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M. Kalenyk
ORCID ID 0000-0001-7416-4233
Sumy State Pedagogical University
named after A.S. Makarenko

DIDACTIC FUNDAMENTALS OF USING MIND MAPS IN THE PROCESS OF TEACHING PHYSICS AT SCHOOL

The article is devoted to the study of the use of mind maps in the teaching of physics at school. The article examines the theoretical principles of using mind maps as an auxiliary tool for physics teaching methods, their advantages, and methodical recommendations for their use in the educational process. The possibilities of making and using mind maps in the process of teaching physics are considered, in particular for fixing and mastering the essential features of the content of the school physics course. Also considered is the use of mind maps for the development of critical thinking, the ability to work with various sources of information, to make interactive notes with the possibility of their further addition, to increase interest in learning and to develop students' creative abilities. The article contains practical advice on creating mind maps, their structure and use in the educational process. Emphasis is placed on the need to consider individual characteristics. It was found that the use of an intelligence map in the process of teaching physics helps students organize their project activities, teaches independent work and the ability to highlight the main points, to have the skill of interpretation, to be able to briefly and clearly formulate one's own thoughts and ideas. Modern analysis of the educational process and numerous studies have shown that making a mental map stimulates memory and allows students to see the root of the problem, to establish relationships, and the use of graphic visualization tools facilitates understanding of educational information, promotes better assimilation of the acquired knowledge. During the research, it was found that the use of the method of intellectual maps makes it possible to cover and formulate any topic as widely as possible, as well as to consider it from different angles, based on a fairly clear factual basis.

Key words: *content structuring, motivation, mind maps, work with educational texts, developmental learning, structural elements, component, communicative space, interactive notes.*

Formulation of the problem. Many studies in the field of psychology and pedagogy show that people absorb information most effectively when it is presented in a visual form. Sight is the most powerful of the five senses and provides 50 to 80 percent of information. Visualization of information is related to the fact that people remember images better than words, especially if you need to remember information for a long time. Understanding information presented in visual form provides stronger knowledge. One of the reasons people perceive images more quickly than text is the way the brain processes information. Drawings and images are read at once, while text is read sequentially, character by character. Each letter is perceived as a separate image, which is then combined into words and sentences [1].

The use of the information visualization method contributes to the development of "clip thinking" in the younger generation, which was noted by domestic and foreign psychologists and educators. Clip thinking is a way of perceiving information in the form of short graphic images with a minimum amount of text. However, this tendency can turn out to be negative, as it can lead to a decrease in attention and the difficulty of perceiving more complex texts. To overcome this negative tendency, students should be taught the correct use of graphic images and visual text.

The element-by-element study of the educational content involves dividing it into educational and didactic material, requires the organization of such activities of the teacher and students, the result of which is the formation of structural elements that are combined into a block system, the determination of what and how it is necessary to substantiate, prove, illustrate, etc. The result of this work must be recorded.

This is facilitated by the preparation of notes by students. This kind of work is not new in the methodology of physics. In practical work, the physics teacher needs to conduct explanations and demonstrations, considering that students have time to listen, observe the phenomenon, schematically sketch experimental setups and write down conclusions at the same time as the teacher works in the classroom. For drawings, drawings, concise notes of the main provisions, conclusions, laws, formulas, etc., students should have special notebooks that are intended for these notes. Such notebooks are needed even if there is a stable textbook. They are notes that facilitate and facilitate quick, easy learning of what is being studied. These notes allow students to easily recall at home everything they saw and heard in class. In the same way, they use notebooks when preparing for final certifications. By making notes, students learn to make their own conclusions, make drawings and sketches that explain the structural elements of the components of the content of the school physics course [2].

Mind maps (MM) are a way of visual representation of information that allows you to organize and structure thoughts and ideas in the form of a diagram. They consist of a central theme, which is presented in the center of the diagram, and branching off from it with sub-themes and ideas. This method allows you to visualize and structure a large amount of information, as well as analyze and synthesize different ideas.

One of the features of the MM method is that it uses both hemispheres of the brain. The right hemisphere perceives colors, images and pictures, while the left hemisphere works with logic, analysis and abstract concepts. Therefore, MM combines both types of thinking and allows to improve memory and analytical abilities.

In modern pedagogy, the MM method is widely used in education, as it helps students better organize information and remember it. The use of MM allows you to create more effective educational materials and reduce the load on students' memory. In addition, MM can be used to develop lesson plans, presentations, and other educational materials.

Thus, the method of information visualization, including the MM method, is an effective teaching tool that helps students better organize and remember information. It allows you to combine both types of thinking and promotes the development of memory, analytical abilities and creative thinking.

Mind maps improve understanding of material and stimulate students' thinking, helping them to perceive, process and connect information more effectively. This is especially useful for complex concepts and where you need to see the relationship between different aspects.

Mind maps can also be used as a tool for creating plans, organizing projects and managing information. They can help students structure their thoughts and ideas, simplify complex tasks, formulate questions, and build logical chains of reasoning.

Thus, the use of smart maps in the learning process can help students become more active participants in learning, develop their mental abilities, and improve their understanding of the material.

The use of multidimensional didactic tools, such as intellectual maps, allows to present information more effectively and demonstrate connections between elements of knowledge. Moreover, such tools allow you to condense and collapse information, presenting it in a more compact and convenient form. In addition, the use of multidimensional didactic tools helps to move from non-algorithmized operations to algorithmic structures of thinking and activity. Thus, such tools are an effective way to develop systems thinking and knowledge analysis [3].

In addition, the use of mind maps can help students organize and structure their thoughts more effectively, which contributes to a deeper and more meaningful learning of the educational material. They can also be used as a tool for preparing for exams and testing knowledge, helping to systematize and remember a large amount of information. In general, the use of mind maps in

education can significantly increase the effectiveness of the educational process and facilitate the assimilation of new knowledge and material notes.

The relevance of the research problem and its insufficient development in the scientific and pedagogical literature, namely the use of mind maps in the preparation and use of notes in the study of physics, determined the choice of the research topic.

Analysis of current research. For many years, the method of mind maps has been used in various fields and has proven its effectiveness in practice, it helps:

- effectively remember facts and dates,
- effectively plan your activities;
- solve various intellectual tasks.

The method of mind maps (MM) was first used in professional education, especially in the teaching of management and economic activities, but it was also used in school and preschool education around the world. Such interest is due to the fact that the MM method allows for complex solving of tasks related to learning, facilitates the integration of knowledge into cognitive structures.

There are several areas of application of the MM method in the educational process, including its use in the professional activity of teachers, individual work of students, collective work of students, the process of knowledge control and corrective pedagogy.

The technique of using mind maps was initiated by the writer and lecturer Tony Busen. This technique has shown high results in working with students. It was considered in their works by domestic researchers: O. Vishnevska, A. Makarovskikh, A. Ostroumova, A. Babich, K. Tabunova, T. Vakalyuk, I. Kindrat, A. Naidyonova, N. Tereshchenko and others [4; 5; 6; 7; 8]. In their research, the authors identify areas of application of the MM method in education:

- possibility of in-depth analysis of students' personalities;
- development of a correction program;
- stimulating the development of students' creativity;
- formation of general cultural competences (the ability to build logically correct, reasoned and clear oral and written speech), readiness to cooperate with colleagues, work in a team;
- development of skills related to the perception of information, its processing and exchange;
- the ability to implement the learning process in a short period of time;
- stimulate students' development of all types of memory and the ability to control their intellectual activity;
- in solving didactic design problems.

The problem of using mind maps in teaching physics as a means of visualizing knowledge and increasing the effectiveness of learning was studied by O. Smolyar, O. Borysenko, L. Polkovnikova, V. Baranova, O. Ivashchenko, M. Potiychuk, O. Krupska [9; 10; 11; 12; 13; 14; 15].

The application of the MM method in the professional activity of teachers is described in many studies. According to the authors, this method makes it possible to make classes more visual, to focus students' attention, and to make lecture material easier to learn due to a noticeable reduction in the amount of information and a visual display of connections between concepts, which contributes to a more thorough understanding of the educational material by students.

In the works of T. Vakalyuk, I. Kindrat, O. Naidyonova, and N. Tereshchenko, the enormous potential of using the MM method in the activity of the teacher as an effective means of presenting lecture material was revealed [5; 6; 7; 8].

IC models created by teachers may contain a certain subjectivity, as they reflect the professional views of teachers, and any qualified teacher brings his author's position to the interpretation of the subject.

Mind maps have several advantages when used in education. They can be used to accelerate the perception of the material due to the visual presentation of the entire content of the lecture, as well as reducing the time for preparing for classes. In addition, the MM method allows students to freely imagine the proposed stimuli and to systematize and summarize the material they have learned more quickly.

Maria Piera Fornari considers the application of the MM method for the didactic design of computer-based learning technologies. The proposed methods make it possible to realize the main advantages of MM in the tasks of supporting e-didactics [16]. Due to the great possibilities of visualization and methods of determining interdisciplinary connections, the MM method significantly reduces the time spent by the developer of educational programs on didactic design. The recommendations proposed by the authors of the study can be used to support the process of forming a list of interdisciplinary educational and cognitive tasks or competence-oriented tasks at all levels of educational process management.

The purpose of the article: to investigate the features and possibilities of using mind maps in the process of teaching physics, in particular for recording, mastering, illustrating the essential features of the components of the content of the school physics course, using them for the development of critical thinking, the ability to work with various sources of information, to make interactive notes with the possibility their further addition, increased interest in learning and development of students' creative abilities.

Research methods: study of scientific sources and methodical material; methods of analysis and synthesis, methods of generalization, induction and deduction, comparison, qualitative analysis of research results.

Presenting main material. Pier Paolo Bianchi suggests the joint activity of the teacher and students to restore the content of MM or to fill in the developed layout of MM [17]. In this technology, two types of associations are used:

For the effective use of the MM method in education, two types of associations are used: controlled and free. Guided association consists in the fact that learners are offered a stimulus word to which they must respond with a word that is semantically related to the stimulus. Free association, in turn, encourages the learner to freely imagine the proposed stimuli, expressed not only by individual words, but also by word combinations and phrases. Joint work with the teacher increases interest in the topic and increases students' motivation, which in turn contributes to better assimilation and memorization of educational material.

The MM method can really be useful for the individual activity of students. It allows you to improve learning and memorization of the material, as well as to increase the efficiency of work on projects and research activities.

Creating a mind map can help students better organize information and see connections between different concepts and topics. This can be especially useful for complex topics where there is a lot of information that needs to be linked and remembered.

In addition, the use of the MM method can reduce the time spent preparing for exams and tests, as it helps to organize and systematize the material. Instead of spending a lot of time reading and rewriting notes, students can use the MM method to absorb information faster and more efficiently.

Also, the MM method can be useful in planning projects and scientific activities, as it helps students organize their thoughts and ideas into logical chains and connect them to the final goal of the project. This can help students to work more effectively on the project and achieve the set goal.

David Greenberg's research touches on the issues of teaching psychological disciplines to law students and emphasizes the importance of using the MM method in this process. They claim that the use of MM allows students to better understand and remember educational material, as well as develop logical thinking and analysis skills. In addition, the MM method can be used as a means of monitoring and evaluating students' knowledge, which increases the effectiveness of education. The personal experience of the authors confirms that the use of the MM method really improved the results of practical training of law students [18].

Using the MM method as an interactive method of teaching lectures and practices is an effective way of attracting students' attention and increasing their activity in the learning process. Creating MMs in lectures allows students not only to systematize information, but also to visualize it, which contributes to better memorization and assimilation of the material. As a result of such an approach, students become more interested and involved in the educational

process, which in turn improves the quality of their knowledge and test results.

Bryna McLennan suggests that using the MM method when working on coursework and final projects can really stimulate a creative approach to writing texts and organizing information. This can be especially helpful for students who have difficulty organizing material and highlighting key ideas. However, it should be noted that the MM method is not a universal solution for all types of tasks and types of information. In some cases, it may be more effective to use other methods of organizing information and thinking [19].

In some studies, the application of the MM method in the collective work of students, as a means of developing plans and implementing projects, "brainstorming", presentations of completed works, has been considered.

The process of applying the MM method in planning and organizing educational projects is presented in the works of Andrew Gibson [20].

According to the described stages, work on a project using the MM method begins with establishing the relevance, goals and objectives of the project. At this stage, the topic and main directions of the research are determined.

Next, the material is collected and processed, which includes the study of information and its analysis. At this stage, it is important to search and analyze information that allows you to solve the set goals and objectives of the project.

After that, the material is systematized and a coherent text is compiled that reflects the results of the research. It is important to monitor the sequence of the presentation of information and the accuracy of its presentation.

Next, it is necessary to select drawings and photos that emphasize and complement the project material, making it clearer and more understandable.

At the stage of distribution of roles and responsibilities of group members, the tasks of each project participant are determined, as well as the distribution of responsibilities necessary for the implementation of the project.

Creating a creative product is one of the main stages of working on a project. Here the results of the research are processed in accordance with the tasks and goals of the project.

Project protection is the last stage of work. At this stage, the project is defended before the commission, which evaluates the work performed and makes a decision on the quality of the work and the degree of its compliance with the set goals and objectives.

In some works, the MM method is used to assess students' knowledge, as well as automated analysis of their learning of educational material. This makes it possible to increase the effectiveness of education and determine the individual needs of each student.

In addition, the MM method can contribute to the development of critical thinking, creative abilities, analytical and logical skills, which is also an important aspect of professional competence. When working with mind maps, students are forced to structure information, determine its importance and connection with other elements, analyze and generalize, which requires them to actively participate in the learning process and constantly develop cognitive skills. Thus, the application of the MM method in the educational process can significantly increase the effectiveness of training and development of students' professional competencies.

Indeed, the use of electronic services for the creation of MM makes it possible to create modern and effective educational resources that can be used in various forms of education, including distance learning and self-education. They can be accessed anytime and anywhere with the help of the internet, which makes them very convenient to use.

In addition, electronic IRs can contain multimedia elements, such as images, videos, audio, graphics, which makes the learning process more interactive and allows students to learn the material better. Electronic IRs can also have links to other resources, which allows you to expand your horizons and get a more complete picture of the topic.

In general, the use of electronic services for the creation of MM is one of the important tools in modern education, which allows creating modern and effective educational resources and teaching aids.

In addition, the electronic MM as a synopsis allows you to easily make changes and additions, including when updating educational programs and the appearance of new information. This allows you to maintain the relevance of the educational material and ensure its timely updating. Also, the use of electronic MM makes it possible to quickly move from one topic to another and quickly find the necessary information thanks to hyperlinks and structuring of the material. In general, the use of electronic MM as a means of creating an electronic synopsis contributes to more efficient and convenient learning of educational material.

However, the use of electronic MMs in the educational process, including their use as notes, is insufficiently considered in the educational and methodological literature.

Thus, having conducted a didactic justification of the application of the MM method in the educational process, it is urgent to identify the most appropriate software products for creating electronic MMs.

Indeed, today there are many software products for creating electronic MMs. Different services have their own characteristics and advantages. For example, online services do not require the installation of additional software and can be accessed from any computer with Internet access. Desktop programs often have more functionality and can work without access to the Internet, which allows you to keep data confidential. Mobile apps are usually easy and convenient to use on the go or away from home or school. However, the choice of the appropriate service depends on the specific needs of the user and requirements for functionality.

In addition to these features, some software products may also offer:

- MM export in various formats (for example, PNG, PDF, HTML);
- the possibility of working with several maps at the same time within the framework of one project;
- search and replace text in all associations of one or more maps;
- support of teamwork on the project;
- the ability to create a Gantt chart based on MM for project planning;
- the "think aloud" function, which allows you to record audio comments on associations and connections.

All these functionalities in electronic MMs help to improve the visualization of educational material and its structuring, which contributes to more effective memorization and understanding of the material. Also, the possibility of adding laboratory and practical tasks to MM allows students to better learn the material by applying it in practice. This can increase students' motivation to study the learning material and improve their academic performance.

For work, we mainly use the online service Coogle.

Features of Coggle:

- pop-up tips;
- export in PNG, PDF formats;
- joint work on the map, availability of chat and comments;
- history of changes (the slider moving along the scale returns the map to the desired section of editing);
- more than 1600 icons;
- the possibility of accessing the gallery of other people's maps;
- synchronization with Google Drive.

Simple controls (hints nearby), lines and blocks are easy to create, change direction. Paid rates allow an unlimited number of maps, presentation mode, shared folders, uploading high-resolution images, a wide selection of color schemes; adding a separate workspace, consolidated billing, user and term management, corporate identity.

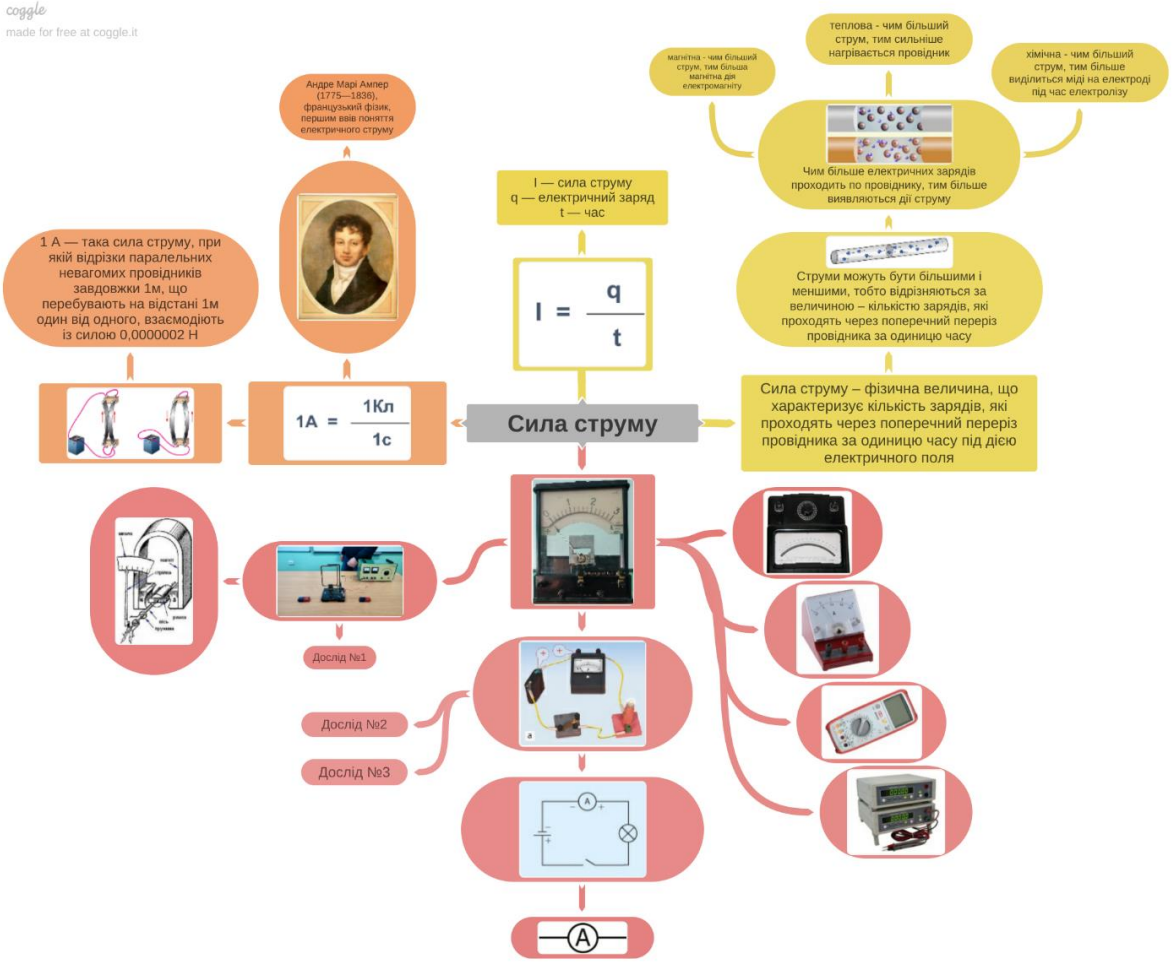

Fig. 1. Students' synopsis on the topic "Power of current" in the form of an mind map, created with the help of the online service Coogle.

There are several rules for the assembly of electronic MMs, which must be followed in order to form a complete structure with respect to the hierarchy of elements and connections.

To draw up an effective mind map, one should take into account not only the laws of structure, but also the laws of content and design.

According to the laws of content, it is necessary to: use key words and phrases that most accurately reflect the essence of the thought; avoid complex phrases and turns that distract attention from the main idea; use colors, icons, and other visual elements to improve information recall.

According to the design laws, it is necessary to: use a clear and understandable graphic structure that will help to easily perceive information; use different font sizes to reflect the levels of the thought hierarchy; adhere to the unity of style and color harmony.

Compliance with all these laws will help create an intelligence map that will be as effective as possible in transmitting information and memorizing material.

In addition, non-observance of the rules regarding the compilation of MM can lead to difficulties in its use and understanding, as well as complicate its further modification and refinement. For example, if ambiguous terms or inconsistent relationships are used in MM, this can lead to misunderstanding and misuse of the information received. Also, an incorrect hierarchical structure can lead to the fact that some important concepts are lost or distorted. In addition, failure to follow the principle of font hierarchy can lead to the fact that important elements are lost among less significant ones, which makes it difficult to understand the overall structure of the MM.

The presence of errors leads to a violation of the structure, incorrect visual perception of the map, which can affect the speed of learning material and the quality of the formation of a system characteristic of knowledge.

Compliance with the rules for the construction of electronic MMs allows:

- it is easy to update and correct information in the MM if necessary;
- reduce the time of preparation of educational materials, as most of the material can be transferred from existing knowledge bases;
- improve interaction between the teacher and students, for example, by using electronic feedback forms;
- make the learning process more accessible to students in remote regions or with limited mobility, as they can access MM from anywhere with Internet access;
- create more interactive educational materials, which may include audio and video materials, graphic elements, interactive tasks and tests, which can increase students' interest in the discipline being studied;
- create a common information environment that can be used by both students and teachers to share knowledge and experience;
- reduce the costs of printing and distributing educational materials, which can reduce the cost of education.

Conclusions and prospects of further scientific investigations. As a result of this reasoning, it is possible to highlight the principles of using electronic MM as a means of controlling the quality of knowledge: visibility, accessibility, individualization.

During the training sessions, students listen to the teacher, at various stages of studying the discipline, they compose and develop their MM workers, filling them with educational information. Supplement with hyperlinks, comments, visual objects. The teacher accompanies the student at this stage, helps in the formation of MM.

When studying the material, the student forms a personal information workspace based on electronic information channels. This space allows:

- present large amounts of educational material in a clearly structured and graphic form;
- quickly remember information using the properties of associative and visual memory;
- apply navigation using cross-links that direct the student to information both within blocks and modules and between them;
- use sources of information that are available on the Internet and on students' personal computers.

Electronic MM becomes a kind of electronic synopsis with a simple and clear structure that presents all the annotated educational material on one worksheet. Constant reference to MM helps the student remember its structure, using the properties of associative and visual memory. The electronic MM can be easily increased or decreased, expanded or collapsed depending on the need. The learner can open comments and additions to elements to repeat the wording of a given concept and clarify its characteristics. Using hyperlinks, the student can go to documents, sites, tests and other additional materials.

In further research, it is necessary to consider the use of MM during practical classes, where students copy practical tasks placed on cloud storage, perform them, save them on their disk space and add links to completed tasks to their work information maps, make a report on the completed work. Also, the issue of using mind maps in the process of organizing activities to solve physical tasks remains interesting.

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Анотація. *Стаття присвячена дослідженню використання інтелект-карт у навчанні фізики в школі. У статті розглядаються теоретичні засади використання інтелект-карт як допоміжного інструменту методів навчання фізики, їхні переваги та методичні рекомендації щодо їх використання у навчальному процесі. Розглядаються можливості складання й використання інтелект-карт в процесі навчання фізики, зокрема для фіксації та опанування істотних ознак компонентів змісту шкільного курсу фізики. Також розглядається використання інтелект-карт для розвитку критичного мислення, уміння працювати з різними джерелами інформації, складати інтерактивні конспекти з можливістю їх подальшого доповнення, підвищення інтересу до навчання та розвитку творчих здібностей учнів. Стаття містить практичні поради щодо створення інтелект-карт, їхньої структури та використання у навчальному процесі. Наголошується на необхідності врахування індивідуальних особливостей Виявлено, що застосування інтелект-карти у процесі навчання фізики допомагає учням організовувати свою проєктну діяльність, навчає самостійної роботи та вміння виділяти головне, мати навик інтерпретації, вміти коротко та чітко формулювати власні думки та ідеї. Сучасний аналіз навчального процесу та численних досліджень показав, що складання ментальної карти стимулює роботу пам'яті та дозволяє студентам побачити корінь поставленої проблеми, встановити взаємозв'язки, а використання графічних засобів візуалізації полегшує розуміння навчальної інформації, сприяє кращому засвоєнню отриманих знань. У ході дослідження було виявлено, що використання методу інтелектуальних карт дає змогу максимально широко охопити та сформулювати будь-яку тему, а також розглянути її з різних сторін, спираючись на досить ясну фактичну базу.*

Ключові слова: *структурування змісту, мотивація, ментальна карта, робота з навчальними текстами, розвиваюче навчання, структурні елементи, компонент, комунікативний простір, інтерактивні конспекти.*