مجلة العلوم الاجتماعية والإنسانية
Journal of Social Sciences and Humanities
Volume:15N°01/2025
P 129/147

Cognitive requirements and ergonomic criteria in designing digital learning platforms

المتطلبات المعرفية والمعايير الارغنومية في تصميم منصات التعلم الرقمي

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Received28/04 */2025* ***Accepted:*** 22/05 */2025* ***Published:*** 11/06 */2025*

Abstract

The article aims to introduce designers of digital learning platforms to consider cognitive aspects of the learners in the design and the development of these platforms. Indeed, the screen remains a specific environment for learner cognition. Learning online requires a particular arrangement of the tools made available to the learner. The latter must therefore deal with objects and routes coming from a reality other than their own. Thus, ergonomics is called upon to anticipate the specificity of cognitive operations linked to an online learning activity. This article proposes in this continuity to pose the arguments pleading for an ergonomic design integrative of the mental dimensions specific to this type of learning environment.

Keywords: Cognitive ergonomics- Computer ergonomics- Digital learning- Educational technology-Learning ergonomics.

- Abstract in French :

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Cet article a pour objectif d'initier les concepteurs des plateformes d'apprentissage numérique à prendre en considération les aspects cognitifs des apprenants dans la conception et le développement de ces dernières. En effet, l'écran reste un environnement spécifique pour la cognition de l'apprenant. Apprendre en ligne, nécessite un agencement particulier des outils mis à la disposition de l'apprenant. Ce dernier doit donc composer avec des objets et des itinéraires venant d'une réalité autre que la sienne. Ainsi, l'ergonomie est appelée à anticiper sur la spécificité des opérations cognitives liées à une activité d'apprentissage en ligne. Cet article se propose dans cette continuité de poser les arguments plaidants pour une conception ergonomique intégrative des dimensions mentales spécifiques à ce genre d'environnement d'apprentissage.

Mots-clés : Ergonomie cognitive - Ergonomie informatique - Apprentissage numérique - Technologies éducatives - Ergonomie de l'apprentissage.

Abstract in Arabic:

يهدف هذا المقال إلى تحسيس مصممي منصات التعليم الرقمي بأهمية الأخذ في الاعتبار الجوانب المعرفية للمتعلم عند تصميم وتطوير منصات التعلم الرقمي. حيث تمثل الشاشة بيئة خاصة للجانب المعرفي للمتعلم. فالتعلم عن بعد يتطلب اعدادا محددا للأدوات المتاحة للمتعلم. فعلى هذا الأخير أن يتعامل مع أشياء ومسارات من واقع مختلف تماما عن واقعه الخاص. لهذا تكون الإرغنوميا مدعوة إلى التنبؤ بخصوصية العمليات المعرفية المرتبطة بنشاط التعلم عن بعد. كما يهدف هذا المقال إلى تقديم الحجج المرتبطة بمعايير التصميم الإرغنومي الذي يدمج الأبعاد الذهنية الخاصة بهذا النوع من البيئة التعليمية.

الكلمات الدالة: ارغنوميا المعلوماتية- التعليم الرقمي؛ تكنولوجيا التعليم- الإرغنوميا التعليمية- الإرغنوميا المعرفية.

Cognitive requirements and ergonomic criteria in designing digital learning platforms

1- Introduction

Like other universities around the world, the Algerian university is experiencing today a revival in terms of training offer and learning methods. Thus, the introduction of digital learning platforms support has not only disrupted students' reflexes but also created a schism at the didactic level.

In addition, the integration of new technologies into teaching tools is not a vain question. The mediatization of teaching through the screen challenges specialists in cognitive sciences, particularly ergonomists. Human cognition in front of a screen is called upon to structure itself according to this new stimulus and this specific configuration. According to the modality so described by Houssaye (1988), learning has always taken place in classroom situations. The creation of learning software requires mediation. Cognitive ergonomics is very early specialized in dealing with this mediation.

The aim of this article is to emphasize the contribution of cognitive ergonomics in the mediation between the cognitive dimension of the learner, and the educational technology used. Its role is to offer navigability, usability in harmony with mental, and psychological characteristics of the user. Many pioneering laboratories have understood this cooperation very early, such as the AMICAL project (Architecture Multi-Agents Interactive Companion for Learning to Read) or the Baghera platform. These multidisciplinary laboratories are called upon cognitive specialists to work on themes such as: the ergonomics of educational dialogue, ergonomics of educational instructions, and the individualization of learning, etc.

Cognitive ergonomics is a discipline that has been structured according to the technological developments imposed by computers production, which began to become more widespread in the 1980s. This article suggests the popularization of knowledge that is based on measuring cognitive ergonomics in an online learning situation. It is also based on the specificity of the cognitive dimension in learning situation to discuss the ergonomic design requirements.

The paper examines how digital platforms are transforming education, addressing cognitive challenges and the role of cognitive ergonomics in online learning. First, it explores the shift from traditional to digital learning, emphasizing flexibility, personalization, and human-computer interactions. Then, Key cognitive factors such as categorization, perception and learning strategies are discussed, along with AI's impact on usability and accessibility. Houssaye's pedagogical triangle is introduced to enhance interface design, and Bastien and Scapin's ergonomic criteria are proposed to assess platform usability. Finaly, the paper highlights the importance of cognitive ergonomics in digital learning and advocates further research on AI-driven learning environments.

2- From ergonomics to cognitive ergonomics

Ergonomics has two fundamental objectives: one focused on organizations (efficiency, productivity, quality) and another focused-on people (health, safety, skills development, etc.). In 2000, the International Ergonomics Association (IEA) stated: "Ergonomists contribute the planning, and evaluation of tasks, jobs, products, organizations, environments and systems to make them compatible with people's needs, abilities and limitations" (Falzon, 2004, p 19) .

Therefore, the design of products compatible with the expectations of the users (learners), their capabilities and their limits are at the heart of the concerns of ergonomists design actors. A good ergonomic design of the product must satisfy ergonomic recommendations criteria such as safety, efficiency, usefulness, error tolerance, grip, comfort and pleasure (Dejean & Naël, 2004). In fact, to ensure a wide consumption of computer products for example, the tendency to use the term «ergonomics» as a selling point is more and more recurrent, because this indicates a better adaptation of these products to their users, more fun and agreeable interactions (Brangier & Bastien, 2010). As we will see later, cognitive ergonomics applied to computer products play an important role in the optimization of Human Machine Interface (HMI).

Cognitive requirements and ergonomic criteria in designing digital learning platforms

Inspired by cognitive psychology and artificial intelligence, cognitive ergonomics emerged in the 1970s to describe human-computer interactions. A sub-discipline of general ergonomics, cognitive ergonomics is an applied science: it applies knowledge, methods, techniques and tools from cognitive sciences to solve problems related to the use of artifacts. These origins return to the earlier works of the thirties of the previous century. These include pioneering works, such as those relating to typing, carried out by Lahy and Estop or those carried out in the 1960s on the work of air traffic control by Leplat, Bessert, Enard, Spérandio, etc., In addition, the first European Conference on Cognitive Ergonomics, titled "Mind and Computer" was held in Amsterdam in the 1980s, then the European Association of Cognitive Ergonomics was created a few years later (Hoc, 2004).

The evolution of the technical systems, the interest is more and more oriented towards the study of the dialogue man – machine, and the design of the interfaces in the ergonomists, psychologists, industrial doctors, and biomechanicians who faced this problem, seeking to make compatible the hardware and software characteristics of computers with the physiological and mental characteristics of human operators. Consequently, these studies have led to defining the material characteristics of (HMI). In fact, four areas structure the ergonomics of digital products, chronologically and theoretically, in relation to technological development (Van De Leemput & Amiel, 2010):

a-Accessibility: Problems of access to technologies and their content, for the public and people with special needs

b-Ease of use: The interface is adapted to users and their task objectives promote the use of products.

c- Importance of emotions: Emotions influence interaction with technical products.

d-Technical persuasion: Technical systems influence user behavior and can manage forms of persuasion to guide human behavior.

Nowadays, the use of information and communication technologies (ICT) in higher education (Caron, 2021), enshrined in the general policy of the Algerian Ministry of Higher Education, since 2000, tended to be widespread in universities (Slimani & Bentahar, 2019), especially since the COVID19 pandemic that was invaded the world since late 2019. Distance education, imposed mainly by the global health circumstances of COVID19, is increasingly adopted, despite the difficulties noted: the lack of contact with students and the quality of the connection... etc., (Lassassi et al., 2020).

These changes in traditional pedagogical practices, particularly in academic settings, raise questions at several levels among various authors (Caro, 2021; Lassassi et al., 2020). First, they directly concern teachers and learners involved in these new teaching methods. Then, they call on the administration and the pedagogues in charge of the planning and the organization of the courses. Finally, they involve experts in the design of teaching tools, which its role is to facilitate optimal interaction between teachers, learners and computer tools. At this stage ergonomists can play a role in digital teaching. As we have already shown, cognitive ergonomics makes it possible to adapt computer systems to the characteristics of users, particularly remote learners using computer tools.

3- From traditional to digital learning

The development of information and communication technologies (ICT), computers, applications and social networks contributed significantly to the transformation of teaching practices (Larose et al., 1999; Charlier & Peraya, 2007). These are no longer carried out only in traditional classroom mode but are increasingly scripted and insured online .

Digitized teaching is gradually taking hold, to overcome certain limits of traditional teaching (Crook et al., 2004). First, the rigidity of schedules, which does not consider individual differences in terms of learning pace and availability, which can lead, therefore, to increased fatigue and decreased student engagement. In addition, unidirectional transmission of knowledge, where students are primarily information receivers rather than

active participants, can reduce learner motivation and knowledge acquisition. Finally, the lack of personalization of learning, teachers encounter difficulties in adapting their courses to the individual needs of each learner.

Digitized teaching, on the other hand, allows students to access educational resources and follow courses at their own pace, which allows better time management and adaptation to the biological rhythms and personal constraints of each. Modern educational platforms and digitized teaching offer interactive tools such as quizzes, discussion forums, interactive videos and simulations, which encourage active student participation. It can also adapt, thanks to artificial intelligence technologies and data analysis, the content and teaching methods to the specific needs of each learner. This personalization better responds to individual differences, providing additional resources for those who need it and additional challenges for those who are willing to move faster (Van De Leemput & Amiel, 2010).

Digital teaching is generally done through teaching platforms. A distance learning platform is a multi-layered dematerialized computer system used to meet a pedagogical need in an institutionalized or not. There are several distance learning platforms. Here are some of them:

3.1- Zoom Meetings

Zoom is a video conference service that allows users to chat online by using cloud computer technology, and 256-bit TLS encryption security (Sihotang, 2023, p. 475). This program simplifies videos communications and messages exchanges on various devices. It offers HD video and sound quality during meetings, with support for up to 1,000 videos participants and up to 49 videos simultaneously screened. Participants can share their screens, annotate them together and exchange messages. In addition, the software offers various tools like filters, reactions, polls and hand-ups to make meetings more dynamic and engaging.

3.2- Google Meet

It's a meeting tool built into Google Workspace; the number of participants who can attend a video conference depends on the price agreed with the customer. Users can join meetings via calendar events, email invitations, or directly from Gmail. In addition, meetings organized by Google Workspace users generate a phone number to dial, allowing each guest to connect easily from their smartphone with a simple touch. "Google Meet was officially introduced in February 2017 for iOS users. In the following month, Google Meet was officially introduced to the public, and can be accessed via browser, iOS and Android" (Sihotang, 2023, p. 475).

3.3- WebinarNinja

It is a versatile webinar platform offering options for live, automated, hybrid and serial webinars. In addition to the usual features such as live presentation, interaction with the audience, screen and slide sharing, as well as holding surveys and Q&A sessions, it also allows you to plan events, send confirmations and reminder emails to registrants, manage registrations, and analyze conversions and participation rates.

3.4- Google Classroom

For Iftakhar (2016) Google Classroom is considered as one of the best platforms out there for enhancing teachers' workflow. It provides a set of powerful features that make it an ideal tool to use with students. Classroom helps teachers to save time, keep classes organized, and improve communication with students. Many teachers adopt it as a virtual learning platform for their classrooms, because it is easy to use.

3.5- E-learning:

Van de Leemput and Amiel (2010), and from the Higher Education Funding Council for England (2005) consider that E-learning refers to "The use of technology in learning situations, encompassing both flexible learning and distance learning. It involves the use of information and communication technologies as a tool for communication, and

dissemination between individuals and groups, to support learners and improve learning management.

4- Cognitive specificity of the learner in front of a display screen

The arrival of artificial intelligence (AI) on the mass scale means that humanity is experiencing a new existential evolution. Accordingly, the (AI) has been present in force and for more than three decades now in the world of learning. Several technologies have been used to model human expertise in training. Expert systems, through neural networks or multi-agent systems; the main problem of computer designers was always to produce an effort to understand how humans treat, structure and interact with a smart learning platform. In fact, adapting classroom pedagogical scenarios for digital platforms requires a certain understanding of the learner's learning determinants in such situations. We present here some essential cognitive determinants in the computer implementation of the learner's behavior in front of a screen.

4.1- Categorization

It is a strategic cognitive process in ergonomics for designing digital platforms. This cognitive operation consists of classifying units integrated into a system by differentiating and then grouping artifacts according to previously defined criteria (Bardin, 2013). It manages the flow of information by entering the cognitive processing system to identify and classify it in a similar group. The human brain categorizes to simplify the mass of information. So, objects such as a table are detected by the sensory system, it is treated as an artifact composed of several properties and will be recorded in the class of "furniture" or within "office automation" devices. The information presented on the screen for the learner must be easy to categorize. Each object must be presented sequentially, respecting educational progression, and identified by properties known for the learner. The artifact in

question must echo with the learner. (Example: red color can be used in a critical situation when learning on screen), it will help the learner to detect objects or situations of vigilance.

The learner searches for knowledge and learned schemes in the real system to exploit them in the screen learning system. Therefore, real-life categorization skills will be exploited in the virtual system. It is worth noting that the learner draws on real-world logic to evolve in the digital environment. So, he uses affective appropriation techniques (Guillemot and all., 2015) to make digital objects tangible.

The objects presented on the screen must be used for a specific educational context. They are in themselves learning aids. Indeed, we tend to classify objects by using pen and pencil for example offers the same functionality, that of producing writing. The computer system must be able to adopt this logic to offer on screen a certain coherence between the input, learning and output systems in the design of an online course.

4.2- The perception of objects

The human being is a cognitive being (Saint-Marc, 1994), Working on the display screen makes this biological configuration more enhanced. Indeed, working on a digital platform enhances certain cognitive abilities. Perception is an active construction (Auvray & Fuchs, 2007), was developed by the learner to identify an object. The virtual world is detached from the individual's psychobiological reference points. It is useful to shape, present, and arrange the artifacts in such a way that they constitute «habitus» familiar to the semiological context of the learner. The computer designer will work with the ergonomist/psychologist to model one of the existing theories of perception, to produce it as part of its computer implementation. The theory of perception proposed in the context of the Gestalt can be an interesting opportunity for designers to implement an artificial agent based on the principles of continuity, similarity, proximity, and common region. Other possibilities are offered for designers, especially since theories of visual perception are numerous. It is interesting to note here that the process of perception constitutes a global behavioral system

(Tarroux & Auvray, 2012), and not a process exclusively resulting from the activity of reasoning stricto sensu.

4.3- The learning strategy

Another concept of the psychology of learning, the learning strategy is often declined in the plural. It designates all the behaviors deployed by the learner to concretize his learning activity (Bégin, 2008). The digital learning platform is called upon to anticipate how the learner learns. It must suggest a pedagogical scenario based on individualization (Chambreuil et al., 2000). One of the challenges of the technologies used in the digital field, in particular AI, lies in the ability of the devices chosen to suggest variety strategies. AI must be capable of learning from the learner and offering a variety of strategies according to the specificities of each learner. Learning strategies are diverse and varied.

5- The contribution of cognitive ergonomics in the design of a digital learning environment:

Studies in cognitive ergonomics support the idea that cognitive aspects are decisive in the design of digital learning tools. According to (Lambropoulos, 2005), the need for a user-centered approach in design of learning platforms intended for users. He argued that the design process is based on the development of intermediate representations that facilitate dialogues, and which allows the interfaces to be gradually adjusted to the cognitive requirements of users.

In addition, Soufi and Bouziane (2022), affirmed the importance of setting up evaluation criteria in the development of digital learning platforms, such as the AMICAL project which was one of the pioneering laboratories in 1990s-2000s. And it has given itself the means to include in its design an ergonomic intervention that achieved a certain performance in navigability within the proposed activities.

Additionally, Cinquin, Guitton and Sauzéon (2018), examined the issue of the accessibility of e-learning platforms for learners with cognitive troubles. They proposed a wealthy literature review. This focused on several shortcomings in the design of these tools, which included a weak integration of accessibility standards.

Bouziane (2021), suggested a reflection on the integration of artificial intelligence in digitalized teaching. He put forward the need to integrate the principles of educational engineering into the design of devices. He also suggested the importance of providing artificial agents with imitative properties based on the analysis of the postures of natural agents.

In a broader perspective, Boucheix (2003) suggested an approach to designing training devices based on a cognitive ergonomics approach dedicated to learning. He also suggested a theoretical framework based on three areas: cognitive ergonomics, cognitive approach to learning, and training engineering. He also mentioned the need to contribute the principles of professional didactics, to the development of learning tools.

The study done by (Firescu, 2025) focused on the importance of cooperation between natural agents and technologies within organizations, from a perspective of education for sustainability. This study suggests the concept of "Engineering Education 5.0", this last is based on promotion of engineering training oriented towards solving challenges by promoting among other things, the intervention of ergonomics. This study reveals that the development of cooperation, and huge learning environments contributes to strengthening the capacity of students to become actors of change towards more supportable society.

5.1- Integrating educational technologies into digital learning

Technological offers constitute diverse realities. In fact, the main role of cognitive ergonomics is to understand the contributions of educational technologies proposed by the learner. The ergonomist is asked to establish an intervention strategy, according to the technological limitations of his computer system. A digital learning program developed the "object-oriented", language will not have the same ergonomic performance as a program

developed as part of learning Management System (LMS). The emergence of more than thirty-five years of artificial intelligence (AI) in this field, bringing diverse possibilities such as multi-agent systems or other systems, has revolutionized cognitive ergonomics. This last is invited to include its efforts in its ability to imitate human expertise (Bouziane, 2021). The various IT agents will take on various roles to be able to reproduce the classical pedagogical situation in an environment adequate to digital deployment. These agents can learn, make referrals, and communicate (Ferber, 1995), etc. Cognitive ergonomics face the challenge of offering on screen a faithful replication of the traditional learning environment while combining with the specificities of the technology used.

Thus, the main challenge of cognitive ergonomics in the field of digital learning lies in their ability to articulate classic pedagogical requirements with the potential offered by new technologies. This integration raises questions about the adaptability of interfaces and learning environments, which leads to the need to push a reflection on the specificity of human cognition in such devices.

5.2- Implementation of educational requirements on software :

Educational objectives, teaching methods, learning strategies, management of emotions, observable behavior, dynamics of exchanges in Houssaye's pedagogical triangle and many other themes, constitute the central foundation of pedagogy .

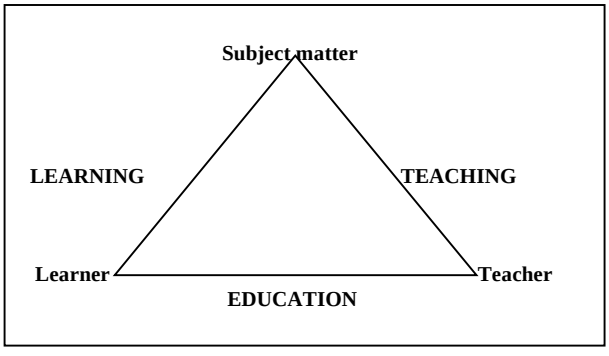

Figure 1. Pedagogical triangle of Jean Houssaye (1988)

Cognitive ergonomics in cooperation with computer science, will have the challenge of restoring these hundreds of research operations in the design of digital learning devices. They will ask the technological capacity of the proposed computer system to meet the specific needs of the user, as recorded by the client. The research registers here are incalculable, and specific themes can be the subject of research, such as awareness of the writing process, improvement of written production (Quanquin & Foucher, 2017), analysis of editorial contributions (Durand; Lotin, & Rodrigues, 2022), dialogue modeling on ChatGPT (Huang et al., 2024), etc.

5.3- Knowledge representation :

A key issue for cognitive ergonomics, knowledge representation involves several disciplines such as logic, mathematics, cognitive science and ergonomics. It is a high-level investigation to understand how the learner detects, processes and uses the information perceived on screen. The ergonomic consequences of the study of the representation of contextualized knowledge will also make it possible to understand the formal and semantic stakes (Fournier-Viger, 2005) of the processing of educational signals within these HMIs.

5.4- Implementation of pedagogical dialogue :

Long contextualized formal exchanges between different protagonists of communication, such as pilot-control tower conversation, use of GPS, or formerly standardized conversations for example, "firefighters using Talkie walkies". The engineering of dialogue gradually invited itself into the sphere of digital learning environments, from the 1990s to find its apogee with the emergence of computer prompts. Today, the challenge of cognitive ergonomics is to address the expertise of the algorithms for implementing dialogues in AI-based platforms, such as in the case of OpenAI products.

Dialogue systems with useful theoretical reflection will provide the training device architecture with intelligent navigability. These systems will make the use of semantics

appropriate to the nature of the user's activity. They will also provide syntactic structures: personalized, respectful of the learner's representations and helpful (Lafarge, 2007).

5.5- User interfaces design consideration

Work has become classic, particularly with the emergence of taxonomies as well as different methods of ergonomic evaluation of learning environments, the criteria of Scapin and Bastien (1993) were a definite success for ergonomics. In addition, their ability to identify the focal points of the main aspects that could be evaluated, they had the particularity of becoming a safe reference and now appear among the classics of ergonomics. The following table is a general overview to understand the contributions of the ergonomic criteria of Bastien & Scapin in the evaluation of digital platforms.

Table N°1 : Evaluation criteria for human-computer interfaces (Bastien & Scapin, 1993)

Criteria	Description
Guidance	Guidance allows the guidance of the learner in a complex learning device made of back and forth or allowing a possible orientation.
Workload	The mental load is understood from the perspective of optimal management of the information flow according to the situation of the learner.
Explicit control	The learner maintains control throughout the navigation process. It is the learner who controls the computer system not the other way around.
Adaptability	In terms of skill levels or proficiency, the computer system must position Itself at the level of the learner's situation.
Error Management	The computer system must offer the user an opportunity to anticipate, manage and correct potential errors.
Homogeneity / Coherence	Proficiency must be characterized by a certain consistency and homogeneity in its approach. This consists in proposing an intuitive and Constant semiology and artefacts.

Meanings of Codes and Names	Some correspondence must be proposed in an intuitive way between the signifier and the signifier allowing the improvement of the correspondence of navigation and decoding of the information.
Compatibility	The better the computer system adapts to technological standards, the more e it operates. .

These criteria constitute a synthesis of the various works carried out by (Bastien & Scapin, 1993) on the evaluation of software. They focus on the need for ergonomic intervention in the design of "Human-Machine" interfaces. This major contribution in ergonomics has been exported to professional and academic spheres and many researchers are still working today on the appropriation and development of these criteria. The use of these criteria allows the implementation of a navigability strategy based on the principles of rationality and performance. Thus, a sequence displayed on the screen will offer the user univocal treatment.

6- Conclusion

To sum up, the goal of this contribution was to illustrate the importance of cognitive ergonomics in the development of digital learning platforms. So, human cognition in learning situation on screen implies adequate expertise of the cognitive performances mobilized according to the nature of the information processed. It is crucial for the designers of such products to understand the cognitive issues mobilized by the learner in learning context via specific interface, which is the screen.

Finally, cognitive ergonomics is now called upon to raise the level of new ramifications induced by artificial intelligence. Digital learning platforms designed using this technology offer more complex posture characterized among other things by individualization, increased interactivity and scalability.

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