

**COGNITIVE ASPECTS AND THE EDUCATIONAL POTENTIAL
OF INFOGRAPHICS IN THE CONTEXT
OF INCREASING INFORMATION FLOWS**

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***Abstract.** This study examines the cognitive aspects of information perception through infographics and substantiates its educational potential in the context of information overload. Theories of dual coding, cognitive load, and visual thinking are analyzed as the basis for the effectiveness of infographics. The principles of creating infographics, taking into account the characteristics of cognitive perception, have been identified. The didactic possibilities of infographics and its impact on the development of analytical thinking and visual-communicative competence have been examined. It has been proven that the use of infographics increases the effectiveness of learning information and optimizes the educational process.*

***Keywords:** infographics, cognitive processes, information visualization, educational technologies, cognitive load, visual thinking, digital learning.*

Introduction

The current stage of development of the information society is characterized by the phenomenon of information overload, which poses entirely new challenges for pedagogy, psychology, and related fields of knowledge. The exponential growth of information volumes, its high dynamism, fragmentation, and multimedia nature are leading to changes in cognitive data processing strategies, a transformation of learning methods, and a rethinking of the role of educational tools in the knowledge formation process.

Under these conditions, traditional text-centered learning models, which are based primarily on a linear presentation of information, are increasingly demonstrating limited effectiveness. This is due both to the physiological limitations of the human cognitive system (in particular, the limited capacity of working memory) and to sociocultural changes manifested in the phenomena of «clip-based thinking», a

shortened attention span, and an increased need for rapid access to structured information [1, 2].

Information overload in today's educational environment manifests itself in an excessive amount of educational content, the complexity of structuring it, and the need to quickly assimilate large amounts of data. Under these conditions, the challenge arises not only in the transfer of knowledge but also in its optimal organization, visualization, and cognitively effective presentation. This necessitates the implementation of tools capable of reducing cognitive load and improving the quality of information perception.

One such tool is infographics, which combines textual, graphical, and symbolic elements for a compact, visual, and structured presentation of information. Infographics serve not only as a means of visualization but also as a powerful cognitive tool that promotes active thinking, improves understanding of complex concepts, and fosters a systematic view of information.

Scientific research in the field of cognitive psychology confirms the effectiveness of combining verbal and visual channels of information processing. In particular, according to A. Paivio's dual-coding theory [3], information presented simultaneously in both textual and graphical forms is processed more effectively than when only a single channel is used. J. Sweller's cognitive load theory [2] also emphasizes the importance of optimal information structuring to prevent working memory overload.

In the context of educational technology, infographics serve a number of important functions:

- organizing complex data;
- enhancing understanding of educational material;
- developing analytical and critical thinking skills;
- stimulating learners' cognitive engagement;
- developing visual literacy.

The use of infographics is particularly relevant in the context of the digitalization of education and the transition to blended and distance learning. In the digital environment, infographics serve as a universal means of communication that ensures effective information transfer regardless of platform format or device type. Additionally, interactive infographics expand opportunities for user engagement, promote personalized learning, and enhance material retention.

Another important aspect is the development of visual-communicative competence [4, 5], which involves the ability not only to perceive but also to create infographics as a tool for presenting knowledge. This is particularly important for training professionals in fields related to media, design, publishing, education, and information technology.

Thus, in the modern educational environment, infographics are viewed not merely as an auxiliary tool but as a full-fledged instrument for the cognitive optimization of the learning process. Their use enhances learning effectiveness, ensures

a deeper understanding of the material, and contributes to the development of modern competencies necessary for functioning in the information society.

Thus, the relevance of researching the cognitive aspects and educational potential of infographics stems from the need to find effective ways to organize and present information in an environment of information overload. Further study of this issue opens up opportunities for improving teaching methods, integrating innovative technologies, and enhancing the quality of the educational process as a whole.

Purpose and Objectives of the Study

In today's Ukrainian educational landscape, infographics are gradually evolving from a supplementary visual element into a full-fledged pedagogical tool. This is linked to the digitization of education, the development of distance and blended learning, as well as the need to adapt educational content to the ways in which today's students process information.

The reform of Ukraine's educational system, particularly the implementation of the New Ukrainian School concept, has brought to the forefront the development of visual literacy, critical thinking, and information literacy. One of the key areas of modernizing the educational process has been the introduction of multimedia and interactive forms of presenting information, among which infographics play a significant role.

Infographics in Ukrainian education are used in several main areas [6,7]:

- as a means of visualizing educational material;
- as a tool for developing analytical thinking;
- as a way to structure large amounts of information;
- as an element of digital educational resources;
- as a method for encouraging independent student work.

Infographics are particularly widely used in:

- distance learning;
- STEM education;
- media education;
- preparing presentations;
- online courses;
- educational platforms and massive open online courses (MOOCs).

The digitization of the educational environment has significantly amplified the role of visual communication. After a significant number of educational institutions transitioned to distance and blended learning, there arose a need to adapt educational content for on-screen viewing. In this context, traditional large blocks of text often prove less effective than structured visual models[7].

Modern digital educational platforms in Ukraine actively use infographics as a component of multimedia educational content. For example, the educational projects Prometheus [8] and EdEra [9] widely employ:

- diagrams;

- visual algorithms;
- charts;
- information blocks;
- interactive visualizations.

This helps to: reduce cognitive load, facilitate quicker orientation within the material, increase learner engagement, and improve information retention.

Ukrainian researchers also emphasize that infographics are an effective means of integrating textual, graphical, and statistical information into a single cognitive structure, which is particularly important in the context of information overload.

In Ukrainian higher education institutions, infographics are increasingly being used as a means of presenting educational material, a form of independent student work, an element of scientific communication, and a tool for developing digital competencies.

In the learning process, infographics provide opportunities to visualize complex concepts and demonstrate cause-and-effect relationships, model processes, and organize large amounts of information, while also helping to improve analytical thinking skills [10].

Importantly, the creation of infographics by students, in particular, contributes to the development of visual thinking skills and the ability to analyze and synthesize information. It fosters an understanding of information culture and promotes the development of design competencies and digital literacy.

In the context of the competency-based approach, infographics serve not only as a form of information presentation but also as a means of developing comprehensive professional competencies.

In Ukrainian scientific and pedagogical discourse, infographics are increasingly viewed as an important component of media education. This is linked to the growing role of visual communication in the digital information environment. Since infographics allow for the critical analysis of informational messages and the interpretation of statistical data, as well as the recognition of manipulative visual practices, they contribute to the development of media literacy skills.

In today's climate of information warfare and disinformation, visual literacy has taken on strategic importance. The ability to correctly interpret graphical information has become a vital component of information security and civic competence.

Despite its significant potential, the integration of infographics into domestic educational practice is accompanied by a number of challenges. There is an insufficient level of digital training among educators – some of them lack the necessary skills to create high-quality infographics and use specialized digital tools; there is a lack of methodological standards, manifested in the insufficient development of criteria for evaluating infographics, methods for their creation, and didactic principles for their use. Among the challenges of creating and implementing infographics in the educational environment is the risk of visual overload, which stems from an excessive number of graphic elements. This, in turn, can hinder information comprehension and

reduce the effectiveness of learning. Another issue is the superficial use of infographics as a decorative element without any real cognitive function.

The future development of infographics in Ukrainian education is linked to:

- the integration of artificial intelligence technologies;
- the development of interactive infographics;
- the implementation of adaptive learning;
- the use of VR/AR technologies;
- the automation of educational content creation.

Another promising area is the application of: analytical infographics, dynamic visualizations, multimedia educational models, and interactive cognitive maps.

In the context of the digital transformation of education, infographics have the potential to become one of the fundamental tools for organizing educational communication.

Given the rapid growth of information volumes, its fragmentation, and the high speed of its dissemination, the issue of effective knowledge acquisition in the educational environment has become particularly relevant. Information overload, limited human cognitive resources, and the transformation of ways of perceiving information (in particular, the development of visual and clip-based thinking) necessitate the search for innovative approaches to organizing educational content.

In this context, infographics are viewed as a promising tool that combines visual and verbal components, ensuring the effective communication of complex information. However, despite the widespread use of infographics in educational practice, their cognitive mechanisms and didactic potential require systematic theoretical analysis and scientific justification.

The aim of this study is to provide a theoretical foundation for the cognitive aspects of infographics and to identify its educational potential in the context of intensifying information flows, as well as to develop scientifically grounded approaches to the effective use of infographics in the modern educational process.

Achieving this goal involves integrating principles of cognitive psychology, visual communication theory, pedagogy, and digital educational technologies to form a comprehensive understanding of infographics as a tool for optimizing educational activities.

To achieve this goal, it is necessary to solve a set of interrelated scientific tasks:

Theoretical and conceptual tasks involve analyzing contemporary scientific approaches to understanding the phenomenon of infographics in the context of visual communication; refining the conceptual and categorical framework of the study (infographics, data visualization, cognitive processes, cognitive load, etc.); determining the place of infographics within the system of modern information and communication technologies.

The cognitive-psychological objectives consist of studying the mechanisms of perception and processing of visual information; analyzing the impact of infographics on working memory, attention, and memorization processes; substantiating the effectiveness of infographics based on dual-coding theory and cognitive load theory;

identifying the cognitive factors that influence the effectiveness of visualizing educational material.

The didactic objectives are to identify the educational functions of infographics in the learning process; to explore the potential of infographics in developing key competencies among learners; to establish didactic principles for the creation and use of infographics; and to develop criteria for evaluating the effectiveness of infographics as a pedagogical tool.

The analytical and applied tasks are based on analyzing current practices in the use of infographics in the educational environment, particularly in Ukraine; identifying common errors and limitations in the use of infographics; classifying types of infographics according to their functional and pedagogical purposes; and exploring the possibility of integrating infographics into digital educational platforms.

The methodological tasks consist of developing recommendations for creating effective infographics that take into account the cognitive characteristics of information perception; defining algorithms for using infographics in various forms of instruction (classroom, distance, and blended); proposing a model for integrating infographics into educational courses, and justifying a methodology for developing visual-communicative competence.

Prospective and predictive tasks define the directions of infographics development in the context of the digitalization of education and make it possible to assess the potential for integrating infographics with artificial intelligence technologies. An important task is to outline the prospects for using infographics in multimedia educational environments.

Research object: the process of visualizing educational information in the context of the modern information society.

Research subject: the cognitive mechanisms underlying the functioning of infographics and its didactic potential in the educational process.

To achieve the research objectives and tasks, a set of methods was applied:

– theoretical: analysis, synthesis, generalization, and systematization of scientific sources;

– comparative analysis: comparison of different approaches to information visualization;

– structural-functional method: to determine the role of infographics in the educational process;

– modeling: to develop conceptual models for the use of infographics;

– empirical (as needed): observation, surveys, analysis of learning outcomes.

The scientific novelty of the study lies in the systematic justification of infographics as a cognitively oriented educational tool and the integration of cognitive-psychological and pedagogical approaches to its analysis; the refinement of didactic principles for creating infographics; and the development of models for the effective use of infographics in the educational process.

The practical significance lies in the possibility of using the research findings to develop educational courses that incorporate infographics, thereby enhancing the

effectiveness of the educational process and improving teaching methods. The results can be utilized in the creation of digital educational resources for training professionals in the fields of media, education, design, and information technology.

Thus, the formulated research objectives and tasks reflect the comprehensive nature of the issue, combining cognitive, pedagogical, and technological aspects of infographic use. Their implementation allows not only for a deeper understanding of the mechanisms underlying the effectiveness of information visualization but also for the development of practical recommendations to improve the modern educational process in the context of information overload.

Presentation of the main research findings

The intensification of information flows in modern society has led to a situation where the volume of information exceeds human cognitive capacity for processing it. The limitations of working memory, the selective nature of attention, and the need for rapid decision-making necessitate the use of effective methods for presenting knowledge. In this context, visual forms of information presentation, particularly infographics, take on special significance. From the perspective of cognitive psychology, the effectiveness of infographics is explained by the integration of two channels of information processing – verbal and visual. According to the dual-coding theory [3], the simultaneous use of textual and graphic elements facilitates the formation of more stable cognitive connections. This ensures better interpretation and long-term retention of information.

In addition, cognitive load theory [2] emphasizes that the optimal organization of educational material should minimize excessive load on working memory. Infographics, thanks to their structure and compactness, allow for a reduction in the amount of information to be processed simultaneously and facilitate more effective knowledge acquisition.

Thus, infographics serve as a cognitive tool that:

- optimizes the process of information perception;
- reduces cognitive overload;
- stimulates visual thinking;
- facilitates the formation of systematic understanding.

Let us consider the theoretical and methodological foundations of studying infographics as a cognitive tool. The contemporary paradigm of infographics research is shaped at the intersection of cognitive psychology, learning theory, visual communication, and information design. Within this approach, infographics are viewed not merely as a form of information representation, but as a cognitively mediated tool for knowledge construction that influences the structure of the learner's mental models.

The key methodological foundation of the study is the integration of the following theoretical frameworks:

- dual coding theory [3];

- cognitive theory of multimedia learning [1];
- cognitive load theory [2];
- theory of visual perception and information visualization [4];
- the concept of mental models [10] (Johnson-Laird, 1983).

Let us consider the theories used for structured theoretical analysis.

The dual-coding theory [3], formulated by Alan Paivio in 1971, is one of the fundamental cognitive theories that explains the mechanisms of information processing by the human brain through the interaction of two specific systems.

The fundamental premise of the DCT is that human cognition is driven by two functionally independent yet interconnected information-processing systems. The verbal system specializes in processing linguistic units such as text and speech, while the nonverbal (imaginative) system is responsible for processing visual images, spatial characteristics, and other nonverbal objects. Paivio argues that memory and thinking are more effective when information is encoded simultaneously in both systems, as this creates two independent pathways for subsequent data retrieval.

To describe the representational units within each system, Paivio introduced special terms: logogens and imagens. Logogens are the operational units of the verbal system. They are organized hierarchically according to a linear principle, like words in a sentence. Logogens are processed sequentially (successively). Imagens are the units of the nonverbal system. They store information about holistic images and spatial relationships. Unlike logogens, images are processed in parallel (simultaneously), which allows for the instantaneous perception of complex visual scenes.

The theory identifies three levels of interaction between stimuli and cognitive systems.

1. Representational processing – the direct activation of logogens by linguistic stimuli or of imagens by sensory images (for example, you see an apple, and the image of an apple is activated).

2. Referential processing – intersystem activation. This is the ability of the verbal system to trigger activity in the nonverbal system and vice versa (for example, when you hear the word «sea», you imagine waves).

3. Associative processing – intra-system activation. The connection between units within a single system (for example, the word «school» evokes the association «teacher», and the image of a «table» is associated with the image of a «chair»).

One of the theory's key conclusions is an explanation of why concrete nouns (e.g., «*bicycle*») are remembered better than abstract concepts (e.g., «*justice*»). This is called the Concreteness Effect: concrete words are easily subject to dual encoding and activate both the logogen and the image. In contrast, abstract words are usually encoded only verbally, which makes the cognitive trace less durable.

In the current context, the use of multimodal stimuli is essentially a technical implementation of dual coding, in which textual and visual tokens interact through the cross-attention mechanism. Thus, A. Paivio's dual-coding theory remains fundamental to understanding how multimodal stimuli (text + images) create more integrated and

stable cognitive structures, which is critically important for the development of intelligent decision-support systems.

Within these approaches, infographics are interpreted as a means of externalizing knowledge, facilitating the transition from linear textual representation to a multidimensional cognitive structure.

Cognitive load theory [2], developed by John Sweller in the late 1980s, is one of the most influential concepts in contemporary educational psychology and knowledge engineering. It is based on an understanding of the architecture of human memory and its limitations in the process of acquiring new information.

J. Sweller's cognitive load theory is based on the existence of working memory and long-term memory. CLT is based on a model of information processing that accounts for the critical difference between the two types of memory; specifically, working memory has an extremely limited capacity (according to Miller, about 7 ± 2 units of information) and storage duration. It is here that active processing of new data takes place. Long-term memory has virtually unlimited capacity and stores knowledge in the form of complex cognitive structures – schemas. A schema is a cognitive unit that integrates a set of information elements into a single whole. The learning process consists of creating new schemas or automating existing ones, which frees up working memory resources.

Swellers identifies three specific types of cognitive load that collectively determine the total demand on working memory.

1. Intrinsic Cognitive Load is determined by the complexity of the instructional material itself and the learner's level of preparation. It depends on the number of elements that must be processed simultaneously (the interactivity of the elements). This load is an integral part of the task and cannot be altered without simplifying the learning content itself.

2. Extraneous Cognitive Load is caused by the way information is presented or by instructional actions that do not directly contribute to knowledge acquisition (e.g., poor interface design, excessive text on slides). This load is destructive because it consumes the working memory resources necessary for learning.

3. Relevant (constructive) cognitive load: efforts aimed at directly creating and automating cognitive schemas. This is a «useful» load that promotes deep understanding and the transfer of knowledge.

Research conducted within the CLT framework has identified a number of effects that help reduce extraneous cognitive load. The first is the split-attention effect, which occurs when a student is forced to mentally integrate two sources of information separated in space or time (for example, text on one page and a diagram on another). The second is the modality effect, where working memory has separate channels for visual and auditory information. Presenting part of the material verbally and part visually expands the overall capacity of working memory. The third highlighted effect is the redundancy effect, which involves duplicating information (for example, reading text from a slide that is already written) creates an unnecessary burden, as the brain is forced to expend resources comparing identical data streams.

Cognitive load theory posits that the effectiveness of learning and intellectual activity directly depends on the balance between types of load. The primary task of an educational content or interface designer is to minimize extraneous load, optimize internal load, and stimulate relevant load, taking into account the strict limitations of human working memory.

In contemporary scientific research, eye-tracking plays a key role in objectively evaluating the effectiveness of visual content [10] – a technology that records gaze coordinates, pupil movement dynamics, and the duration of fixations during a user’s interaction with a visual stimulus.

Eye-tracking is based on the «Eye-Mind Hypothesis», formulated by M. Just and P. Carpenter [11]. According to this hypothesis, there is a direct correlation between the point of gaze fixation and the process of cognitive information processing at that point. Analysis of eye movements allows for the reconstruction of the process of cognitive resource allocation (according to J. Sweller’s Cognitive Load Theory) and the identification of stages of information encoding.

The following metrics are typically used to evaluate visual content in monographic studies:

- fixations are periods of relative eye rest (lasting 100 to 500 ms) during which information is processed. A large number or duration of fixations on a specific element may indicate its high significance or, conversely, difficulty in perception;

- saccades characterize rapid, jerky eye movements between fixations. Analysis of saccades helps understand the information-seeking strategy and the logic of “scanning” the interface;

- time to First Fixation (TTFF) determines the speed of detecting a specific object, which is critical for assessing the visibility of safety elements or warning signals;

- areas of Interest (AOI) are specific zones of visual content that are analyzed separately to compare the effectiveness of different elements (e.g., a graph versus a text description).

The results of eye-tracking studies are presented in the form of heat maps and gaze plots. The first is a color-coded graphical representation of fixation density. «Hot» zones indicate areas that attracted the most attention, allowing for the validation of the hierarchy of visual elements. The second is a sequence of eye movements reflecting the chronology of content perception. This is important for analyzing whether the user’s gaze path aligns with the logic intended by the developer.

The eye-tracking method transforms the subjective assessment of a visualization’s «usability» into objective quantitative data. This allows for the design of systems with minimal cognitive load, ensuring a quick and error-free human response to complex digital stimuli.

Heatmaps reflect the intensity of the user’s attention by overlaying a color gradient on the image.

The formation of mental models during interaction with information systems. The term «mental model» was first proposed by Kenneth Craik in 1943 and later

developed by Philip Johnson-Laird[3]. A mental model is an internal simulation of external reality that is stored in long-term memory in the form of interconnected cognitive schemas.

Unlike formal mathematical or computational models, mental models are characterized by: dynamism, as they constantly evolve through learning and experience; functionality – they are not necessarily exact copies of reality, but must be sufficiently useful for decision-making; and limitations, as they depend on working memory capacity according to J. Sweller’s Cognitive Load Theory.

The process of constructing a mental model goes through several stages:

– perception through dual coding: the user receives visual and verbal stimuli. According to A. Paivio, the combination of text and graphics accelerates the creation of an initial «mental image» of the system;

– assimilation: new data is compared with existing knowledge. If the system is similar to previously known ones (for example, it has a familiar «trash can» icon), the model is formed more quickly;

– experimental verification: the user performs an action and observes the system’s response. At this stage, A/B testing of interfaces is critical to identify which elements contribute to a correct understanding of the system’s logic;

– aggregation and automation: individual cognitive schemas are combined into a complex model, allowing tasks to be performed with minimal conscious attention.

There are three types of models, and aligning them is the goal of successful design: the design model reflects how the developer sees the system and is based on algorithms and code; the system image indicates how the system is presented through the interface, documentation, and illustrations; the user’s mental model indicates what is formed in a person’s mind based on interaction with the «system image.»

Critical errors or crises often arise when the user’s mental model does not match the actual logic of the system – that is, the design model.

High-quality visualization acts as a «bridge» between a complex mathematical model (such as the ViT neural network) and human consciousness. The use of concept mapping methods allows us to make the connections within the system explicit (visible), helping the user to build an adequate mental model more quickly, as confirmed by eye-tracking data.

When analyzing the cognitive mechanisms underlying the effectiveness of infographics – including dual-channel information processing, working memory limitations, and the formation of mental models – perceptual mechanisms play a central role.

Within the fields of cognitive psychology and ergonomics, the study of perceptual mechanisms is critical for understanding how humans extract, structure, and interpret visual information. For this section of the monograph, this description should be based on a synthesis of the physiology of perception and cognitive theories of information processing.

Perceptual mechanisms are the set of processes through which sensory stimuli are transformed into meaningful mental images. Unlike simple sensation (the

registration of light or color), perception involves interpretation based on the subject's prior experience and expectations.

The process of perception unfolds in two opposing directions: bottom-up processing – analysis begins with the basic physical characteristics of the stimulus (lines, angles, color, contrast). This is an automatic process driven by the object's characteristics. Top-down processing characterizes the formation of an image under the influence of knowledge, context, and cognitive schemas. For example, an experienced researcher is more likely to recognize an anomaly on a wavelet graph because their perceptual mechanisms are «tuned» to specific patterns.

Before attention is consciously directed toward an object, preattentive mechanisms are at work. They allow the brain to instantly (in <200 ms) detect specific visual cues, such as:

- color contrasts;
- line orientation (horizontal/vertical);
- motion and intensity. Effective visualization in IT systems must utilize these mechanisms to highlight critical events so that they «pop out» (pop-out effect) even before the operator fully becomes aware of them.

One of the basic mechanisms of perception is the grouping of elements into coherent structures. Key Gestalt principles include:

- proximity: objects located close together are perceived as a group;
- similarity: elements of the same shape or color are mentally grouped together;
- continuity: the eye follows lines or curves, seeking smooth transitions;
- closure: the brain tends to «fill in» missing fragments of shapes to create a complete image.

Perceptual mechanisms are closely linked to the limitations of working memory. An excessive number of small details or a chaotic arrangement of elements overloads the perceptual channel, leading to an increase in extraneous cognitive load (according to J. Swellers). The use of the eye-tracking method allows for the objective recording of how these mechanisms work: prolonged fixations often indicate areas where perceptual recognition is difficult due to the complexity of the visual geometry or low image quality.

Research findings

Based on an in-depth analysis of the psychological foundations of visualization, an examination of scientific approaches, and the methodological tools used in contemporary psychological and educational research, it can be concluded that infographics are effective in education.

To achieve this goal, we integrated principles from cognitive psychology, visual communication theory, pedagogy, and digital educational technologies to form a comprehensive understanding of infographics as a tool for optimizing educational activities.

Analytical research has established the principles for creating effective infographics.

The effectiveness of infographics as a teaching tool depends to a large extent on adherence to certain principles of their creation, which are based on the patterns of information perception.

The main principles include: the principle of hierarchy, according to which information should be organized by level of importance. Visual hierarchy is achieved through the size of elements, contrast, layout, and typography. The principle of cognitive economy involves minimizing unnecessary elements that do not convey meaning. Excessive detail complicates perception and reduces learning effectiveness. The principle of integration states that textual and graphic elements must interact to form a unified semantic structure. Separating these components in space or time can reduce the effectiveness of perception. The principle of visual consistency ensures unity in style, color scheme, fonts, and graphic elements, which contributes to the formation of a holistic perception of information. The principle of audience relevance emphasizes that infographics must take into account the level of preparation, cognitive characteristics, and learning needs of learners.

In the educational process, infographics can serve various functions, which leads to their classification based on several criteria.

1. By functional purpose:

- explanatory – explains the nature of phenomena or processes;
- comparative – demonstrates differences between objects;
- process-based – depicts a sequence of actions;
- statistical – presents quantitative data;
- structural – demonstrates relationships between elements.

2. By presentation format:

- static;
- dynamic;
- interactive.

3. By level of complexity:

- basic (for general familiarization);
- analytical (for in-depth study);
- expert (for professional use).

Infographics have significant educational potential, which manifests in the following aspects: improving learning effectiveness – in particular, visualization promotes a better understanding of complex concepts and reduces the time needed to master the material; fostering the development of analytical thinking – stimulating the ability to analyze, generalize, and interpret information; it helps develop visual literacy, as learners learn not only to perceive but also to create visual messages; it stimulates cognitive activity by increasing motivation to learn and encourages students to engage in active work.

Infographics should be viewed as a formalized information model that can be presented in the form of:

$$IG = \{D, V, S, C\}, \quad (1)$$

where D – data set;

V – visual variables (color, shape, size);

S – relationship structure;

C – interpretive context.

This model describes infographics not merely as a graphic image or design element, but as a structured cognitive system that organizes, conveys, and facilitates human perception of information. It formalizes the process of interaction between the visual representation of data and the user's cognitive mechanisms.

This model implies that an infographic consists of four interrelated components.

Component D – Data Set. This component represents the informational content, i.e., all the data that needs to be conveyed to the user.

The data set may include: statistical indicators; textual information; numerical values; time series; process diagrams; analytical relationships. In other words, D is «what exactly needs to be communicated».

Component V – Visual Variables. These are means of visually encoding information, such as color, shape, size, contrast, texture, spatial arrangement, and typography. Visual variables determine: what the user will pay attention to, which elements will dominate, and how quickly the information will be recognized. For example:

- red color → emphasis;
- large size → importance;
- thick line → priority.

In other words, V is «how information is presented visually».

Component S – Structure. This element describes: the logic behind the infographic's design, the relationships between elements, the hierarchy of information, and the order of perception. Structure determines: the reading sequence, cognitive navigation, and cause-and-effect relationships.

For example:

- flowchart;
- tree;
- cyclical model;
- modular structure.

So S is «how the elements are connected to each other».

Component C is the context of interpretation (Context). Context determines: for whom the infographic is created, under what conditions it is perceived, what prior knowledge the user has, and what task is being performed. Context may include: the audience's level of preparation, educational background, cultural characteristics, presentation format, and technical environment.

For example.

The same infographic will be perceived differently by:

- a student;

- a professional;
- a schoolchild;
- a designer.

C represents «under what conditions and by whom the information is interpreted».

The infographic effectiveness model can be described by the function:

$$E = f(R, L, C_1), \quad (2)$$

where R – level of understanding;

L – cognitive load;

C₁ – user's cognitive characteristics.

The formula describes what determines the effectiveness of an infographic. The R component stands for «Understanding». It measures how well the user has understood the information, whether a correct mental model has been formed, and how quickly the content is interpreted. The higher the level of understanding (R↑), the more effective the infographic is.

Component L – Cognitive Load. This refers to the amount of cognitive resources a user expends to process information. Excessive cognitive load occurs when there is an overload of details, a chaotic layout, excessive colors, or complex navigation. If L decreases, the effectiveness of the infographic increases.

Component C₁ - user cognitive characteristics. These are an individual's personal traits, including knowledge level, experience, thinking style, visual literacy, working memory capacity, and analytical ability.

Thus, the model emphasizes that the same infographic can be effective for one audience and difficult for another. The model demonstrates that infographics are not merely graphic design, but that their effectiveness depends on the cognitive interaction between:

- data;
- visualization;
- structure;
- the user.

The scientific significance of the model lies in the fact that it allows for formalizing the infographic design process and evaluating the quality of visualization, predicting the effectiveness of perception, building adaptive multimedia systems, and, importantly, integrating AI and eye-tracking analysis.

Thus, the proposed formalization treats infographics as a cognitively oriented information system, the effectiveness of which is determined not only by the content of the data, but also by the manner of its visual representation, the structure of relationships, and the user's cognitive characteristics. The model demonstrates that optimal infographics should ensure a high level of information comprehension with minimal cognitive load.

Empirical studies show that the use of infographics increases retention by 20-40%, thereby reducing information processing time and improving the ability to transfer knowledge. Infographics also promote the development of systematic thinking.

Studies [12] have found that structured visualizations significantly improve data interpretation compared to textual descriptions.

As a tool for external validation of the proposed visualization models, we propose a cognitive-didactic model diagram: «Infographics → Attention → Cognitive Load → Learning Effectiveness.» The cognitive model of the impact of infographics on learning effectiveness is presented in Figure 1.

Cognitive Model of the Influence of Infographics on Learning Effectiveness

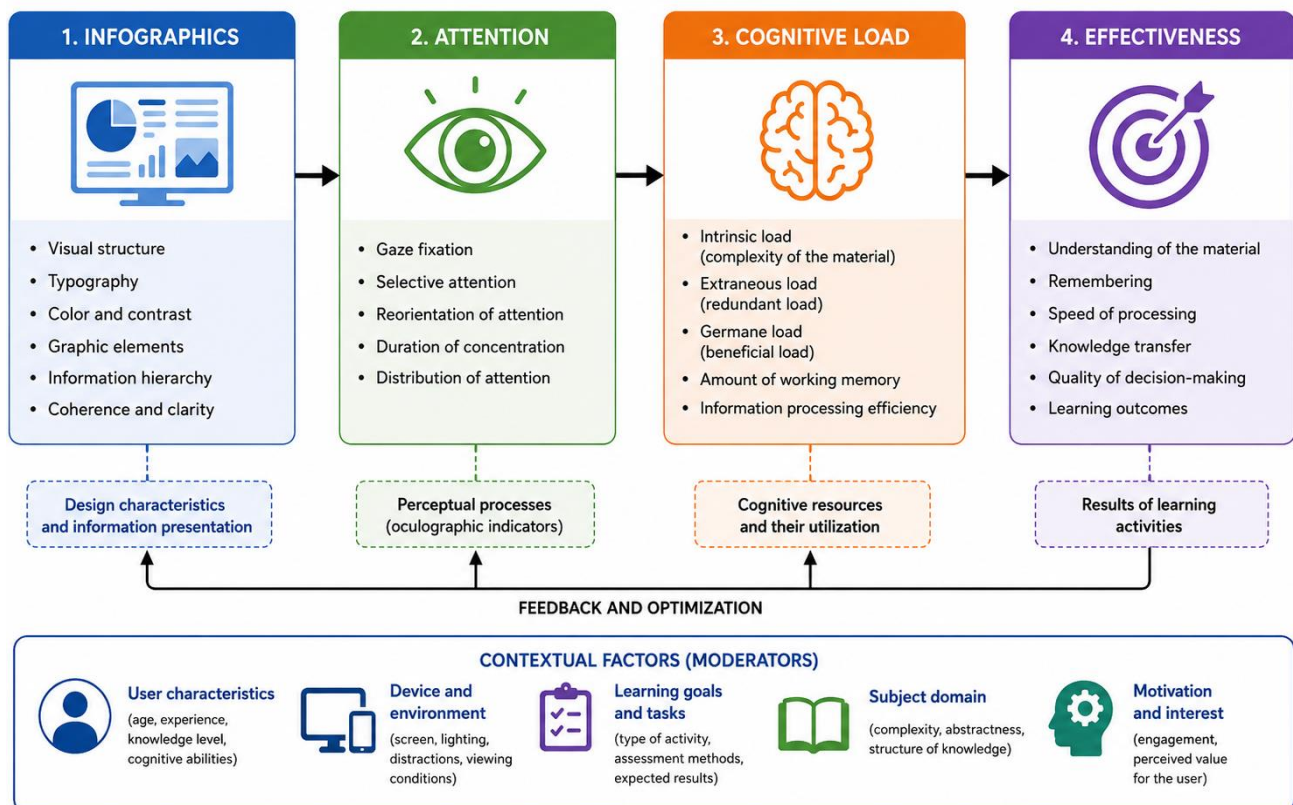


Figure 1 – A cognitive model of the impact of infographics on learning effectiveness (developed by the author)

The interpretation of the model can be presented as follows.

Infographics serve as the entry point and act as the primary informational stimulus that determines attention allocation, cognitive navigation, and the structure of perception. It should be noted that the quality of the design directly influences all subsequent stages.

Attention characterizes the perceptual level and is an intermediate variable that moderates the interaction between infographics and cognitive processes, determines which specific elements will be processed, and depends on: contrast, composition, and visual cues. Eye-tracking results (Heat Maps, Gaze Plots) are applied here.

Cognitive load characterizes information processing. This is the central level of the model, where interpretation, integration, and knowledge formation take place.

The balance between intrinsic (complexity), extraneous (noise), and germane (learning) factors determines learning effectiveness.

Effectiveness is the final outcome, manifested in the quality of learning, the speed of information processing, long-term retention, and the ability to transfer knowledge.

The cognitive model of the impact of infographics on learning effectiveness allows for a systematic description of the relationship between the visual presentation of information, attention mechanisms, cognitive load, and the effectiveness of learning material assimilation. The analysis revealed that infographics serve not only as a means of visualizing information but also as a cognitive tool for organizing learning activities.

The results confirm the feasibility of using infographics as an effective means of cognitive support for the learning process in the context of intensifying information flows. The proposed model can serve as a theoretical foundation for further research in the fields of visual communication, multimedia learning, digital pedagogy, and cognitive design.

Conclusions

Infographics are a complex cognitive-communicative system that combines visual, verbal, and structural components. Their effectiveness stems from their alignment with cognitive information-processing mechanisms and their ability to optimize the learning process in an environment of information overload.

Thus, infographics are an effective tool for optimizing the learning process in conditions of information overload. Their use allows for improving the quality of knowledge acquisition, developing cognitive abilities, and fostering modern educational competencies.

In the education system of the information society, infographics serve as a powerful tool for visual communication, optimizing the processes of perception, understanding, and memorization of information. They help overcome the barrier of complex educational material, making it accessible and easy to grasp without losing scientific depth. Further research in this area should focus on developing methods for the automated generation of educational infographics based on intelligent algorithms for analyzing text content.

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