orbitofrontal cortex as this region is activated. This produces a state of positive affect and psychological comfort.

Link 2: The creation of the halo effect and apparent usability.

The rapid onset of the Aesthetic-Usability Effect is driven by users' positive affect. Through a heuristic process, the operator forms a judgment of apparent usability that may be favorable, unconsciously assuming that a visually clean and institutional-looking interface reflects reliable, efficient internal engineering free of logical errors.

Link 3: The buffering trigger and its cognitive tolerance.

When the user begins instrumental interaction and inevitably encounters the system's first points of friction (ambiguities in menus, minor backend delays), the positive affective state broadens attentional resources. Instead of displaying frustration at the technological error or anxiety about the machine, the operator exhibits cognitive flexibility: they continue with the task, find other ways to navigate, and take responsibility for the error, which they classify as an accidental failure.

Link 4: Coupling to inherent usability and value conversion

Ultimately, users experience genuine intrinsic usability structured in the logical layers of the software ISO, 2019. If the information design and the skeletal structure of the interface are aligned with the worker's mental model, their interaction is highly effective and efficient.

In line with this perfect synergy, the Perceived Value Balance (CPV) is affected (Zeithaml, 1988): operational and hedonic benefits are maximized while time sacrifices and mental fatigue decrease, technical support costs are reduced, and the organization's sustainable competitive advantage is scientifically blinded.

8.2. OPERATIONAL DEFINITION OF VARIABLES (INDEPENDENT, MEDIATING AND DEPENDENT)

The MIUE constructs must be operationalized to enable validation, auditing and replicability in corporate technology development projects (ISO, 2019; Schumpeter, 1934). This methodological process translates the abstract ideas of HCI and business strategy into measurable variables with clear dimensions and objective quantitative indicators (Brooke, 1996; Zeithaml, 1988).

The MIUE structure comprises two primary independent variables, two cognitive-relational mediating variables, and one economic-impact dependent variable. The independent variables refer to the sociotechnical design stimuli and the engineering components that are directly manipulated by the organization's multidisciplinary development teams. The interface is the software component through which users perform operations.

•The degree of formal visual harmony, balance, neatness, symmetry and sophistication of the outer layer of the GUI (e.g., of a website or an app), which aims to appeal to the visceral level.

According to Tractinsky (2018), the dimensions of design are classical aesthetics, which refers to order, symmetry and geometric neatness, and expressive aesthetics, which encompasses the creativity, originality and dynamism of the visual style.

Functional indicators. Consistency of the color palette associated with the corporate image, typographic legibility according to contrast parameters, the frequency of use of geometric alignment grids, and heat maps derived from primary attentional fixations in eye-tracking tests.

• Usability in the sense that characterizes objects.

Conceptual Definition: The actual and objective capacity of the interactive system to enable users to perform their work tasks effectively and efficiently, a capacity determined by the logical structural robustness of the software or hardware (Kurosu and Kashimura, 1995).

The effectiveness of the system is related to its completeness, and the effectiveness of the system to effort and speed (ISO, 2018).

According to ISO (2018) and Nielsen (1993), command errors or incorrect input errors cannot be avoided. However, the aim is to mitigate their impact. One of the main objectives is to measure the impact of errors. To this end, the following indicators are used: success in completing operational business tasks, time required to complete the logical business flow, and a strict count of command errors or incorrect inputs (made by the operator during the session).

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Mediating variables are the psychophysical constructs and psychological biases that are activated at an intermediate level in the subject's brain during the processing of the independent stimuli, and that transfer their effect to the organizational outcome.

• Mediating variable 1 (M1): Apparent usability (the cognitive buffer).

Conceptual Definition: refers to the immediate and predictive idea or judgment that users form about how easy, intuitive and pleasant they will find the system to use, a judgment that will be strongly conditioned by primary visual attraction.

It refers to the design given to the product so that we, as humans, can recognize it quickly.

The operational indicators are the user's persistence index in the face of minor logical failures, the causal attribution of the error (users blame themselves rather than the system), and the initial subjective usability scores obtained on standardized, rapid-response psychometric scales.

• Mediating variable 2 (m2): Value perceived by the consumer (c)

Technology valuation can be defined as the analysis that the consumer and/or human capital makes of the technology's net utility. It is their weighing of the benefits they have received against what they have had to sacrifice.

Dimensions: Total perceived benefits (functional, hedonic and reflective) and Total perceived sacrifices (monetary, temporal and mental fatigue).

Operational indicators: global scores on the UMUX (Metric for Usability Scale), levels of technostress assessed using psychometric cognitive ergonomics questionnaires, and self-reported psychological comfort resulting from repetitive use.

As a strategic objective, the organization seeks to maximize the dependent variable, the indicator of macroeconomic outcomes and business performance that will enable its competitive success. (Porter, 1985)

• Y: Business sustainability

The firm's capacity to sustain and enhance a profitable competitive advantage by defending its market share and efficiently managing its operational financial resources (Porter, 1985).

Dimensions: internal operational sustainability (cost efficiency) and external commercial resilience (market traction and value retention).

• Utilization performance.

It is not possible to provide the result you require. However, I can offer you my own original development, based on the information you have provided. I need you to accept these terms in order to begin.

External resilience metrics: an increase in the conversion rate on digital platforms and a reduction in the user abandonment rate (churn rate), the capture of premium price margins (price premium), and a net reduction in Customer Acquisition Cost (CAC) relative to the increase in Customer Lifetime Value (LTV).

The analytical definition and operationalization of these variables mean that the integrative usability–aesthetics model does not remain at the level of abstract judgments but instead becomes an exact science oriented toward quantitative evidence. This evidence is incorporated into executive control panels (dashboards) that can withstand the test of profitability and resilience in the digital economy.

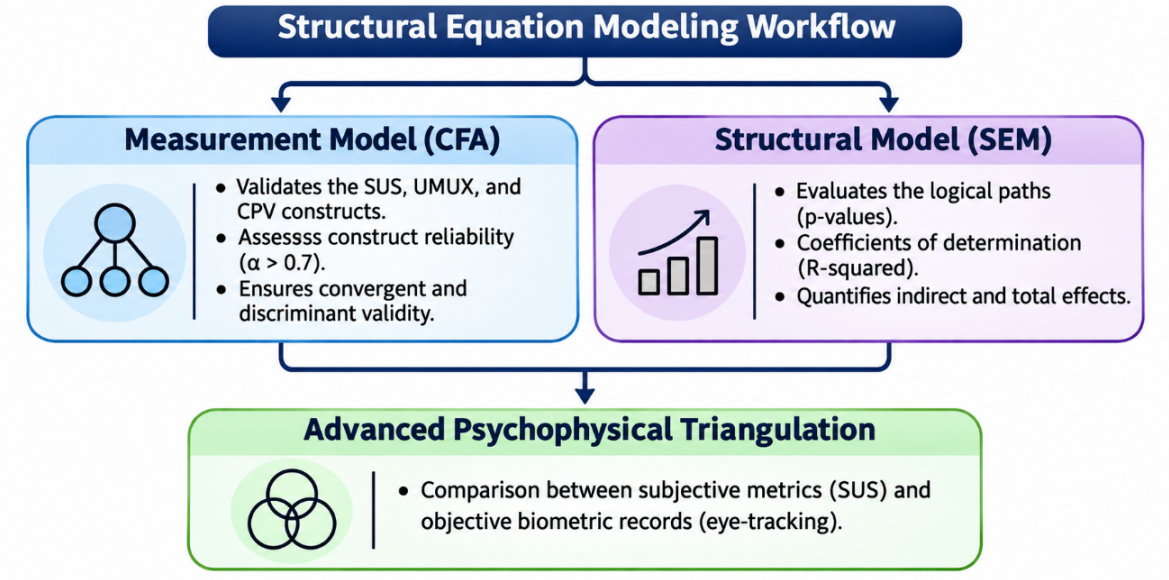
8.3. EMPIRICAL VERIFICATION PATHWAYS AND HYPOTHESIS COHERENCE

Establishing the scientific validity of the network of logical relationships that make up the Usability-Aesthetics Integrative Model (MIUE) requires standardized methodological pathways for its empirical verification. Using multivariate statistical models and methodological triangulation techniques, these pathways will make it possible to test the coherence of the research hypotheses.

The aim is to provide conclusive evidence demonstrating how the properties of the graphical user interface (GUI) mitigate cognitive load and translate predictably into financial sustainability for the business.

The dominant and methodologically appropriate statistical technique for verifying the coherence of the hypotheses proposed in the MIUE is *Structural Equation Modeling* (SEM), in either its covariance-based (CB-SEM) or partial least squares (PLS-SEM) form. SEM allows researchers to simultaneously assess a complex network of linear mediation relationships while controlling for measurement error in the latent variables.

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The analytical verification pathway is carried out in two mandatory stages:

- The first stage of hypothesis testing is to verify that the indicators and psychometric scales used (SUS, UMUX, Perceived Value Surveys) rigorously measure the dimensions or constructs to be assessed. Confirmatory Factor Analysis (CFA) is used for this purpose. Construct reliability is assessed using Cronbach's alpha (which must be greater than 0.70) and Composite Reliability (CR). Convergent validity is also examined using Average Variance Extracted (AVE > 0.50), and discriminant validity using the Fornell-Larcker criterion, to ensure that the latent variables do not overlap conceptually.
- Structural Model Evaluation: Once the measurement model has been validated, the path coefficients (≈í‚§), statistical significance values (p-value<0.05) and coefficients of determination (R2) are evaluated. The model's mediation hypothesis will be formally analyzed to test the direct impact of Aesthetics (X1) and Inherent Usability (X2) on Apparent Usability (M1) and Perceived Value (M2), as well as its transmission to Business Sustainability (Y).
- To avoid the self-report biases that are always present in satisfaction questionnaires, the MIUE's empirical verification path requires triangulation of evidence, that is, comparing subjective perception metrics with behavioral records and objective biometrics collected in usability laboratories.
- The relationship between high scores on the System Usability Scale, also known as schaal van usabiliteit (SUS), and a reduction in fixation times (eye tracking) is evaluated. If an interface receives a high subjective score but the eye-tracking data reveal visual dispersion or attentional regressions, the empirical approach warns of an aesthetic trap.
- Analysing the Think-Aloud Protocol, together with strict recording of Command Error Rates and Task Completion Times, allows Task Load to be contrasted with Logical Efficiency. This ensures the consistency of the internal usability applied at the lower planes of Garrett (2011).
- Empirical validation of the model's consistency is most critical when boundary conditions are assessed under low-level failures. The MIUE experimental study proposes that the buffering effect of Apparent Usability (M1), underpinned by dopaminergic positive affect, is statistically significant only in the presence of minor errors or transient system friction.
- When the experimental trial introduces catastrophic failures or extended interactions with severe engineering deficiencies (X2 drastically undermining inherent usability), the mediation of surface visual aesthetics (X1) breaks down statistically and loses its capacity to sustain Perceived Value (M2).
- The verification path in a mediation assessment reveals the relationships between the visual design of the company's website and the mediating variable. Thus, from this boundary onward, statistically evident relationships emerge, confirming that visual design neither isolates nor disguises faulty programming. Instead, it serves as an ergonomic and emotional catalyst that enhances the adoption of logically grounded digital architectures.
- For CEOs, this methodological rigor turns all user experience spending into a predictive and audited process. Every change to the graphical interface should translate directly into

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safeguarding the company's labor productivity and sustainable competitive advantage.

CONCLUSIONS

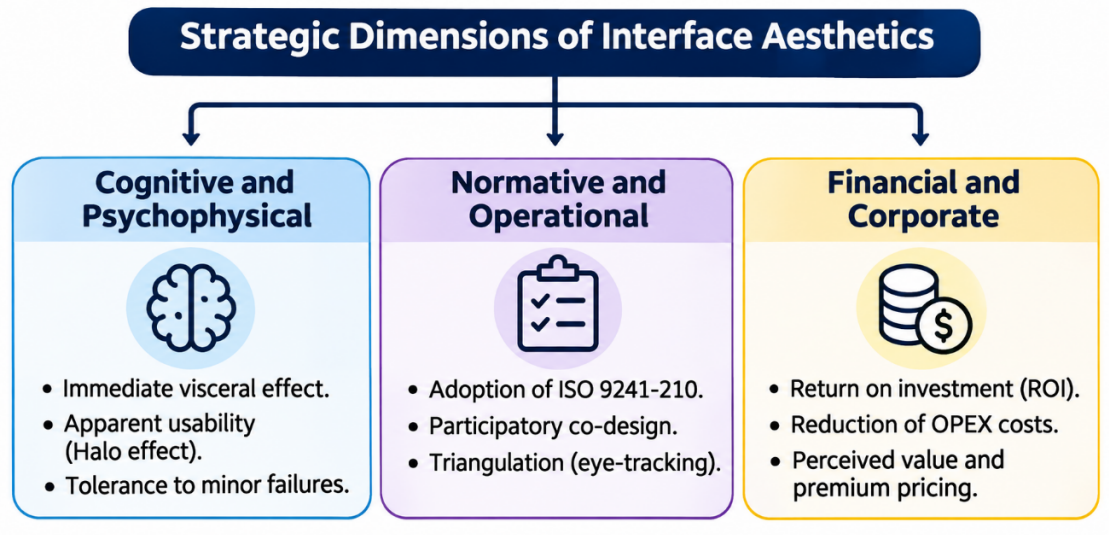
The research analyzed the convergence of the usability of interactive systems and the aesthetics of interfaces The development of corporate interactive systems: Usability of interactive systems and aesthetics of interfaces, designing a governance framework that keeps aesthetics from turning into cosmetics.

We use them for fun, to get organized, and to have hundreds of experiences that were only a fantasy a few decades ago. However, this is such a new phenomenon that the case of interface design studies in the functioning of interactive systems cannot be assured.

The development and analysis of the Usability-Aesthetics Integrative Model (MIUE) made it possible to unify the psychophysical principles of Human-Computer Interaction (HCI) with classical theories of competitive advantage. The result gives senior management a theoretical-analytical framework oriented toward quantitative evidence.

The main conclusions of the research address these three dimensions.

- The test demonstrates that the hue of the object in question triggers a change in the user's emotional processing, and that the overall image also produces an alerting effect in which the perceived color intensity does not remain static but varies. Because the Aesthetic-Usability Effect is activated rapidly, it generates a buffering of cognitive tolerance through a reinforcement of apparent usability (M1). A positive neurochemical state allows the operator to broaden their attentional focus, showing flexibility and persistence in the face of technical problems or minor tasks.
- The structural boundary condition refers to one of the aspects defined by this model. An interface perceived as visually sophisticated may offer aesthetic benefits, to the point of maximizing acceptance and minimizing the subjective impact of delays or transient failures. However, this effect breaks down statistically in the face of catastrophic system failures or critical engineering defects that compromise and severely affect the usability of its inherent system (X2). We can therefore dispel the notion that the visual factor can permanently mask or substitute for deficient programming or a disorganized information architecture. Surface aesthetics are interdependent with the structural soundness of the planes at Garrett's lower levels.
- The MIUE formally adopts the ISO 9241-210 standard (Human-Centered Design) and is operationalized. From a business perspective, impacting macroeconomic performance and remaining sustainable translates into an outstanding ROI (in UX). Ergonomic suitability concretely eliminates the non-monetary sacrifices of human capital (learning curves, cognitive fatigue and technostress), directly reducing operating expenses (OPEX) and drastically decreasing the number of incidents referred to technical support. At the same time, it increases hedonic benefits and Customer Perceived Value (CPV). This enables technology organizations to capture premium prices and build loyalty among highly profitable market niches in hypersaturated global economies.



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FUTURE RESEARCH DIRECTIONS

Despite the rigor with which the constructs of the Integrative Usability-Aesthetics Model have been operationalized and verified, the pace at which sociotechnical ecosystems change and the emergence of new interaction paradigms open up critical avenues for future scientific inquiry.

According to the developers and creators of the Zero UI concept, when we interact with the computer through gestures, by voice, or in the way our machine will soon interact with us, there should be no computer as such. Just as we would say of a physician or an architect, the aesthetic standard is defined by considering it in the real, operative context of that type of interaction with machines. Future research will be driven to address human heuristics and affects in response to symmetry and order in the fluidity of conversational AI dialogues, to determine whether the aesthetic-usability effect is replicated at the auditory, syntactic, or relational level.

Interactional aesthetics built around the augmented, mixed or virtual reality environment. The importance of nonverbal communication and of how geolocation permeates interaction with interfaces. It is imperative to develop empirical methodologies and structural factor models that measure the effect of 3D balance, rendering power, global illumination and occlusion, as well as deep cognitive load, visual discomfort (cybersickness) and work efficiency in digital twins and virtual enterprise control rooms.

Encrypted Communicational Encapsulation of Dark Social for Social Change. In the context of contemporary ethical transformations and users' growing resistance to commercial data-surveillance models, a priority line of research emerges concerning Dark Social flows (private and encrypted communication channels). This line examines how the design and usability of interfaces that explicitly incorporate end-to-end cryptography and decentralized open-source protocols influence the perception of security, trust and reflective value among vulnerable groups and social change organizations. It thus seeks to determine whether elegance and simplicity in the visualization of complex cryptographic keys contribute to the mass adoption of secure communication tools.

Neurological Design and Real-Time Automated Biometrics: Although this work highlights classical psychophysical triangulation (administration of standardized SUS/UMUX questionnaires + fixed eye-tracking), future lines of research should move toward developing computational neurological design systems. Portable electroencephalography (EEG), galvanic skin response (GSR) sensors, and real-time facial micro-expression recognition algorithms will enable the automation of the iterative operational loop of the DCU (Unmanned Combat Drone). This will allow systems to dynamically modify the graphic density, contrast, and composition of the graphical user interface skeleton according to the worker's instantaneous levels of mental workload and stress.

Implementing these lines of research will enable the disciplines of interface design and usability engineering to remain cutting-edge and predictive. In other words, their approaches will allow them to guide the organizational actors of the future toward developing technologies that protect the dignity, cognitive comfort and productivity of human beings and, in parallel, toward the resilience and profitability of the corporation in the new knowledge economy.

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REFERENCIAS

Admin. (2024). La Evolución del Hardware y Software: Un Vistazo a las Últimas Tendencias. OR Design. https://or-design.org/la-evolucion-del-hardware-y-software-un-vistazo-a-las-ultimas-tendencias/
alekvs.com. (2025). ¿Qué es la norma ISO 9241? Una guía completa sobre estándares de HCI y usabilidad. ALEKVS. https://www.alekvs.com/es/what-is-iso-9241-a-complete-guide-to-hci-and-usability-standards/
Arimetrics. (s.f.). Qué es Software - Definición, tipos y ejemplos de Software. https://www.arimetrics.com/glosario-digital/software
Base, B. (2021). Importancia de la tecnología para el comercio exterior. Blog Banco Base. https://blog.bancobase.com/importancia-de-la-tecnologia-para-el-comercio-exterior
Canal, P. (2023). ¿Qué es el diseño centrado en el usuario? Thinking for Innovation - IEBSchool. https://www.iebschool.com/hub/diseno-centrado-en-el-usuario-analitica-usabilidad/
De Redacción de la Universidad Internacional de La Rioja. (2023). El valor percibido por el cliente sobre un producto, ¿se puede cambiar? UNIR. https://www.unir.net/revista/marketing-comunicacion/valor-percibido-cliente/
De Redacción de la Universidad Internacional de La Rioja. (2026). ¿Qué es el hardware y para qué sirve? UNIR. https://www.unir.net/revista/ingenieria/que-es-hardware/
Edu Salado. (2024). Mejor ecosistema digital: Apple vs Google vs Microsoft [Video]. YouTube. https://www.youtube.com/watch?v=6eMYD1VejiA
Ermete, S. (2024). La usabilidad, el factor diferenciador en las nuevas tecnologías. CyberPlan. https://www.cyberplan.it/es/la-utilizabilidad-el-factor-diferenciante-en-nuevas-tecnologias/
Escalante, J. R. (2021). La estética, usabilidad y los reportes. Sentido Analítica. https://sentidoanalitica.com/experiencia-de-usuario/estetica-usabilidad-reportes
García, M. (2026). Innovación tecnológica: qué es, sus tipos y sus beneficios. Maestrías y Diplomados - Tec. https://blog.maestriasydiplomados.tec.mx/innovacion-tecnologica-que-es-sus-tipos-y-sus-beneficios
GeeksforGeeks. (2025). Evolution of Software Development | History, phases and future trends. https://www.geeksforgeeks.org/software-engineering/evolution-of-software-development-history-phases-and-future-trends/
Giménez, A. (2020). Relación entre estética y usabilidad. Aunitz. https://www.aunitz.net/relacion-estetica-usabilidad/
Google Design. (s.f.). Material Design: Secrets & Stories behind Google's UI. Google Design. https://design.google/m10
Grigoryan, S. (2024). Emotional Design Examples: How to enhance your product UI/UX design. Userpilot Blog. https://userpilot.com/blog/emotional-design-examples
GUI: qué es una interfaz gráfica de usuario. (2021). IONOS Digital Guide. https://www.ionos.mx/digitalguide/paginas-web/desarrollo-web/que-es-una-gui/
Intecat. (2024). El Primer iPhone y su impacto en la historia de la tecnología. INTECAT Apple Premium Partner. https://www.intecat.com/apps/blog/el-primer-iphone-y-su-impacto-en-la-historia-de-la-tecnologia
Interaction Design Foundation. (2026). What is Material Design? The Interaction Design Foundation. https://ixdf.org/literature/topics/material-design
Jvarela. (2025). Microsoft, medio siglo del gigante del software. RACE. https://www.race.es/revista-autoclub/estilo/historia/microsoft-medio-siglo-del-gigante-del-software/
K R Pavan Tej. (2025). The Evolution of Windows: From Windows 1.0 to Windows 11's Modern UI Transformation. LinkedIn. https://www.linkedin.com/pulse/evolution-windows-from-10-11s-modern-ui-k-r-pavantej-lyclc
LA EVOLUCIÓN DEL HARDWARE y SOFTWARE. (2019). Sutori. https://www.sutori.com/es/historia/la-evolucion-del-hardware-y-software--H924gKiKFxurrWZgwDXfreYV
Lomener, G. (2024). Despidos masivos y una jugada maestra: cuando Apple parecía condenada, Steve Jobs tomó las riendas y cambió la historia en solo 90 días. Applesfera. https://www.applesfera.com/curiosidades/despidos-masivos-jugada-maestra-cuando-apple-parecia-condenada-steve-jobs-tomo-riendas-cambio-historia-solo-90-dias
Luján, L. (2026). *ISO 9241-210: Diseño centrado en el usuario*. Aacademica. https://www.aacademica.org/leandro.lujan/2
Marciante, M. (2024). The Evolution of Apple's Design Philosophy Over the Years. Mission Leather Co. https://missionleatherco.com/blogs/news/the-evolution-of-apple-s-design-philosophy-over-the-years
Martínez, M. S., Martínez, D. I., Filoniuk, V. R., Chiappori, G. G., Diz, A. C., & Arias, S. E. (2022). Aplicación de Norma ISO 9241-11 para la Evaluación de la Usabilidad en Simuladores de Vuelo. Innovación y Software, *3*(2), 70-80. https://www.redalyc.org/journal/6738/673870841005/html/
Martinez, A. (2022). Competencia monopolística: Diferenciación de producto. Policonomics. https://policonomics.com/es/lp-competencia-monopolistica-diferenciacion-producto/
Microsoft Research. (2016). Metro Design Principles. Microsoft Research. https://www.microsoft.com/en-us/research/video/metro-design-principles/
Moran, K. (2024). The Aesthetic-Usability Effect. Nielsen Norman Group. https://www.nngroup.com/articles/aesthetic-usability-effect/
Murillo, A. (2024). Microsoft vs. Apple: batalla de titanes. ITD Consulting. https://itdconsulting.com/noticias/microsoft-vs-apple-la-carrera-por-la-supremacia-empresarial-en-el-mundo-tecnologico/
Patel, P. (2024). The Evolution and Impact of Graphical User Interfaces (GUIs). Medium. https://medium.com/@learning3601/in-the-vast-landscape-of-digital-interaction-the-graphical-user-interface-gui-stands-as-

the-3c0b8dcca51c
Pilapil, L. (2026). The Aesthetic-Usability Effect: Why Good-Looking Designs Feel Easier to Use. Pixelmojo. https://www.pixelmojo.io/blogs/the-aesthetic-usability-effect-why-good-looking-designs-feel-easier-to-use
Reviriego, J. F. (2025). La estética en el diseño industrial: ¿por qué empieza a importar también en entornos B2B? Blog SEAS. https://www.seas.es/blog/diseno-mecanico/la-estetica-en-el-diseno-industrial-por-que-empieza-a-importar-tambien-en-entornos-b2b/
Salado, E. (2024). Apple vs Google vs Microsoft ¿qué Ecosistema Digital elegir? Befocusy. https://befocusy.com/apple-vs-google-vs-microsoft-ecosistema-digital/
Shi, A., Huo, F., & Hou, G. (2021). Effects of design aesthetics on the perceived value of a product. Frontiers in Psychology, *12*, 670800. https://doi.org/10.3389/fpsyg.2021.670800
SHIFTA. (2025). Historia del Diseño: Un viaje a través del tiempo y la creatividad. SHIFTA by Elisava. https://weareshifta.com/historia-del-diseno/
Simó, L. P., Díaz, P. G., Busquets, A. P. I., & Simó, L. P. (2024). Usabilidad: ¿qué es y cuáles son sus principios? Tecnología++ - UOC. https://blogs.uoc.edu/informatica/es/usabilidad-que-es-y-cuales-son-sus-principios/
Supfab. (2025). *ISO 9241-11 Definición de usabilidad*. Innovación.mundo. https://innovation.world/es/invention/iso-9241-11-usabilidad/
Telefónica. (2024). 6 emprendedores tecnológicos que cambiaron la historia reciente. Telefónica. https://www.telefonica.com/es/sala-comunicacion/blog/6-emprendedores-tecnologicos-cambiaron-historia-reciente/
Usercentereddesign: cómo aplicar el diseño centrado en el usuario. (2022). IONOS Digital Guide. https://www.ionos.mx/digitalguide/paginas-web/desarrollo-web/user-centered-design/
Villegas, E. (2025). La experiencia de usuario (UX) como ventaja competitiva. Zibor Desarrolladores. https://www.zibor.co/la-experiencia-de-usuario-ux-como-ventaja-competitiva/
Webmaster. (2023). ISO 9241 y la usabilidad. Cognitios - Diseño y Tecnología. https://www.cognitios.co/blog/usabilidad-con-iso-9241/
Yablonski, J. (s.f.). Efecto de Estética-Usabilidad. Laws of UX. https://lawsofux.com/es/efecto-de-est%C3%A9tica-usabilidad/