Chapter 3 / Capítulo 3

Sustainable balance between usability and aesthetics in hardware and software design within the organizational context
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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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