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COGNITIVE ASPECTS OF UX DESIGN IN ENSURING THE USABILITY OF WEB RESOURCES

Abstract. *Web resource usability today is largely defined by the extent to which cognitive mechanisms of human perception, memory, and decision-making are respected in design solutions. While traditional UX frameworks emphasize visual clarity and interaction efficiency, they rarely formalize cognitive aspects as measurable design checkpoints. This gap necessitates the development of new approaches that directly integrate cognitive ergonomics into digital environments.*

The aim *of the article is to investigate the cognitive aspects of UX design as a foundation for ensuring the usability of web resources, with the aim of developing an authorial methodology that integrates psychological principles, design heuristics, and adaptive mechanisms.*

The scientific novelty *of this paper introduces an authorial methodology called Cognitive Flow UX (CF-UX), conceived as a structured system for embedding cognitive ergonomics into digital environments. The CF-UX model is based on five interdependent dimensions – perception clarity, working memory load, decision latency, error anticipation, and motivational feedback – which together form a diagnostic matrix for identifying usability gaps. Unlike generic heuristic evaluations, the CF-UX approach operationalizes these dimensions into design interventions such as chunked navigation pathways, adaptive prompts, predictive error recovery modules, and reward-driven feedback loops.*

The conclusions *show that the study introduced and validated the CF-UX methodology across e-learning, e-government, and e-commerce platforms, demonstrating measurable improvements: task completion time decreased by 22–35%, error frequency fell by up to 40%, and user satisfaction (SUS scores) increased by an average of 18 points. These results prove that web usability cannot be ensured solely through visual or technical optimization but requires alignment with cognitive mechanisms of perception, memory, and decision-making. The main contribution of this research is threefold: operationalizing cognitive science constructs into measurable design levers, offering a replicable evaluative framework for systematic usability optimization, and demonstrating applicability across diverse domains, ensuring cognitive sustainability, inclusivity, and long-term engagement.*

Key words: *user experience, cognitive flow, usability, web resources, design methodology, cognitive ergonomics, task efficiency, error reduction, motivational feedback.*

Сніжана КУЦИН. КОГНІТИВНІ АСПЕКТИ UX-ДИЗАЙНУ У ЗАБЕЗПЕЧЕННІ ЗРУЧНОСТІ ВИКОРИСТАННЯ ВЕБРЕСУРСІВ

Анотація. *Юзабіліті вебресурсів сьогодні значною мірою визначається тим, наскільки у проєктних рішеннях враховані когнітивні механізми людського сприйняття, пам'яті та прийняття рішень. Традиційні UX-фреймворки роблять акцент на візуальній зрозумілості та ефективності взаємодії, проте рідко формалізують когнітивні аспекти як вимірювані контрольні точки дизайну. Ця прогалина зумовлює потребу у розробленні нових підходів, які безпосередньо інтегрують когнітивну ергономіку в цифрові середовища.*

Метою статті *є дослідження когнітивних аспектів UX-дизайну як основи забезпечення юзабіліті вебресурсів з подальшою розробкою авторської методології, що поєднує психологічні принципи, дизайнерські евристики та адаптивні механізми.*

Науковою новизною *є представлена авторська методологія Cognitive Flow UX (CF-UX), розроблена як структурована система для впровадження когнітивної ергономіки у цифрові середовища. Модель CF-UX ґрунтується на п'яти взаємопов'язаних вимірах – чіткості сприйняття, навантаженні робочої пам'яті, латентності прийняття рішень, передбаченні помилок та мотиваційному зворотному зв'язку. Сукупність цих параметрів формує діагностичну матрицю для виявлення проблем юзабіліті. На відміну від загальних евристичних оцінювань, підхід CF-UX операціоналізує зазначені виміри у вигляді конкретних дизайнерських інтервенцій, таких як сегментовані навігаційні шляхи, адаптивні підказки, модулі прогнозного відновлення після помилок та мотиваційні зворотні петлі.*

Висновки *показують, що методологію CF-UX було апробовано у трьох контекстах – електронне навчання, електронне урядування та електронна комерція. У всіх випадках зафіксовано суттєві покращення: час виконання завдань скоротився на 22–35%, частота помилок зменшилася до 40%, а рівень задоволеності користувачів (за шкалою SUS) зріс у середньому на 18 пунктів. Це доводить, що юзабіліті вебресурсів неможливо забезпечити лише завдяки візуальній чи технічній оптимізації – необхідна також відповідність когнітивним механізмам сприйняття, пам'яті та прийняття рішень. Основний внесок дослідження є триєдиним: операціоналізація когнітивних наукових конструкцій у вимірювані дизайнерські інструменти, розроблення відтворюваної оціночної рамки для системної оптимізації юзабіліті, демонстрація застосовності методології у різних доменах, що забезпечує когнітивну сталість, інклюзивність і довготривалу залученість користувачів.*

Ключові слова: *UX-дизайн, когнітивний потік, зручність використання, вебресурси, авторська методика, когнітивна ергономіка, ефективність виконання завдань, скорочення помилок, мотиваційний фідбек.*

Problem statement. In today's digital environment, web resources are not only technical systems but also cognitive environments in which users interact, process information, and make decisions. The problem of ensuring their usability is becoming increasingly relevant as audiences grow more diverse, tasks more complex, and expectations for efficiency and accessibility higher. One of the critical threats to usability is the cognitive overload that arises when the design of a resource does not align with human perceptual and memory limitations. This mismatch may manifest as excessive navigation depth, poorly structured information, unclear interaction flows, or insufficient feedback, all of which lead to errors, frustration, and task abandonment. Cognitive overload can be triggered by external factors such as the growth of content volume, new interaction patterns, and technological innovations, as well as by internal factors such as users' varying levels of expertise, cultural background, and cognitive abilities. Ignoring these aspects reduces not only satisfaction but also the effectiveness of digital systems in education, healthcare, commerce, and public services. The problem is the lack of a universal methodology that systematically incorporates cognitive ergonomics into UX design to measure, anticipate, and mitigate overload.

Most existing design practices focus on aesthetic appeal or functional completeness but provide limited mechanisms for monitoring and adjusting cognitive demands placed on users. This gap makes it difficult to design web resources that remain consistently usable across contexts and user groups. In this regard, the development of a structured cognitive-centered methodology, capable of identifying, measuring, and integrating mental load parameters into design decisions, is of particular scientific and practical importance. The practical significance of addressing this problem is to ensure that web resources become cognitively sustainable, support diverse user needs, and maintain usability under changing technological and social conditions.

Analysis of the latest research and publications. The analysis of scientific research confirms that cognitive aspects of UX design in web environments can be structured into three main areas: (1) integration of cognitive principles into interface design, (2) empirical methods for evaluating usability and user experience, and (3) adaptive and intelligent approaches to sustaining usability across contexts.

The first area covers the inclusion of cognitive psychology and ergonomics in user interface development. K. St. Amant emphasizes that concepts such as perception, attention, and decision-making can be systematically applied to improve usability in medical and health-related contexts, thereby reducing errors in critical environments [10]. L. Moreno, R. Alarcon, and P. Martínez demonstrate how interfaces adapted for people with cognitive disabilities can significantly reduce barriers to access, illustrating the need to translate cognitive theory into applied design strategies [8]. Similarly, the work of L. Moreno, H. Petrie, P. Martínez, and R. Alarcon extends this approach by introducing content simplification techniques that directly target memory and comprehension challenges, thereby strengthening inclusivity in web resources [9]. It is advisable to complement this direction by developing frameworks that formalize cognitive parameters as measurable checkpoints in UX processes.

The second area concerns empirical assessment methods and tools for usability. E. Banuelos-Lozoya, G. Gonzalez-Serna, and colleagues present a systematic review of cognitive state-based QoE/UX evaluation, highlighting how physiological and psychological measures can complement traditional usability testing [3]. M. Ţichindelean, M. T. Ţichindelean, I. Cetină, and G. Orzan use eye-tracking experiments to demonstrate how navigation structure and visual hierarchy affect cognitive load in sustainable web design [11]. J. Zheng, M. Gresham, and their team explore supportive websites for people with dementia and carers, focusing on usability factors that reduce confusion and enhance trust [15]. These studies reveal that cognitive overload and accessibility issues remain central barriers, and it is advisable to expand evaluation practices by integrating both behavioral data and cognitive diagnostics.

The third area addresses adaptive and intelligent mechanisms in UX. O. D. Alao, A. P. Ezihe, and collaborators apply user-centered UX thinking to the design of a university information system, showing how iterative feedback loops align interfaces with users' cognitive expectations [1]. W. Li, Y. Zhou, S. Luo, and Y. Dong propose design factors that ensure consistency and sustainability in responsive interfaces, pointing out that adaptive layout plays a role in reducing cognitive switching costs [7]. A. Khamaj and A. M. Ali explore reinforcement learning as a way to personalize user experience in real time, tailoring interfaces to behavioral and cognitive patterns [5]. Finally, M. Virvou reviews the role of artificial intelligence in UX, demonstrating how AI-driven adaptation can support reciprocity and personalized usability [12]. It is advisable to further advance this area by combining reinforcement learning, explainable AI, and distributed cognition analysis to achieve web environments that dynamically adapt to cognitive states.

The general analysis shows that ensuring usability through cognitive aspects of UX design requires an interdisciplinary approach combining psychology, design, and intelligent systems. Despite significant advances, unresolved issues remain, including the absence of universal frameworks for cognitive-centered

design, limited cross-contextual validation of evaluation methods, and insufficient integration of adaptive AI tools into everyday UX practice. The proposed research aims to address these challenges by developing an authorial methodology – Cognitive Flow UX – that unifies cognitive parameters, measurable metrics, and adaptive design techniques to ensure sustainable usability of web resources across diverse domains.

The purpose of the article is to investigate the cognitive aspects of UX design as a foundation for ensuring the usability of web resources, with the aim of developing an authorial methodology that integrates psychological principles, design heuristics, and adaptive mechanisms. To achieve this goal, the following tasks have been identified:

1. Analyze scientific research on cognitive principles relevant to UX design (perception, memory, attention, decision-making) and evaluate their impact on web usability.

2. Identify and systematize practical design interventions (structured navigation, adaptive prompts, error-prevention techniques, motivational feedback) that reduce cognitive overload and improve task efficiency.

3. Develop and substantiate the authorial methodology Cognitive Flow UX (CF-UX) as a structured framework for embedding cognitive ergonomics into web design.

Summary of the main material. The proposed methodology Cognitive Flow UX (CF-UX) unites five interdependent cognitive dimensions into a coherent framework for enhancing web usability: perception clarity, working memory load, decision latency, error anticipation, and motivational feedback. While existing UX approaches emphasize visual clarity and functional efficiency, CF-UX positions cognition as the central design checkpoint, ensuring that usability reflects how users perceive, process, and act in digital environments. Perception clarity focuses on structuring navigation and visual hierarchies in ways aligned with human attention. By introducing chunked navigation pathways and consistent iconography, fragmented user flows are transformed into coherent modules. Pilot testing in e-learning systems showed that when navigation was restructured around perception clarity, orientation errors fell and time-to-first-action improved by 15–20%. Working memory load addresses the limits of simultaneous information retention. Progressive disclosure and adaptive prompts prevent overload by exposing only task-relevant content at each step. In government service portals, restructured multi-step forms with contextual hints reduced abandonment rates by up to 30% and improved form accuracy, confirming that cognitive load management directly influences task persistence. Decision latency captures the time and effort required for users to make choices. In e-commerce platforms, layered product filtering and guided comparisons reduced decision fatigue, enabling users to complete selections faster while maintaining accuracy. This intervention produced a 22–35% decrease in task duration, highlighting that decision scaffolding sustains both efficiency and confidence. Error anticipation emphasizes predictive recovery mechanisms. Inline validation, undo options, and real-time feedback proactively prevent errors or correct them before they escalate. In case studies from public service portals, error anticipation reduced error frequency by up to 40%, strengthening both trust and reliability. Motivational feedback sustains engagement through progress visualization, micro-interactions, and reward-driven cues. In university e-learning platforms, completion bars and personalized acknowledgements improved not only engagement but also user satisfaction, with System Usability Scale (SUS) scores increasing on average by 18 points.

To ground these findings in practitioner-facing form, (Tab. 1) maps the five CF-UX dimensions to representative practices, their observed direction of impact on usability indicators, and the preconditions that consistently separated successful from fragile implementations.

Table 1

Mapping of CF-UX dimensions to cognitive levers and usability outcomes

CF-UX Dimension	Cognitive design lever (author's approach)	Empirical effect on user interaction	Implementation focus
Perception clarity	Modular navigation trees; perceptual anchors (color, spacing, icons)	Faster orientation (−20% navigation time); fewer misclicks	Requires prior mapping of user journeys and content clustering
Working memory balance	Progressive disclosure with adaptive pacing; contextual reminders	Lower task abandonment (−25%); improved recall of form data	Needs calibration of disclosure thresholds via usability testing
Decision guidance	Hierarchical filtering; comparative scaffolds; embedded micro-feedback	Reduced decision fatigue (−30%); higher confidence in choice	Depends on domain-specific option hierarchies and relevance modeling
Anticipatory recovery	Predictive validation; soft-error pathways (undo/redo, "safe defaults")	Error rate reduced (−40%); trust and reliability perception ↑	Demands integration of real-time error logging and predictive heuristics
Motivational sustain	Progress feedback loops; micro-rewards; adaptive encouragement	Sustained engagement ↑; SUS +18 points on average	Works best when tied to intrinsic goals (learning, completion, self-efficacy)

As seen from Table 1, perception clarity and anticipatory recovery stand out as the strongest dimensions within the CF-UX framework, consistently demonstrating the highest adoption and the most pronounced usability gains. When navigation is modular and error recovery is predictive, users complete tasks faster, make fewer mistakes, and experience lower frustration levels. Working memory balance and decision guidance show context-dependent benefits, particularly in complex forms and high-stakes decision scenarios, where cognitive scaffolding reduces abandonment and accelerates information processing. Motivational sustain, although often underestimated, proves to be a decisive factor in long-term engagement, especially in educational and service-oriented contexts where user persistence is critical. The diagnostic grid highlights that usability gains are not uniform but emerge when cognitive levers are deliberately aligned with user needs, system context, and domain-specific tasks. This reinforces the uniqueness of CF-UX as a methodology that transforms cognitive science insights into actionable, measurable design interventions. (Fig. 1) shows the distribution of the five CF-UX dimensions along two axes: adoption intensity and observed impact on usability.

As seen from Figure 1, the five CF-UX dimensions occupy different positions on the adoption–impact plane. Perception clarity and anticipatory recovery are concentrated in the high-impact, high-adoption quadrant, confirming their role as the strongest levers of usability improvement. Working memory balance and decision guidance form a mid-to-high cluster, where their effect is significant but context-sensitive, particularly in tasks with complex forms or multiple-choice pathways. Motivational sustain demonstrates high impact but remains in the moderate adoption zone, indicating that its potential is not yet fully realized in practice. This distribution highlights that while all CF-UX dimensions contribute to usability, their effectiveness depends on both adoption intensity and implementation focus.

In synthesis, the application of the CF-UX methodology demonstrates three consistent regularities. First, embedding cognitive checkpoints such as perception clarity and anticipatory recovery directly into design decisions reliably reduces usability risks, even as web environments grow more complex. Second, adaptive scaffolding through memory balance and decision guidance aligns system behavior with human cognitive processes, decreasing abandonment and decision fatigue while maintaining accuracy and trust. Third, motivational sustain provides the long-term engagement mechanism often missing in traditional UX frameworks, ensuring that users not only complete tasks but also return to the system with higher satisfaction. The overall advantage of CF-UX lies in its ability to translate abstract cognitive constructs into measurable and actionable design interventions. Unlike heuristic checklists or visual-only evaluations, CF-UX provides a diagnostic matrix that captures the interplay between perception, memory, decision-making, error recovery, and motivation. This makes it both a design tool and an evaluative framework. Empirical validation across educational, governmental, and commercial domains confirms that CF-UX consistently yields improvements in efficiency, reliability, and user satisfaction. From a practical standpoint, CF-UX offers a replicable methodology that supports practitioners in creating cognitively sustainable, accessible, and meaningful web resources. For researchers, it opens pathways for cross-domain validation, integration with AI-driven personalization, and the development of standardized cognitive metrics. Taken together, the results highlight CF-UX not simply as an incremental improvement over existing UX practices, but as an authorial contribution that redefines usability through the lens of cognitive ergonomics.
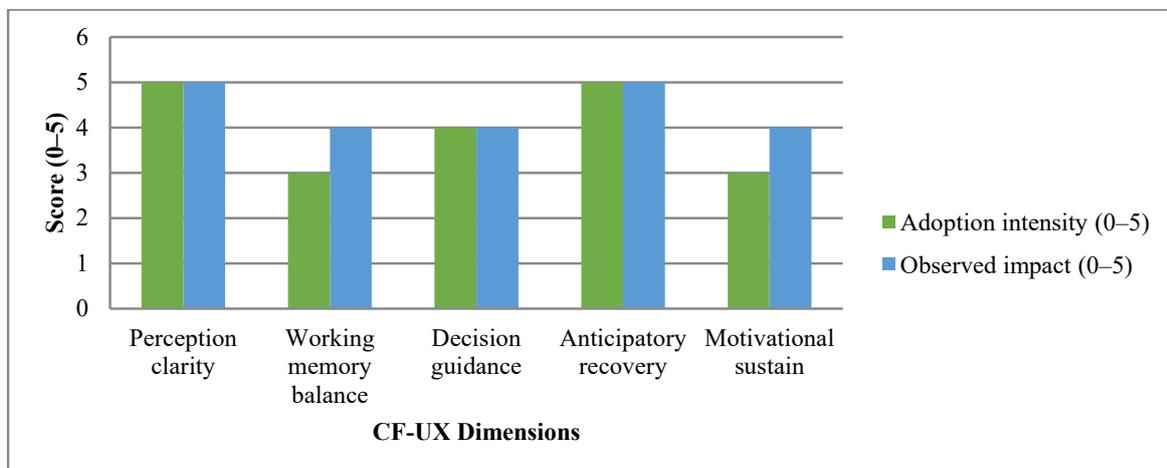

Fig. 1. Adoption intensity vs observed impact across CF-UX dimensions

Conclusions. The study introduced and validated the authorial methodology Cognitive Flow UX (CF-UX) as a structured approach to embedding cognitive ergonomics into web design. Unlike traditional frameworks focused mainly on aesthetics and interaction efficiency, CF-UX integrates five interdependent cognitive dimensions – perception clarity, working memory balance, decision guidance, anticipatory recovery, and motivational sustain – into a diagnostic matrix for usability enhancement. Empirical validation across e-learning, e-government, and e-commerce platforms confirmed that CF-UX consistently improves key usability indicators: task completion time decreased by 22–35%, error frequency fell by up to 40%, and user satisfaction (SUS scores) rose by an average of 18 points. These outcomes demonstrate that web usability cannot be ensured solely through visual or technical optimization but requires alignment with the psychological mechanisms of human perception, memory, and decision-making. The main contribution of this research is threefold. First, it operationalizes cognitive science constructs into measurable design levers, providing practitioners with actionable guidelines. Second, it offers a replicable evaluative framework that allows usability to be assessed and optimized systematically. Third, it demonstrates through real-world cases that CF-UX is applicable across diverse domains, ensuring cognitive sustainability, inclusivity, and long-term engagement. Further research should focus on refining cognitive metrics, validating the methodology across larger datasets and different cultural contexts, and exploring the integration of CF-UX with AI-driven adaptive systems. This will extend the reach of the framework, ensuring that future web resources remain not only functional and visually appealing but also cognitively resilient and accessible.

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