Chapter 5 / Capítulo 5

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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.Ch05
Pages: 28-36

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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).

https://doi.org/10.62486/978-9915-9966-9-1.Ch05

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.

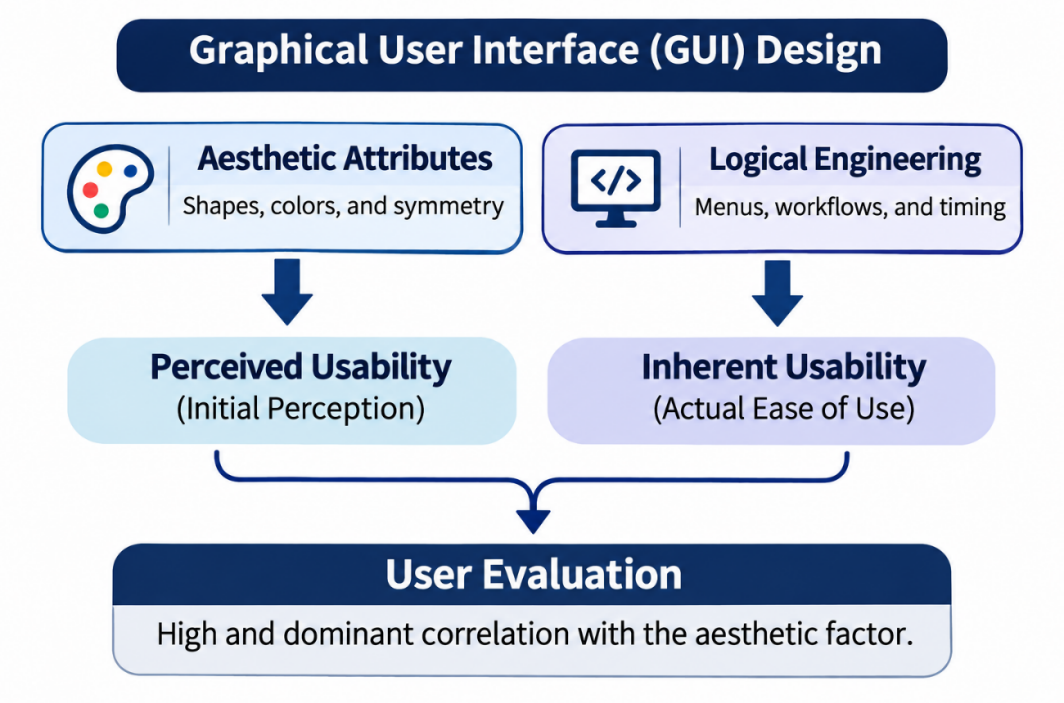
The alterations focused exclusively on the systematic manipulation of the visual and design properties of the Graphical User Interface (GUI) and modified the following formal analytical categories:

- 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.

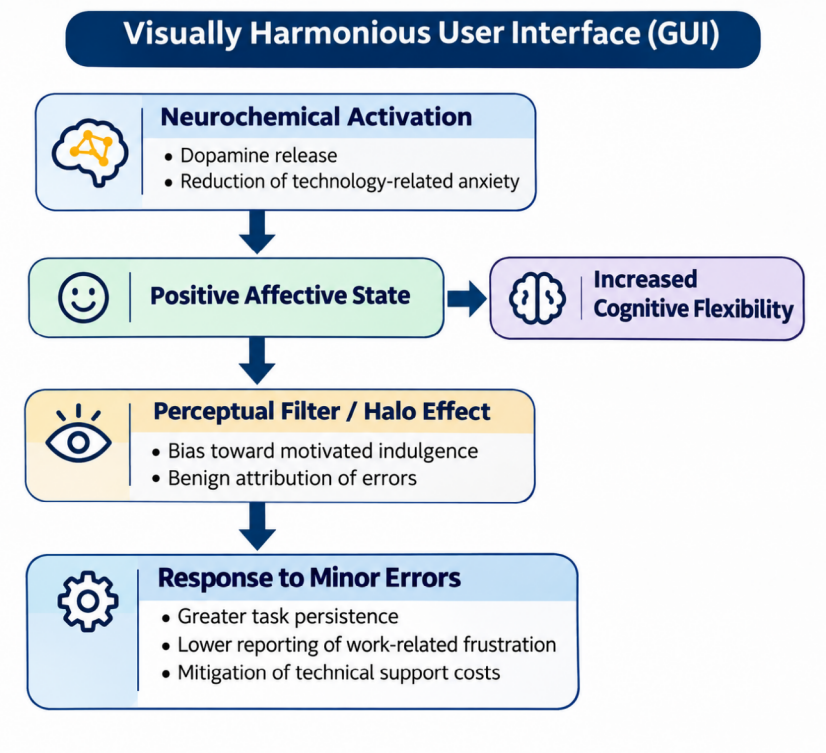
Consequently, a slight delay in data processing or an ambiguous navigation menu in corporate software would lead the operator with greater cognitive flexibility to persist voluntarily with the task, find alternative interaction paths and resolve the problem autonomously, interpreting the anomaly as minor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

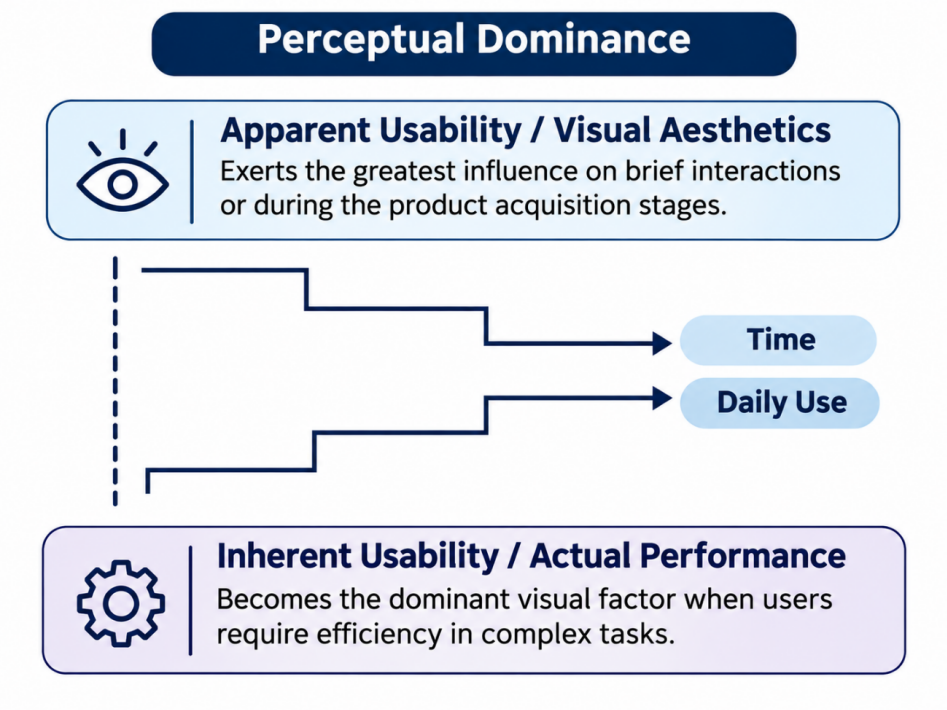
5.4. BOUNDARIES AND LIMITATIONS OF THE AESTHETIC-USABILITY EFFECT

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

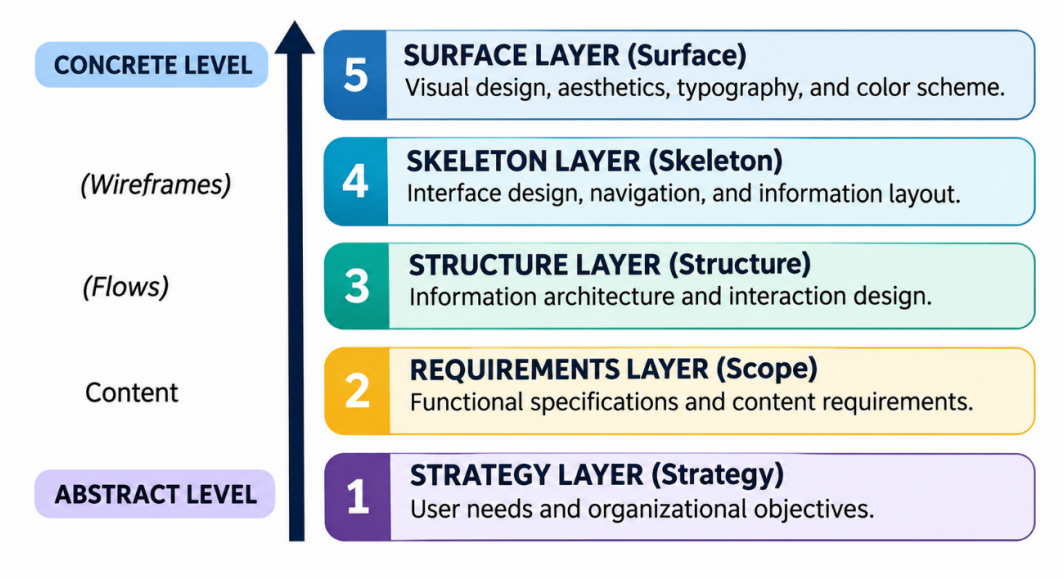
For functional usability and the visual aesthetic standard to be integrated systematically, it is very important that organizations have methodological architecture frameworks to work

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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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