Chapter 1 / Capítulo 1

Sustainable balance between usability and aesthetics in hardware and software design within the organizational context
ISBN: 978-9915-9966-9-1
DOI: 10.62486/978-9915-9966-9-1.Ch01
Pages: 1-8

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Introduction and contextualization of the object of study

Introducción y contextualización del objeto de estudio.

Yennifer Díaz Romero[1]
Melissa Edith Salazar Echeagaray[1]
Víctor Manuel Martínez García[1]
Gonzalo Javier Llamas Rios[1]
Manuel Iván Tostado Ramírez[1]
Jesús Alejandro Vázquez Meza[1]
Rogelio Estrada Lizárraga[1]

1 Universidad Autónoma de Sinaloa, Vicerrectoría. Mazatlán, México.

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

https://doi.org/10.62486/978-9915-9966-9-1.Ch01

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

https://doi.org/10.62486/978-9915-9966-9-1.Ch01

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

https://doi.org/10.62486/978-9915-9966-9-1.Ch01

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).

https://doi.org/10.62486/978-9915-9966-9-1.Ch01

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

https://doi.org/10.62486/978-9915-9966-9-1.Ch01

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.

https://doi.org/10.62486/978-9915-9966-9-1.Ch01