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VISUALIZATION OF INFORMATION AS A DECISIVE FACTOR IN THE EFFECTIVENESS OF THE EDUCATIONAL PROCESS

Z. M. Selmenska, M. M. Dubnevych, O. M. Mykytyuk

Institute of Printing and Media Technologies, National University Lviv Polytechnic, Lviv, Ukraine
19 Pid Holoskom str., Lviv, 79020, Ukraine

Abstract. *The article considers the role of information visualization as one of the key factors in improving the efficiency of the educational process in the context of digitalization of education. The main types of visualization tools, their didactic functions and impact on the learning process are outlined. A comparative analysis of software tools for creating infographics (Canva, Piktochart, Infogram, Easel, Visualize, Adobe Express) is carried out, their advantages and disadvantages in terms of convenience, functionality, adaptability to educational purposes are highlighted.*

Results. *It has been found that the use of visualization increases the motivation of students, promotes a better understanding of complex information, improves memorization and analytical thinking.*

Novelty. *For the first time, an integrative approach to the evaluation of infographics software is proposed in the context of educational application.*

Practical significance. *The materials of the article can be used by teachers to improve the visual support of training courses, as well as by developers of digital educational products.*

Keywords: *information visualization, infographics, educational process, software, learning efficiency.*

Problem statement. The current stage of education development is characterized by the intensive introduction of digital technologies that transform traditional forms of presenting educational material. One of the key trends is the active use of information visualization, which contributes to a deeper understanding, memorization and assimilation of knowledge. In the context of information overload, the effectiveness of the educational process largely depends on the teacher's ability to structure and present complex information in a clear, visual form. This prompts the search for new forms of organizing the educational process, taking into account the psychological characteristics of information perception and cognitive processes of higher education students. Thus, the research problem is to identify the role of information visualization as a tool for optimizing the educational process, increasing its efficiency and motivational potential.

Therefore, the study of the role of visualization in the educational process is of particular relevance, because it acts as an intermediary between abstract knowledge and real learning, affecting the cognitive processes of students.

Analysis of recent research and publications. In the context of the digitalization of education and the growing role of multimedia technologies in the educational sphere, information visualization is increasingly seen as one of the leading factors in improving the quality of the educational process. In the last decade, there has been a significant increase in scientific interest in the visual representation of knowledge, in particular through infographics, digital charts, diagrams, knowledge maps, and interactive resources.

In particular, the works of such researchers as Mayer R.[1,2] emphasize the importance of multimedia design in learning: the author proposed a cognitive theory of multimedia learning, according to which the combined use of text, images, and audio stimulates active processing of information. Krauss J. and Boss S. [3] emphasize the effect of "visual thinking" in project-based learning, noting that infographics contribute to the development of analytical and critical thinking.

At the domestic level, the topic of information visualization in education is presented, in particular, in the works of L. S. Lytvynova [4], T. I. Bodnar [5], I. Holub [6], where the features of presenting educational material through graphic and combined visualization tools are analyzed. Thus, Panchenko R. and Cheremsky R. [7] in their work focus on the classification of infographics and define the criteria for its effective use in the context of a competency-based approach. Vovk O. V. [8] substantiates the use of infographics as a means of increasing motivation and the level of learning. The researchers emphasize that the visual structure of information increases its perception, allows to model complex relationships and simplifies memorization.

The number of publications comparing software tools for creating infographics is also growing. In the works of N. Smiciklas [9], Yildirim S. [10] conducted a comparative analysis of tools such as Canva, Piktochart, Venngage, Infogram, according to the criteria of accessibility, flexibility, and adaptation to educational content. Preference is given to those platforms that have educational templates, support for the Ukrainian language, a simple interface and the ability to export to PDF, PPT or integrate with LMS platforms.

Despite the existence of a significant number of studies, there is still a lack of a systematic approach to comparing programs in the context of specific educational tasks, taking into account the peculiarities of the Ukrainian educational system. Also, there are few examples of practical implementation of infographics in higher education: how visual tools affect learning outcomes, motivation, and the development of critical thinking skills.

Thus, the analysis of scientific sources suggests that information visualization is considered an effective tool in educational practice, but there is a need for further empirical research on the effectiveness of software tools for creating infographics within the educational process.

The purpose of the article. The purpose of the article is to analyze modern scientific approaches to the visualization of information in education and to evaluate the effectiveness of digital tools for creating infographics based on a comparative analysis.

Presentation of the main research material. Effective information visualization should meet several criteria: cognitive relevance (taking into account the peculiarities

of information perception), structural logic (hierarchy, sequence), aesthetic appeal and functionality.

Among the main criteria for the effectiveness of information graphics, researcher M. Smikiklas [9] identifies four key aspects: informativeness, design, credibility, and storytelling. Interactive infographics enhances the potential of each of these criteria, providing a multidirectional impact on the user through a combination of visual, functional and communicative properties.

Thus, informativeness means that interactive mechanisms significantly expand the possibilities of placing and structuring information. The developer of an infographic is not limited to the plane of a single image - part of the data can be displayed at the user's request. This creates a relatively compact, but content-rich resource that attracts attention for a long time.

The design provides dynamic effects, animation, and interactive transitions, which increases the attractiveness of the infographic, makes interaction with it more comfortable and emotionally rich. This enhances memorization and visual identification of the content.

Virality, i.e., the ability of content to spread independently without external promotion. This is an important advantage of interactive infographics. Its attractiveness, user-friendliness, and sharing features (e.g., buttons for sharing on social media) stimulate the organic distribution of content and attract a wider audience.

Storytelling improves the efficiency of learning, promotes concentration, and provides a better logical structure for perception. Interactivity promotes deeper immersion of the user in the content through the gradual disclosure of information.

Interactive infographics integrate the key features of modern multimedia educational materials: flexibility, information-centeredness, and personalized approach. Flexibility is characterized by the ability to quickly update information and vary the presentation of content depending on the user's request. This stimulates interest and supports active interaction. Information-centricity is ensured by hierarchical data structuring, which avoids overloading with details and provides access to deeper levels of content. A personalized approach is realized by customizing the infographic to the needs of a particular user or target group, taking into account their style of perception and cognitive characteristics.

Interactive elements, such as step-by-step scrolling, animation, questionnaires, and testing, enhance the learning process, help focus attention on key information, and encourage reflection and critical thinking. This significantly improves the quality of knowledge acquisition.

Thus, interactive infographics can be characterized as a highly effective tool that:

- allows you to compactly present a large amount of data;
- has an attractive design and adaptive structure;
- encourages the user to actively participate in the learning process.

In today's educational environment, educational literature based on digital technologies and multimedia tools is increasingly being introduced. One of these tools is infographics, in particular its interactive forms, which are most conducive to the

activation of visual perception. The gradual transition from static to dynamic formats is an obvious trend in the educational sector.

The analysis found that the use of infographics, interactive diagrams, video content, presentations, and font design significantly increases the level of knowledge acquisition, especially in visually oriented learning styles. In a digital environment (LMS, Zoom, Google Classroom, Moodle, etc.), visual content is increasingly important: it compensates for the lack of physical contact, promotes cognitive presence, and increases motivation to learn.

Interactive infographics stimulate analytical thinking, generate research interest, and allow for flexible handling of complex information. This is especially important for the development of professional competencies, as a modern specialist must not only have knowledge but also be able to systematize, analyze, and present it.

Given all of the above, it can be argued that infographics is not only a way of visualizing data, but also a full-fledged method of learning and developing cognitive skills. Its use is extremely relevant for modern learning, in particular in higher education, where the intensity of information flows requires new means of effective content presentation.

Comparison of software tools for creating infographics. In today's information society, infographics has gained the status of one of the most effective means of visual representation of data in education, marketing, journalism, analytics, etc. Developing infographics requires not only design skills but also a balanced choice of tools for its creation, which necessitates a comparative analysis of software tools, taking into account their technical capabilities, functional purpose, and compliance with the target tasks.

Currently, there is no universal answer to which software tool is effective for creating infographics. The choice of software depends on many factors: the amount of text content, the type and amount of data visualized, the availability of charts and graphs, as well as the requirements for the scale and expansion of the finished layout. In many cases, infographics are developed in stages using several software tools, which allows you to more efficiently create individual design elements that are subsequently combined into a single visual structure. [11,12]

All software platforms for creating infographics are divided according to the type of graphics used - vector or raster. The main advantage of vector graphics is its scalability without loss of quality: images are formed on the basis of mathematical descriptions (contours, lines, curves), which allows you to maintain clarity regardless of size. This is especially important in cases where infographics need to be scaled, for example, from A4 to billboard size. In contrast, raster graphics (based on pixels) lose quality when scaled, which limits their use in professional printing.

One of the most powerful tools for creating infographics based on vector graphics is Adobe Illustrator. This program allows you to create full-fledged infographic layouts without the need for third-party tools: it contains functions for building charts, graphs, illustrations, and text blocks, which ensures the integrity and control of the composition.

Adobe Photoshop, on the other hand, is a raster editor and is primarily focused on processing photos and images. Although some designers use it as their primary tool for

creating infographics, it has certain limitations: difficulty with scaling, lack of convenient tools for creating graphs, and limited support for vector objects. However, Photoshop remains useful in the final stages of design - for preparing graphic elements, editing and retouching images, and preparing the layout for printing.

Along with desktop programs, a number of online infographic creation services have become widespread, requiring no additional software. Among them: Canva, Piktochart, Venngage, Infogram, Easel.ly, Visualize.me, Creately, Hohli Charts, etc. These services are aimed at users with basic design skills and usually offer a library of templates, icons, color schemes, and integration with cloud storage.

Most online services work on the principle of template design: the user imports data, selects the type of chart (bar chart, line graph, pie chart, etc.), customizes its appearance, and exports the result in PNG, PDF, or SVG formats. These services are focused on simplified infographic creation and provide a wide range of tools for working with graphs, charts, text blocks, and visual elements. At the same time, templating and limited customization tools often lead to a loss of design individuality. This is especially critical for educational and scientific projects, where the visual identity must be unique and consistent with the academic style.

Table 1

Comparison of key criteria for infographic creation software

Criteria	Infogram	Visual	Canva	Easel	Piktochart
Appearance of the resource (1)	5	5	5	5	5
Content of the resource (2)	5	4	4	4	3
User-friendly interface (3)	5	5	5	5	5
Multilingualism (4)	3	1	5	4	1
Linking to social networks (5)	5	1	3	3	3
Possibility of full use without registration (trial period) (6)	0	0	0	0	0
Availability of free templates (7)	5	4	3	4	2
Ability to generate data from other sources (for example, Google) (8)	5	2	5	4	4
Ability to work from a blank canvas (9)	5	5	5	5	5
Ability to upload your own images (10)	5	5	5	5	5
Ability to save in various formats. (11)	5	4	4	5	4
Possibility of previewing (12)	5	5	5	5	5
Availability of an introductory video with the interface and features of the program (13)	3	4	4	4	5
Total points	56	45	55	53	47

The study conducted an analytical review of the above platforms - online services, in particular: Canva, Piktochart, Infogram, Easel, Visualize. Based on the functional characteristics and user experience, a system of key criteria for comparing infographic creation software was formed. For each of the criteria, a scoring was carried out, where 5 points means full satisfaction of the criterion requirements, and 0 points means its complete absence or unsuitability for the realization of the set goals. The results of the study are presented in Table 1 and graphically depicted in the diagrams in Figs. 1 i 2.

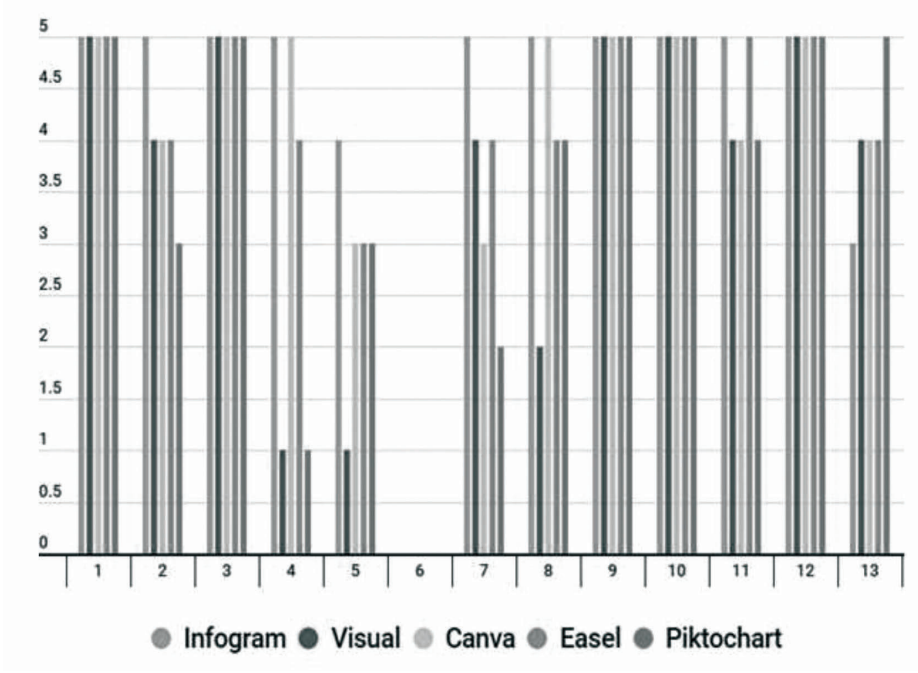

Fig. 1. Results of the scoring of key criteria for comparing infographic creation software

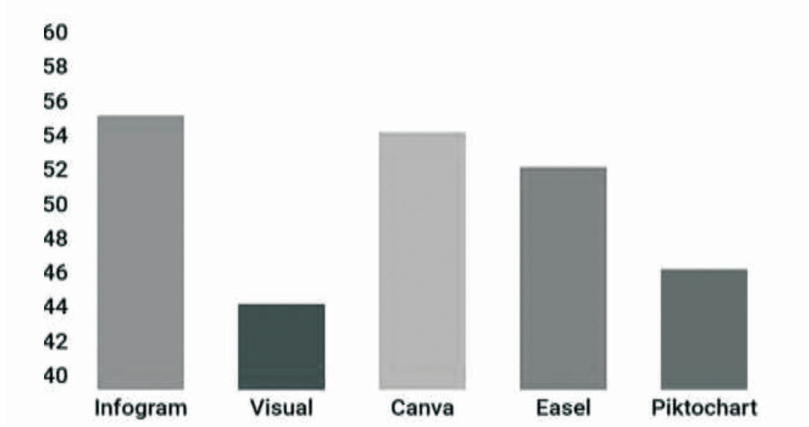

Fig. 2. Results of the distribution of online services by points received

Based on a comparative analysis of the functionality of five popular online infographic creation services, each platform was evaluated according to a set of key criteria: user-friendliness of the interface, flexibility of settings, quality of templates, export capabilities, support for interactivity, adaptability to educational needs, etc. The maximum score for all criteria was 65.

The evaluation results showed that Infogram (56 points), Canva (55 points), and Easel.ly (53 points) received the highest scores. These platforms are distinguished by an intuitive interface, a wide range of templates, flexible data visualization tools, and the ability to export infographics in formats suitable for educational or scientific use.

At the same time, services that have a limited set of templates or insufficient flexibility in customizing graphic elements proved to be less effective, which reduces their suitability for creating individualized or complex infographic projects.

To summarize, the choice of an infographic creation software tool should be based on a comprehensive approach that takes into account the technical characteristics of the editor, the specifics of the educational content, the requirements for playback quality, and the characteristics of the target audience. Vector editors provide high quality and flexibility in design, while online services allow you to quickly create basic visualizations, but are inferior in functionality and aesthetic variability.

Given this, it is advisable to use online services as an auxiliary tool: for the initial construction of charts and graphs, which are subsequently integrated into the main layout created in a professional graphic editor. This approach allows you to combine the convenience of quick visualization with the accuracy and scalability of graphics.

Conclusions. As a result of the study, a comprehensive analysis of modern scientific approaches to the visualization of information in the educational process was carried out, as well as a comparative assessment of the effectiveness of digital tools for creating infographics. It is analyzed that information visualization is a powerful pedagogical tool that helps to increase the motivation of students, improve the perception and memorization of complex material, develop visual thinking and analytical skills. The theoretical basis for the effective use of visualization is the cognitive theory of multimedia learning, which proves the feasibility of integrating visual elements into educational content.

The comparative analysis has shown that Infogram, Canva, and Easel.ly are the most optimal online tools for developing infographics in the educational context, given the combination of functionality, ease of use, and flexibility of visual presentation of information. Their use helps to increase the effectiveness of educational content presentation, in particular in distance or blended learning.

The results obtained can be used by teachers, methodologists, and e-course developers to make an informed choice of tools for visualizing educational material. Further research should be directed to an empirical study of the impact of different types of visualizations on the quality of knowledge acquisition in different forms of learning.

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ВІЗУАЛІЗАЦІЯ ІНФОРМАЦІЇ ЯК ВИРІШАЛЬНИЙ ФАКТОР ЕФЕКТИВНОСТІ НАВЧАЛЬНОГО ПРОЦЕСУ

З. М. Сельменська, М. М. Дубневич, О. М. Микитюк

Інститут поліграфії та медійних технологій Національного університету «Львівська політехніка» м. Львів, Україна
вул. Під Голоском, 19, Львів, 79020, Україна
Zoriana.M.Selmenska@lpnu.ua

Анотація. *У статті розглянуто роль візуалізації інформації як одного з ключових факторів підвищення ефективності навчального процесу в умовах цифровізації освіти. Окреслено основні види засобів візуалізації, їхні дидактичні функції та вплив на засвоєння навчального матеріалу. Здійснено порівняльний аналіз програмних засобів створення інфографіки (Canva, Piktochart, Infogram, Easel, Visualize, Adobe Express), виокремлено їхні переваги та недоліки з погляду зручності, функціональності, адаптивності до освітніх цілей.*

Результати. *Установлено, що використання візуалізації забезпечує підвищення мотивації здобувачів освіти, сприяє кращому розумінню складної інформації, покращує запам'ятовування й аналітичне мислення.*

Новизна. *Уперше запропоновано інтегративний підхід до оцінювання програмних засобів інфографіки саме в контексті освітнього застосування.*

Практична значущість. *Матеріали статті можуть бути використані викладачами для удосконалення візуального супроводу навчальних курсів, а також розробниками цифрових освітніх продуктів.*

Ключові слова: *візуалізація інформації, інфографіка, навчальний процес, програмні засоби, ефективність навчання.*

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