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MODERN TECHNIQUES OF DIGITAL VISUAL DIDACTIC CONTENT OF MATHEMATICAL, INFORMATIC AND NATURAL EDUCA TIONAL BRANCHES IN ELEMENTARY SCHOOL

The article clarifies the concept and features of the visual thinking development of primary school students. The effectiveness of visualization of didactic content in the primary school educational space is theoretically substantiated. Modern techniques of digital visualization of educational material in mathematics, computer science, and natural sciences are characterized. They are the following: scribing, infographics, intelligence cards, comics, crosswords, memes, book trailers, word clouds, etc. The basic principles of creation and presentation of didactic content in the format of digital visualization are singled out, in particular, principles of system quantization and cognitive visualization.

Keywords*: visual thinking; digital visualization; didactic content; primary school students; mathematics education; computer science education; natural education.*

Introduction. There is a tendency among primary school students to form ‘clip thinking’, which is characterized by simplified processing of visual information, the predominance of images or multimedia text objects. The creation of an educational and methodological complex should saturate the illustrative blocks of additional cognitive and productive information aimed at generating new knowledge, stimulating analysis, establishing cause-and-effect relationships, seeing trends, and forecasting the development of the educational situation. Visualization of educational material is a fast

and accurate way to convey verbal information through visual images. They are more understandable and ergonomic compared to text and numerical data. The advantage of visual aids is the ability to compactly present a large array of the same or different types of information, structure, and summarize it, which allows you to present educational material in a concise form.

The information content of modern didactic content requires special preparation of educational material before its presentation in the educational space. The teacher must have modern techniques for creating digital didactic content that will contribute to the effective teaching of mathematics, computer science, and natural science.

Analysis of recent research and publications. In psychological and pedagogical sources, much attention is paid to highlighting the importance of the usage of visualization in the educational process, the study of issues of application, and the creation of visual teaching aids. Psychologists (C. Jung, 1966; R. Mayer, 2001) emphasize that the effectiveness of such tools is due to the psycho-physiological features of the processes of perception and assimilation of information, their ability to provide logical and semantic support for the implementation of basic operations of mental and educational-cognitive activities.

In research by V. Bykov et al. (2017), L. Bilousova & N. Zhitenyova (2019), N. Gibalova & L. Protsai (2018), practical issues and technological aspects of training teachers to create visual teaching aids are considered. Many publications that contain practical recommendations for developers of visual aids for pedagogical purposes, focused on a certain type of such tools, such as presentations (Гібалова & Процай, 2021; Файда, 2019), mental maps (Шахіна & Медведєв, 2015), infographics (Логвіненко, 2018, Морзе & Буйницка, 2017), scribing (Моргунова, 2019, Білоусова & Життєньова, 2018) etc. or to use a specific visualization tool (easel.ly, infogr.am, pictochart.com). At the same time, the urgent need to prepare teachers for the independent creation of digital didactic visual aids actualizes the development of technology for their design. It is effective for different types of such tools and various tools that can be used for their digital implementation.

The purpose of the article. To characterize modern techniques of digital visualization of didactic content and the principles of their creation and presentation in the educational space of the primary school, to highlight the effectiveness of their use in teaching mathematics, science, and computer science education.

Presenting main material. In today's world, there is a trend of visualization, and interest in ways of processing and presenting the information. Well-known American futurist John Naisbitt has devoted his new book 'Megatrends' to the analysis of the present and forecasts of the upcoming development of education, noting that visual culture captures the world. After all, everyone knows that the human brain is arranged so that most of the processed external information is visual. In other words, we perceive the world around us with more than 90% of our eyes, and the other senses play only a supporting role.

Common in pedagogy is the term 'visual thinking', which is defined as a human activity, the product of which is the creation of new images, the creation of new visual forms that carry a certain semantic load and make meaning visible. Interest in the formation of visual thinking is growing due to the rapid development of various forms of information presentation and their combination. The main function of visual thinking, according to R. Arnheim, there is the function of ordering the meaning of images. No information about the subject can be passed on to the observer until the subject is presented in a structurally understandable form. It is the manipulation of the elements of the visible world that creates a new image and is the essence of visual thinking. It performs specific cognitive functions, dialectically complementing the conceptual study of the object, has a synthetic character: it arises on the basis of verbal thinking, but due to the connection with the transformed sensory material loses its verbal character.

Theoretical analysis of existing psychological and pedagogical approaches to defining the concept of visual thinking allowed us to identify the main components of its components, presented in Figure 1.

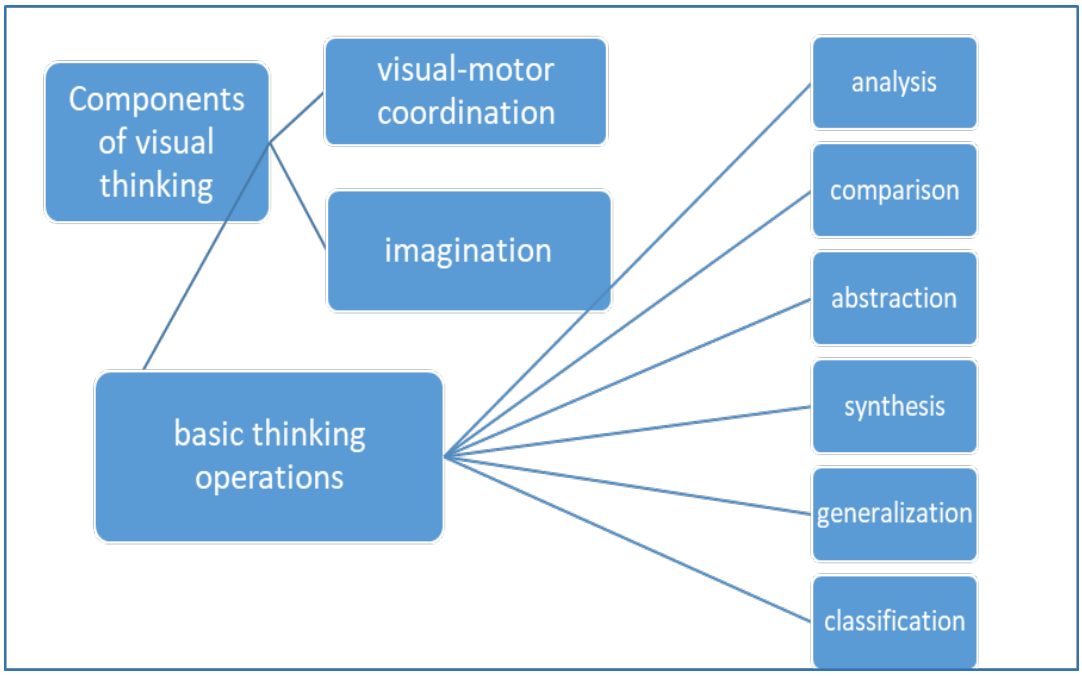

Fig.1. Components of visual thinking.

The specificity of the thinking of younger students is the age of perception and little visual experience. Providing generalized and dynamic ideas about the world around us, children's visual thinking is a process of modeling objects and phenomena of the surrounding reality, search and cognitive activity. The formation of students' visual thinking in learning has a number of advantages (Figure 2):

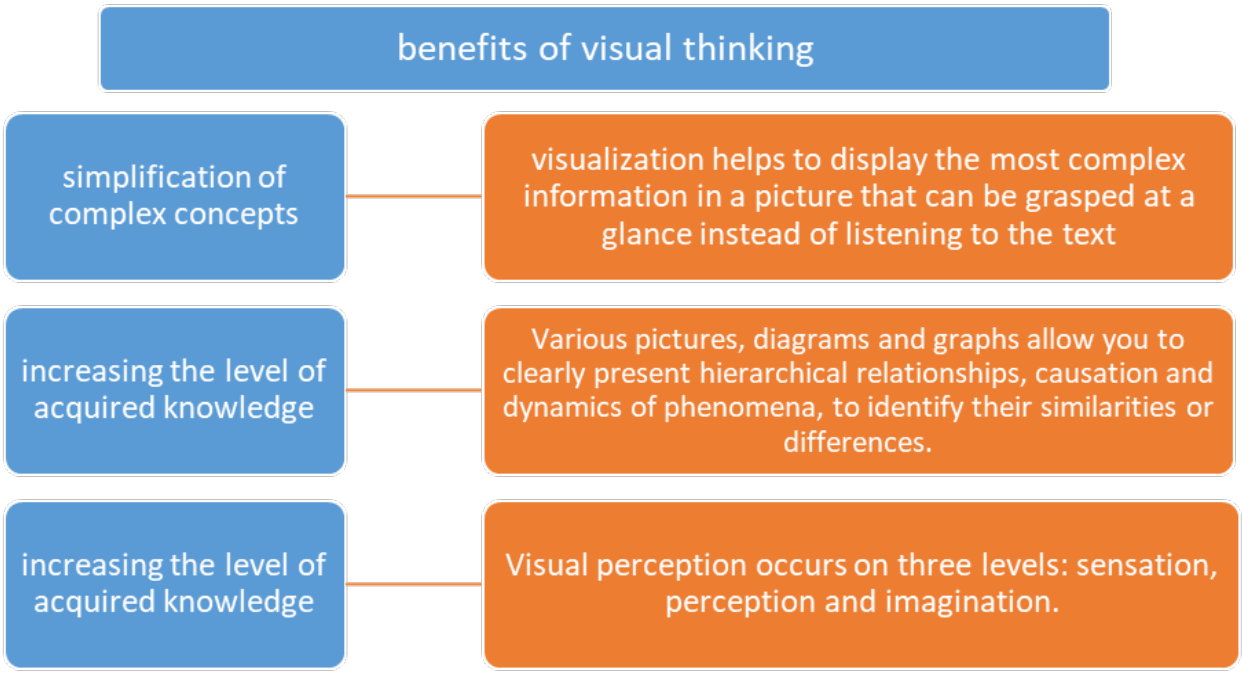

Fig. 2. Advantages of visual thinking

Researching the problem of information visualization in integration with the problem of digitalization of education can not do without the term ‘content’. Content means information content (text or visual), site content, books, etc. It can be text, video, audio, infographics, photos (or some other images). In the pedagogical literature, the term ‘didactic content’ occurs in the sense of an electronic educational tool. In our study, didactic content will be understood as information of any form, the content of which is educational in nature. The concept of digital visualization is interpreted by us as a didactic product (tool) created by using digital applications and saved in digital format or other formats. Digital didactic content can be stored locally or remotely via computer networks.

The technology of digital visualization of didactic content significantly expands the scope of their application in the educational process: facilitates the perception of educational information by students, presenting it taking into account their cognitive characteristics; promotes the formation of correct ideas of students about the object of study, eliminating the need to further correct the initial misconceptions; gives students the opportunity to focus on the main semantic elements of the educational material, highlighting them in the visual image and at the same time filtering out secondary and unnecessary details; allows to intensify the educational process by using the economic volume and time of presentation of educational material in figurative form; activates different types of thinking and memory of students; promotes better integration of new knowledge into the system of previously acquired, as well as their assimilation and memorization by students; develops students’ cognitive interest; gives the opportunity to create a positive emotional background in the lesson; facilitates the implementation of interdisciplinary links in learning.

The methodological foundation of the technology of digital visualization of didactic content is the principles of information visualization, the principles of system quantization, and cognitive visualization.

1. The principle of system quantization: large amounts of educational material are difficult to remember; educational material

presented compactly in a certain system is better remembered; effective memorization involves the selection of semantic reference units in the educational material.

2. The principle of cognitive visualization: the assimilation of educational material will be effective if the clarity in learning performs not only illustrative but also cognitive function, i.e. the principle of cognitive visualization involves the use of cognitive graphic didactic elements.

The functions of digital visualization of didactic content for the intensification of the educational process include:

1) compact presentation of educational material, which allows increasing the information content of the educational process;

2) concentrated presentation of educational material in a comprehensible form while preserving its semantic completeness;

3) ensuring the adequacy of the presentation of educational material to the psychophysiological characteristics of the student; 'Making knowledge visible', visualization helps to reduce the cost of time and energy of the student to perceive and understand a large amount of educational material;

4) maintaining a high pace of learning by reducing its inefficient or low-effective phases;

5) promoting the rational organization of educational and cognitive activities of students in the classroom through its algorithmization.

Types of digital visualization of didactic content: interactive – allows the user to analyze content while direct interaction with him; dynamic – time-line, which illustrates the dynamics of a particular event in time and space; static – the finished product is saved as an image file, after which it can be easily distributed online or printed on paper;

The use of techniques for visualization of didactic content is effective in terms of systematic use in the educational space of visual models of one species or a combination of species. We have singled out the following popular techniques of digital visualization of didactic content – didactic infographics, intelligence maps, comics, crossword puzzles, scribing, word clouds, and memes.

Didactic infographics is a graphic method of presenting didactic information in the format of instructions (fig. 3), explanation of the process or algorithm of action, display of dynamics, development of a specific process or activity, or in the format of video infographics.

Fig. 3. Infographics-instruction in the field of information education

The educational and developmental potential of using didactic infographics in computer science lessons is an effective visual means of presenting educational material to younger students, it promotes its assimilation, trains visual memory, develops imagination and thinking; helps the teacher to present didactic content in an organized form, easy to understand; review and summarize the key concepts of educational material on the topic. Didactic infographics are also means of pointing to action during a lesson. The development of visual thinking of primary school students through infographics allows primary school teachers to carry out the educational process in accordance with the requirements of modern visual and communication space. There are many services for creating infographics, such as Canva, Piktochart, Infogram, Visual.ly, Easel.ly**,** etc.

An intelligence card (mind map) is a complex diagram with a tree-like structure based on associations; the way of depicting the process of thinking with the help of schemes and images; an effective method for processing large arrays of information (Силкова & Лобач, 2018, p.182). Ideas are presented in a schematic format with the

addition of drawings and other auxiliary graphic elements (fig.4) (keywords on the theme, graphics, and arrows).

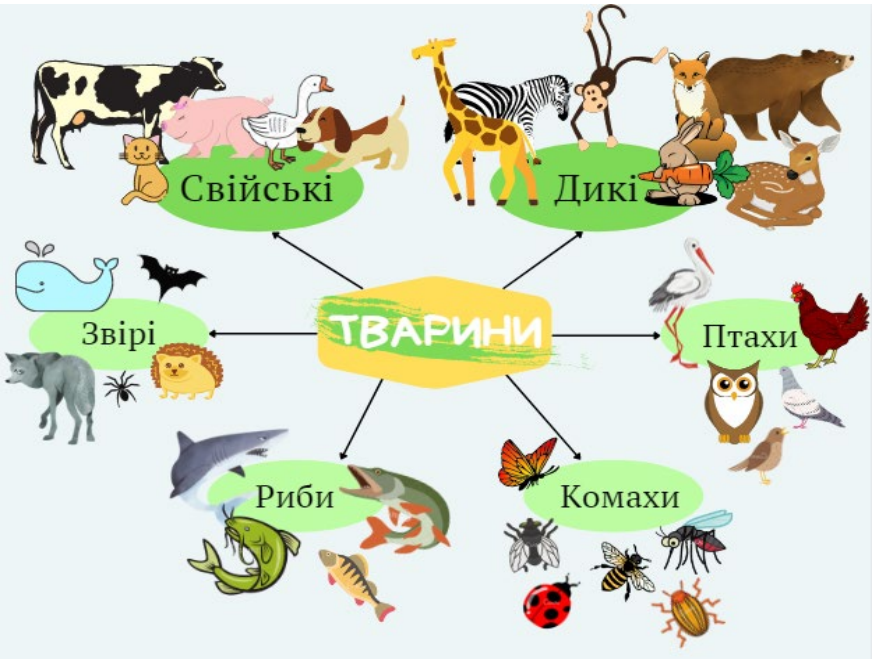

Fig. 4. Intelligence map of natural education

The educational and developmental potential of intelligence maps in science lessons are effective for the organization of the project, blended and distance learning, promote deep and intensive learning, and effective for systematization and generalization of knowledge. Technology teaches thinking, involves both hemispheres of the brain in active work, and forms an intuitive perception of information.

When building a mental map, different types of thinking are activated: figurative, associative, critical, creative, which increases the activation of students' learning activities, the ability to analyze, synthesize, the ability to work conclusions; form creativity, imagination, the level of formation of communicative skills increases; friendly relations are formed when working in groups. Smart cards can be developed by yourself with the help of markers, applications, as well as with the assistance of special computer programs: Freemind, Cacoo, Mindmeister; Mapmyself; Bubbl; Mindomo, Text2mindmap, Dabbleboard, Lucidchart, Flowchart, Mind42, etc.

Comics are effective for working with younger students. It is a literary genre, which is a series of illustrations combined with history, unity of story, and visual action; easily reflects the complexity and

problems of the environment. The use of comics allows students to perceive and memorize learning material better. Comics, as a form of graphic art and digital creativity, can make a lesson interesting and exciting. Working with comics helps intensify cognitive processes, and develop logical thinking and speech, motivating students in educational and cognitive activities. Didactic possibilities of comics: to tell a complex story in several images; provide commentary on any drawing on various topics; use symbols that are easy to identify for all students; the comic script simulates the culture of communication, life situations (adolescence, family relationships, tolerance, etc.). To create comics, there are services such as Pixton**,** Storyboard, Canva, etc**.**

Crosses is a puzzle based on the principle of associations, a collage of pictures connected by logical connections; a modern methodical method of visualization of educational material. The crossword structure contains nine images that are arranged so that each image is related to the previous and next. The central image can combine several images in meaning. There are two types of connections in crossword puzzles: superficial and semantic (deeper). It is advisable to use crosses in both the combined lesson and the test. Solving the crossword puzzle develops the ability to build deductive inferences, skills of working with information, increases the level of curiosity, and develops speech, and critical and creative thinking. Canva and LearningApps are well-known tools for digital visualization.

Scribing is the process of visualizing information in real-time, using a set of fonts, simple drawings, and graphic symbols.

Types of scribing: 1) static scribing (created on paper or graphics tablet during the lesson), 2) dynamic scribing (video scribing) – a dynamic video sequence with the voice of the speaker.

Didactic scribing reflects the teacher's language in graphic form, with the main points and keywords highlighted from the flow of information; the student simultaneously activates two channels of perception: audio and visual (Моргунова, 2019). Simple drawings, supplemented by text, evoke emotions, interest in the subject, and, hence cognitive activity. GoAnimate, PowToon, and Moovly are digital scribing visualization tools.

Word clouds are a visual representation of a list of words, labels, or categories in a single shared image (fig. 5). Using the technique of 'brainstorming', you can visualize the terminology of the educational topic of any educational field in a more visual way. The colored cloud of words catches the eye of the object and forces you to focus on specific conceptual categories. The cloud contains both visual information and content load – the text itself. This contributes to more efficient work with information.

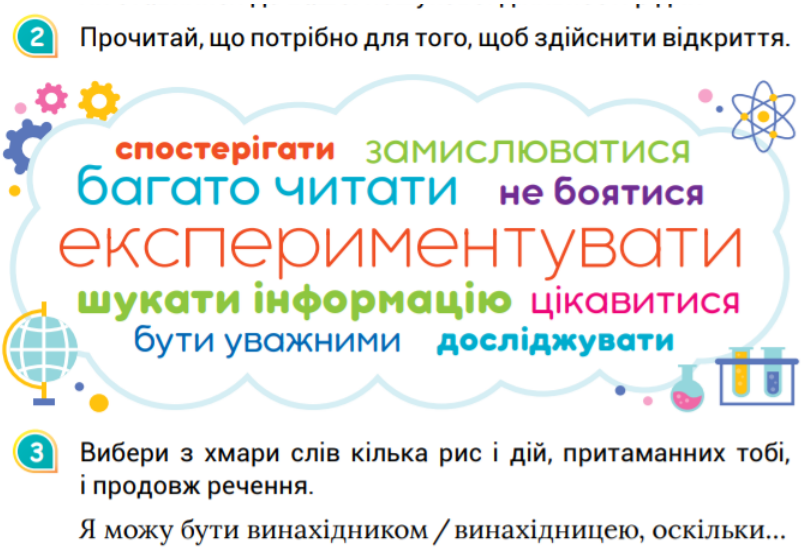

Fig. 5. Infographics – a cloud of words

Meme technology is a short witty phrase, image, or video of an ironic nature (Figure 6). Meme technology is easy to create and versatile; it can complement didactic content in any field of education. Used properly, memes can be an effective and creative addition to a lesson. Meme technology can be considered a kind of didactic infographic. For example, students can create a linguistic (mathematical) meme on their own or under the guidance of a teacher, in which information will be presented in a non-standard humorous way. Technology interestingly complements the educational process, namely develops observation, helps rethink information creatively, and teaches to make concise accents on the key points of the topic. Examples of digital meme visualization tools are the following: Risovach**,** Meme generator**,** and Meme arsenal.

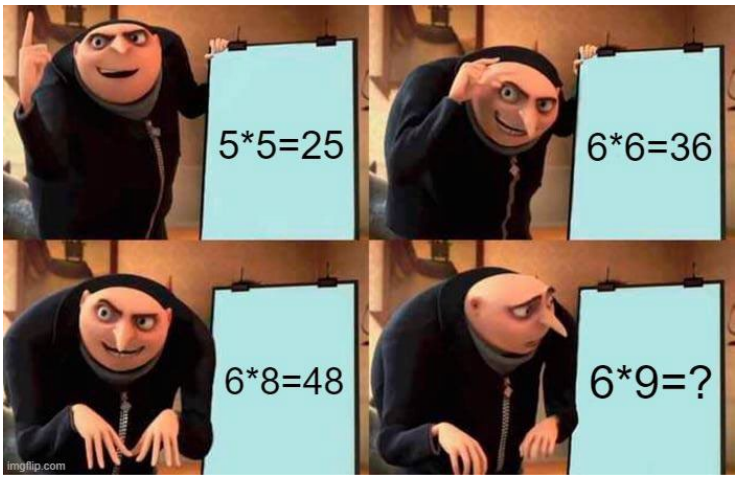

Fig. 6. Infographics - mem

We have developed general recommendations for creating an effective digital visualization of didactic content:

● Identify the main idea, target audience, and purpose of use.

● Highlight basic didactic information that should be most visible and understandable.

● Structure the visualization composition according to the type of object.

● Provide textual information concisely, do not place large amounts of text, use accurate headings and subheadings, and choose an easy-to-read font (Arial).

● Do not use unnecessary elements for decoration, as they distract from the perception of the main idea.

● Choose a color scheme consisting of three colors in combination with several shades.

● Use abstract associations, and intuitive and common symbols.

Conclusions and prospects for further research. Modern techniques and means of visualization of didactic content (didactic infographics, intelligence maps, memes, word clouds, crosswords, scribing) are characterized. Their didactic potential is described as an effective means of activating the educational activities of primary school students, which contributes primarily to the development of visual memory, imagination, and logical and critical thinking. Visualization of didactic content is an essential element of communication in the educational space New Ukrainian School, which facilitates the perception and understanding of information. Infographic manuals activate the process of perception and

understanding of information, ideas, and concepts, increase the ability to think critically, develop an organized idea and improve the assimilation of information.

We consider the problem of preparing future primary school teachers for the development of digital didactic infographics to be promising research. Digital literacy and digital creativity of the teacher in the practice of teaching students of the Alpha generation is extremely important, will allow the teacher to be original in the presentation of educational material, and thus guarantees successful didactic communication.

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СУЧАСНІ ТЕХНІКИ ЦИФРОВОЇ ВІЗУАЛІЗАЦІЇ ДИДАКТИЧНОГО КОНТЕНТУ МАТЕМАТИЧНОЇ, ІНФОРМАТИЧНОЇ ТА ПРИРОДНИЧОЇ ОСВІТНІХ ГАЛУЗЕЙ ПОЧАТКОВОЇ ШКОЛИ

У статті уточнено поняття та особливості розвитку візуального мислення учня початкової школи. Здійснено теоретичний аналіз існуючих психолого-педагогічних підходів до визначення поняття візуального мислення, виокремлено основні його компоненти. З'ясовано, що дидактичним завданням розвитку візуального мислення є спрощення подання складних понять, мотивація учнів до аналізу інформацію і як результат – підвищення рівня знань учнів.

Теоретично обґрунтовано ефективність візуалізації дидактичного контенту в освітньому просторі початкової школи. В дослідженні під дидактичним контентом розуміємо інформацію довільної форми, зміст якої має навчальний характер. Поняття цифрової візуалізації трактується нами як дидактичний продукт (засіб), створений за допомогою цифрових застосунків та збережений у цифровому форматі або інших форматах.

З'ясовано, що технологія цифрової візуалізації дидактичного контенту істотно розширює сфери їх застосування в освітньому процесі: полегшує сприйняття навчальної інформації учнями; сприяє формуванню правильних уявлень школярів про об'єкт вивчення; дає можливість сконцентрувати увагу учнів на головних смислових елементах навчального матеріалу, виділяючи їх у зоровому образі й одночасно фільтруючи другорядні та зайві деталі; активізує різні види мислення й пам'яті учнів; сприяє кращому включенню нових знань у систему раніше набутих, а також їх засвоєнню й запам'ятовуванню учнями; розвиває пізнавальний інтерес дітей; дає можливість створити позитивний емоційний фон на уроці; полегшує реалізацію міжпредметних зв'язків у навчанні.

Схарактеризовано сучасні техніки цифрової візуалізації навчального матеріалу з математики, інформатики та природознавства: скрайбінг, інфографіка, інтелект-карти, комікс, кроссенс, мем, буктрейлер, хмари слів тощо. Презентовано види цифрової візуалізації дидактичного контенту: інтерактивну, динамічну, статичну. Виокремлено принципи створення та подання дидактичного контенту у форматі цифрової візуалізації: принципи системного квантування і когнітивної візуалізації. Визначено основні функції цифрової візуалізації дидактичного контенту щодо вдосконалення навчання математики, інформатики та природознавства: компактне подання навчального матеріалу, що дає змогу підвищити інформаційну насиченість навчального процесу; концентроване подання навчального матеріалу в осяжному вигляді зі збереженням його семантичної повноти; забезпечення адекватності подання навчального матеріалу психофізіологічним особливостям учня; візуалізація, яка «робить знання видимим», сприяє зменшенню витрат часу та енергії учня на сприйняття й розуміння великого за обсягом навчального матеріалу; підтримання високого темпу навчання, скорочуючи його неефективні або низькоефективні фази; сприяння раціональній організації навчально-пізнавальної діяльності учнів на уроці шляхом її алгоритмізації.

***Ключові слова**: візуальне мислення; цифрова візуалізація; дидактичний контент; учні початкової школи; математична освітня галузь; інформатична освітня галузь; природнича освітня галузь.*

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