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SECTION 5. THEORY AND TEACHING METHODS

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5.1 Application of mind mapping technique in teaching physics in general secondary education institutions

Modern education is dynamic and constantly changing under the influence of technological progress and the development of scientific approaches to learning. The introduction of innovative methods and techniques into the educational process is becoming an increasingly important task for teachers and educators, as it allows to increase the effectiveness of learning and the development of critical thinking of students. One of these innovative techniques is mind mapping, which can be useful for teaching physics at school.

The relevance of the study lies in the fact that physics is a complex and abstract science that requires students to have a deep understanding and ability to analyze. Many students face difficulties in learning this discipline due to the large number of abstract concepts and complex mathematical calculations. The use of mind mapping can facilitate the understanding and systematization of physical material, as well as stimulate students' creative thinking.

At the same time, at the current stage of education development, it is important to consider the individual needs and characteristics of students. Teaching methods should be adapted to different learning styles and psychological characteristics of students. In this context, mind mapping can become a tool that will help teachers and students improve learning efficiency and develop critical thinking.

Recent studies and publications on the use of mind mapping in education have shown that this method has a number of advantages, including

- Improves understanding and memorization of information.
- Promotes the development of creative thinking and the generation of new ideas.
- Increases motivation to learn.

The problem of using mind maps as an innovative way of organizing information in the educational process of higher education is raised in the scientific works of V.

Hryneva, S. Kobylianska, T. Koltunovych, N. Lobach, N. Oksentiuk, V. Osadchyi, O. Polishchuk, O. Rezvan, O. Romanovskyi, O. Silkova and others.

The purpose of the study is to determine the possibilities of using the mind mapping technique in teaching physics at school and to develop recommendations for teachers on how to implement this method in the educational process. The results of the study can be useful for teachers of physics and other science subjects, as well as for methodologists and educators working with students with different learning styles.

The concept of mind mapping and the use of mind maps in education have a fascinating history that combines psychology, education, and technology. They have become a powerful tool for creative thinking, learning, creativity, and planning.

Mind mapping has its roots in the work of the English psychologist and psychotherapist Tony Buzan. While working with patients and studying their thinking processes, he developed a methodology for creating graphic diagrams to represent information. The first important step in the development of this idea was made by Buzan in 1960, when he drew a "psycho-graphic" to represent thoughts and planning. This technique later became known as "mind mapping."

By proposing a graphical way to organize information, Buzan explored how the brain perceives and associates' ideas. His innovative approach was to use a central keyword or concept in the middle of a graphic diagram, from which various branches emerged to represent related ideas. This helped improve memory, association, and creative thinking.

Mind mapping has become popular not only among psychologists, but also among students, teachers, and anyone who wants to make their learning and work more effective. Boozan officially published his methodology in 1974 in the book "Using Mind Maps," where he first described the process of creating mind maps.

With the help of mind maps, students began to learn material faster, plan projects, and organize their thoughts better. For the first time, educators saw the potential of this method and its ability to improve the learning process.

As technology evolved, so did mind mapping. Starting with paper graphic diagrams, today there are numerous digital tools and programs for creating them.

The modern educational process is constantly improving and adapting under the influence of technological development and scientific research. One of the innovative techniques that is gaining more and more popularity in educational institutions is the mind mapping technique. This technique has deep theoretical foundations and can be an effective tool in teaching various subjects.

A mind map (mind map, intelligence map, memory map, mind map, consciousness map) is:

1) a set of diagrams and schemes that visually (in the form of "trees", linkage diagrams, lists and diagrams) demonstrate thoughts, theses that are interconnected and united by a common idea;

2) a way of depicting the process of general systemic thinking using diagrams;

3) a convenient tool for structuring information in a visual form (Fig. 1.1) [90, p. 182].

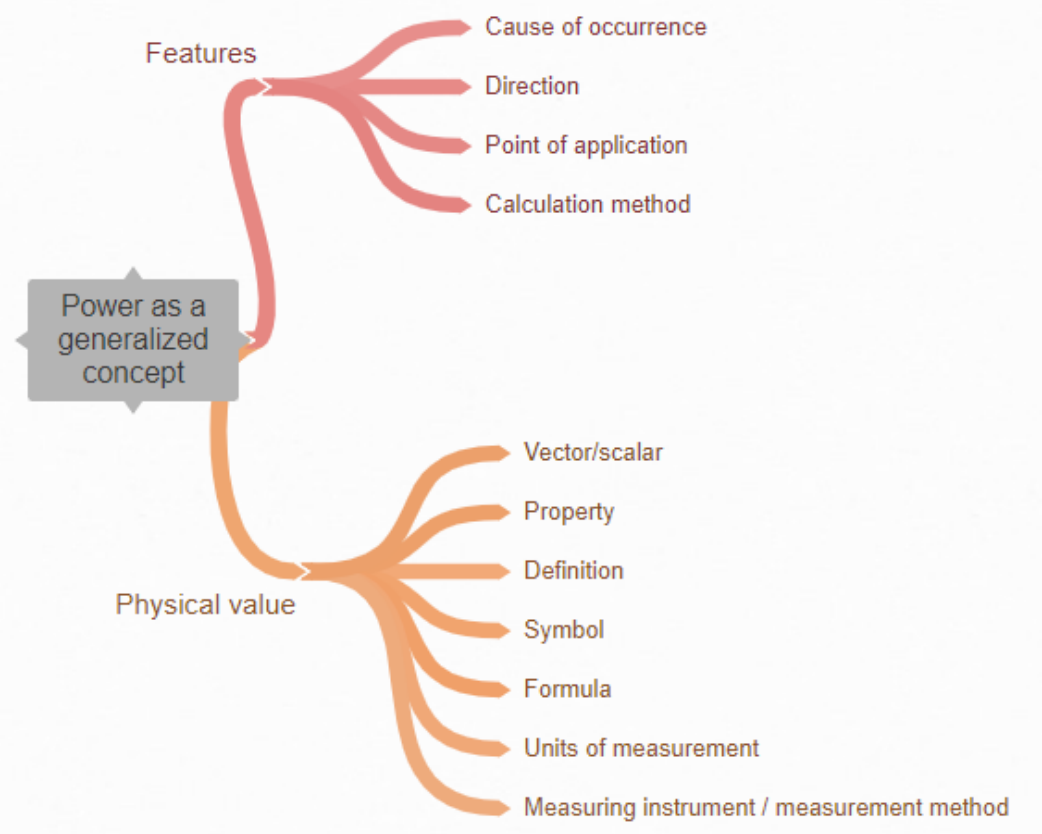

Figure 1. An example of a mind map

The concept of mind maps is based on the principles of the human brain. The peculiarity of mind maps is the activation of memory, visualization of thinking,

realization of its associativity and hierarchy (from general to particular) [91, p. 75], assistance in the holistic perception of the concept or problem under study. They allow "to look at the concept or problem, to see the whole "tree" [92, p. 65], to establish relationships (semantic, associative, causal) between the components of the object of study, to visualize its structure, logic, to implement individualization and differentiation of learning by choosing an individual trajectory by students.

In the process of building mind maps, there is a constant connection between the work of both hemispheres of the brain - the left (analysis of information) and the right (selection of complementary associative information that activates the thought processes of the right hemisphere) [93, p. 189-190]. Depending on the scope or application, T. Buzan distinguishes the following types of mental maps: - standard maps - a set of classic mind maps that serve to learn, record ideas and reveal one's own individuality; - speed maps or lightning maps - stimulate mental processes (what I know about this topic). The map can be, for example, a short one-color summary made before class; - master maps - very large maps of an entire field of knowledge, for example, based on the materials of one semester. They are often drawn up continuously and are intended to provide a general overview of the entire topic; - mega-maps - when the central map (with a relatively small number of levels) is connected to the following ones, which present details or additional aspects [95]. Mind maps can be created using online services or by hand on paper. The second option activates creative thinking, maintains the comfort of the student's thinking activity [93, p. 189].

In our opinion, the use of online programs and services for creating mental maps, such as Coggle (www.coggle.it), XMind (www.xmind.net), MindMeister (www.mindmeister. com), BubblUs (www.bubbl.us), MindMup 2 (www.mindmup.com), LOOPY (www.ncase.me/ loopy/), Mind42 (www.mind42.com), etc. are effective in the context of forming knowledge about the structure of the social competence of a future social worker. These programs differ in design, export capabilities, and management. Some programs will be more useful for personal use, while others will help you plan your work or study effectively. When building an intelligence map, it is necessary to follow a certain algorithm [93, p. 193;

96, p. 18]:

1) define the central concept (the object of study, the main idea);

2) select basic structural units that are related to the main object (main branches from the main concept);

3) arrange them in relation to the main concept (branches with words around the main node);

4) supplement the mind map with additional information (branches that extend from the structural units);

5) if necessary, edit the mind map (considering incompletely or exaggeratedly reproduced structural units). It should be emphasized that when mastering a topic in a lecture class, the first and second stages of creating a mind map are the responsibility of the teacher, the third and fourth stages are the responsibility of the students, and the fifth stage is a collective effort (of the teacher and students).

Independent construction of mind maps by students using the presented algorithm may involve an author's approach at all stages (depending on the task to be solved). When working on the development of mind maps, it is recommended to use several colors (at least three) to optimize the perception of information, highlight and structure thoughts: the central image and branches coming out of it should be depicted in one color, the colors of the branches of subparagraphs - in another color, and the inscriptions above them - in a third color; for particularly important issues, it is advisable to highlight the branches in warm colors, and make the inscriptions above them achromatic (black and gray) [94, p. 18].

Several branches should be used in the structure of the map [95, p. 65]; the branches should be alive, flexible, organic; only one keyword should be written on each line; the length of the line should be equal to the length of the word; the inscription should be written in block letters clearly and distinctly, varying the size of the letters and the thickness of the lines depending on the importance of the keyword, using drawings and symbols; for a small mental map, use an A4 sheet of paper, for a large topic - A3; overgrown branches should be placed in contours so that they do not mix with neighboring branches, and for better readability, place the sheet horizontally [95,

p. 69]. The analysis of the works of scientists [93, 96, 97, 98] and our own experience allow us to conclude that the use of mental maps in the educational process of a higher education institution in the context of the formation of social competence of future social workers contributes to the development of social competence:

- increasing the effectiveness of learning (for example, through categorization of knowledge, development of thesauri, visualization of the process of comprehension and assimilation of learning content) by activating students' cognitive interest, stimulating their logical thinking;

- comparing theoretical material with specifically practical one;

- development of social, professional, subject competencies (e.g., equipping students with social knowledge, subject knowledge, knowledge of "how to act" and "how to be", knowledge of the content of social competence, etc;)

- increasing students' motivation, quality of education and, as a result, their competitiveness in the labor market;

- activation of students' activities, organization of interaction between them in group work, development of communication skills, emotional intelligence;

- self-analysis (for example, when making a decision, determining one's own social or professional goals, life values);

- reflection (e.g., it allows to identify problems of understanding the content of information and timely adjust the logic of the process of its perception, makes it possible to identify problems of one's own social and professional development with their subsequent correction either in consultation with the teacher or independently);

- creating an atmosphere of relaxed communication and productive dialog.

There are many ways to apply the technique: by creating effective notes (it allows you to visualize the hierarchy and connections between topics and concepts, simplify information that is difficult to understand, and see the big picture), discussion templates, working on group projects, etc. You can use mind mapping technology during a lecture, a practical lesson, distance learning, in independent work, and to control the quality of students' knowledge. In particular, during the lesson - as an alternative way to record information, visualize information, visualize and explain a

complex problem, speed up the process of generating ideas (brainstorming), demonstrate concepts and diagrams, analyze results or events, identify the causes of cognitive difficulties, correct students' knowledge, summarize what has been done, organize interaction during group activities, as a way to actively listen and associate, etc. Before presenting the material, it is important for the teacher to identify the main key concepts that will be covered in the class, since the radial presentation of information should be based on the main nodal concept, which is then supplemented by associative connections. It should be noted that the use of maps saves time.

Mind maps represent a three-dimensional reality in space, time, and color. A mind map is always based around a central object, with each subsequent word and image, by definition, becoming the center of another association. The basis for their creation is radiant thinking - the natural ability of the brain to think associatively - "from the center to the periphery," i.e., it is a thinking process in which an object is in the center, which gives an impetus to the formation of many associations that become the central image for another associative process.

Thus, mental maps allow you to involve all parts of the brain in the process of perceiving and processing information. Also, based on the concept of "gestalt," which reveals the three-dimensional nature of the thinking process (information is distributed through brain regions in the most predictable way), it can be argued that mental maps allow you to study a certain object holistically, from different angles. This kind of information study is not available in a classical linear synopsis. Thus, as a reflection of radical thinking, mind maps form an external mirror that reflects what is happening inside you. This uses the potential of both the left hemisphere (graphic signs, symbols) and the right hemisphere (figurative pictures, color).

A mind map has four basic distinguishing features:

- the object of attention/study is focused in the central image;

- the main topics and ideas related to the object of attention diverge from the central image in the form of ideas;

- branches, which take the form of smooth lines, are explained and labeled with key images and words.

Ideas of the next order (level) are also depicted as branches extending from the central branches, and so on; the branches form a coherent nodal structure (system).

The mind mapping technique is a powerful tool for improving learning and developing students' critical thinking. It is based on clear and logical principles that help to structure information and understand its connections. mind mapping can be applied in teaching various subjects and meets the requirements of the modern educational environment, which seeks to develop students' creativity, independence and critical thinking. Therefore, its use in education should be seen as an innovative way to improve the quality of education and prepare students for the challenges of the modern world.

In the modern world of education, where learning is becoming more interactive and individualized, an important task for teachers and psychologists is to find effective teaching methods that would promote the development of creative thinking, increase motivation and improve students' mental skills.

The psychological aspects of using mind mapping in teaching include several important aspects:

1. Active learning: mind mapping promotes active learning. Students do not just consume information but create the structure of knowledge themselves. This active approach increases the level of engagement and understanding of the material.

2. Memorization of information: One of the benefits of mind mapping is the ability to better memorize information. Visualization helps to form associations, and the structure of the cards supports easy recall of knowledge from memory.

3. Development of critical thinking: When creating mind maps, students analyze and consider the connections between concepts. This contributes to the development of critical thinking and the ability to analyze information.

4. Increase motivation: The ability to create mind maps can increase students' motivation. They become active participants in the learning process and feel responsible for their own learning.

5. Adaptation to learning styles: mind mapping is suitable for different learning styles. It allows you to use visual, audio, and kinesthetic approaches to meet the needs

of different learners.

From a pedagogical point of view, mind mapping is also important:

1. Individualization of learning: mind mapping allows teachers to create individualized learning materials for each student, considering their needs and learning level.

2. Questions and focus of learning: Educators can use mind mapping to create questions and tasks that guide students to actively seek information and analyze.

3. Development of creativity: The use of mind mapping helps to develop the creativity of both students and teachers. Teachers can create engaging and interactive mappings for learning.

4. Monitoring and evaluation: Mind mapping allows teachers to visually track student progress and evaluate their achievements.

Considering the psychophysiological abilities of students, namely the fact that they have a predominantly visual and figurative type of information perception and thinking. When studying new material of theoretical or practical content, a diagram plays the role of a knowledge support. At the end of the topic, such schemes are used to summarize, reflect, and visualize the main material of the topic. Mind maps cover and help to record, memorize, connect, and display information visually. They are created on paper (the original method) or with the help of software, of which there are many types today. The main elements of the map are keys (or triggers) - words and pictures, each of which symbolizes a specific memory, promotes the emergence of new thoughts and ideas, and, therefore, helps to make full use of the mind's capabilities. Triggers radially diverge from the central idea through a series of connecting branches. The process of building a map imitates the behavior of neurons in the process of thinking when connections between them are activated [99, p. 234]. When building a mental map, various abilities of our thinking are activated. When compiling branches and keywords, we use hierarchies, for pictures we use visualizations and associative thinking, and in general, we use spatial and figurative thinking. All this activates memory and allows you to remember both the structure of the data and its important aspects, so the use of mind maps improves the memorization of information by about

32% [94].

The mind mapping technique combines psychological and pedagogical aspects, making learning a more effective and interesting process. It meets the requirements of modern education, which aims to develop creative thinking, critical thinking, and student independence. The use of mind mapping allows teachers and psychologists to promote the development of these important skills and achieve better learning outcomes. Thus, this technique has the potential to become an important tool in modern pedagogical practice.

The practice of using brainstorming in the classroom ensures the formation of professionally important qualities, the main ones being initiative, responsibility, activity, mobility and creativity of thinking. Every technique and tool has its advantages and disadvantages, and mind maps are no exception.

The main advantages of brainstorming are:

- provisioning equal participation of each member of the group in discussing the problem and putting forward ideas;

- opportunity fixation and permanent recording of the ideas put forward;

- favorable psychological microclimate;

- creation conditions for the emergence of a "chain reaction" effect of ideas;

- identical productivity at any stage of the decision-making process;

- visualization and structuring of information: one of the main advantages of mind mapping is the ability to visualize information and structure it into an understandable form. This helps students to perceive and memorize the material more easily.

- Stimulation of creative thinking: Mind mapping promotes creative thinking as students freely associate ideas and create new connections between concepts.

- active learning: When creating a mind map, students are actively involved in the learning process, structuring information and drawing their own conclusions.

- memorization of information: The visual nature of mind mapping helps learners to better retain information by creating associations and images.

- Adaptation to different learning styles: Mind mapping suits different learning

styles as it allows for visual, audio, and kinesthetic approaches.

Disadvantages of using the mind mapping technique in training:

- limited for some types of information: mind mapping may be less effective for structuring detailed and technical information that requires consistency and accuracy.
- sometimes requires more effort: creating complex mind maps can be more time-consuming than traditional teaching methods, which may not be feasible when time is limited.
- requires skills: to use mind mapping effectively, students need to have the skills to create maps and understand their structure.
- not always suitable for assessment: some teachers may find it difficult to assess mind maps because they can be less structured and uniform.
- not all students accept this method: some students may not feel comfortable using mind mapping or prefer other learning methods.

Obviously, the advantages of using knowledge maps in organizing learning activities are much greater than the disadvantages. Of course, everything is individual. Some people can't imagine their lives without mind maps, others have tried them but didn't find them useful, and others are just hearing about them for the first time.

The mind mapping technique has its obvious advantages, such as visualization of information, stimulation of creative thinking, and active learning. However, it also has limitations, such as limited effectiveness for certain types of information and a requirement for skill. It is important to take these advantages and disadvantages into account when implementing mind mapping techniques in the classroom and ensure that they are adapted to the specific needs of students and learning objectives. Overall, mind mapping can be a valuable tool for enhancing learning if used in accordance with the context and learning objectives.

Thus, the practice has shown that the use of mind mapping technology and the construction of mental maps as its main tool is appropriate in the process of forming the components of social competence of future social workers, as it allows:

- to activate the internal cognitive motivation of students (motivational and value component of the structure of social competence);

- acquire and structure knowledge about the content of the competence itself, the main areas of activity;
- to form social, professional, subject competencies; to activate students' activities,
- organize interaction between them in group work (cognitive-activity component of the structure of social competence);
- to form and develop communication skills, emotional intelligence, personal reflection, self-presentation skills, self-analysis, etc. (personal-reflective component of the social competence structure).

We believe that the prospect of further research is to reveal the possibilities of other innovative technologies that can be used in the process of training future social workers and forming their social competence. The mind mapping technique, which is based on a structured visual representation of information, has proven to be an important tool for learning and development in the modern educational environment.

The main psychological and pedagogical aspects of using mind mapping include increasing students' motivation and interest in learning, developing their creative thinking and analytical skills, and improving their self-regulation and independent learning skills. The use of visual diagrams helps to engage more sensory channels of perception, which improves understanding and memorization of the material. In addition, mind mapping promotes active learning, as students actively interact with the content, developing their own concepts and ideas.

So, we can conclude that the use of mind mapping in education has many advantages. It helps to visualize and structure information, which makes it easier to perceive and memorize. This approach develops critical thinking and contributes to a better understanding of complex concepts. mind mapping can stimulate creative thinking and promote independent learning. Its flexibility allows it to be adapted to different learning styles and types of tasks.

Therefore, the mind mapping technique is proving to be an important tool for learning and development in the modern educational environment. It helps to structure and visualize information, develops critical thinking, and stimulates students'

creativity. The psychological and pedagogical aspects of mind mapping emphasize the importance of this method for engaging and motivating students. The benefits of mind mapping in education are to improve understanding of the material, develop critical thinking, and create a favorable environment for independent learning.

All things considered, the mind mapping technique is a powerful tool for teachers and students that can improve the learning process, make it more effective and interesting, and promote critical thinking and creativity. The use of this technique in educational programs can help prepare competent and independent learners who can successfully cope with the challenges of the modern world.

In today's educational environment, physics teachers are faced with the task of making the teaching of this science more interesting, understandable, and effective for students. One of the ways to achieve this goal is to use mind mapping techniques in physics lessons. mind mapping can be a powerful tool for planning and organizing a physics lesson that will help students learn better, develop critical thinking, and stimulate creativity.

The development of a mind map includes the following main stages:

A central image is drawn in the center of the sheet, symbolizing the main idea.

From the central image, branches of the first level extend, revealing the central idea.

From the first-level branches (if necessary), second-level branches extend to reveal the ideas written on the first-level branches.

Wherever possible, symbols and graphics associated with key concepts and words are added.

If necessary, arrows are drawn to connect different concepts on different branches. The branches may be numbered for easier understanding.

Creating mind maps involves working with several colors (at least three), as color is a powerful tool of perception, and using it to highlight and structure thoughts is a must. The easiest way to use color is to draw the central image and the branches coming out of it in one color, the colors of the subparagraph branches in another color, and the inscriptions above them in a third color. Color should be used as effectively as possible.

Thus, according to T. Buzan, for particularly important issues, it is desirable to highlight the branches in warm colors and make the inscriptions above them contrasting (black and gray).

Planning and organizing a physics lesson using the mind mapping technique includes several stages [100]:

1. Defining the objectives of the lesson. The first step is to define the main goals and objectives of the lesson. Choose a specific topic or concept that you want to teach.

2. Create a central idea. Place a central idea that reflects the topic of the lesson in the center of your mind map.

3. Identifying key points. Identify the main points or key concepts that need to be covered in the lesson. Arrange them like branches coming out of the central idea.

4. Add details. For each key point, add details and specific information. Use short keywords, diagrams, and images whenever possible.

5. Specify the sequence. Determine the sequence in which you will present the material in class. A Mind Map can help you build a logical sequence of topics.

6. Add tasks and activities. For each key point, you can add tasks for students or ideas for activities that will help them to consolidate their knowledge.

7. Evaluation and correction. Before teaching the lesson, evaluate your mind map and make sure it meets the purpose and objectives of the lesson. Adjust it if necessary.

8. Use in the classroom. During the lesson, use the mind map as a supplementary material for explanations and as a tool to stimulate discussion and student responses.

The laws of mind maps, according to Tony Buzan, are divided into laws of content and design and laws of structure.

Mind mapping can be especially useful in physics classes with the following advantages:

1. Display a large amount of information: Physics contains many concepts and formulas. Mind mapping allows you to structure this information in an understandable and accessible way.

2. Helps to solve complex problems: Students can use Mind Map to analyze and solve complex physics problems.

3. Stimulates critical thinking: Mind mapping facilitates the analysis and discussion of physical phenomena and laws.

4. Increases motivation: Creating a mind map can be an interesting task that encourages students to actively participate in learning.

5. Improves understanding of physical concepts: Visualizing concepts and connections helps students better understand complex physics concepts.

The use of mind mapping techniques in physics teaching at school can be an important step in improving the learning process. It helps to visualize and structure information, develops critical thinking, and stimulates creativity in learning physics. Physics teachers can use mind mapping as an effective tool for planning and organizing lessons, which facilitates learning and increases students' interest in physics.

Learning physics can be a challenge for students because it often involves abstract concepts and complex mathematical calculations. However, one way to make learning easier and understand complex physical processes is to use mind mapping techniques to visualize and structure them.

Using mind mapping to visualize physical processes opens many possibilities. Here are some ways to help students better understand physical phenomena:

1. Charts and diagrams: Mind mapping allows you to create diagrams and schemes that illustrate physical processes. For example, to explain Archimedes' law, you can create a diagram showing a body immersed in a liquid and the resulting Archimedean force.

2. Sequence of events: mind mapping allows you to structure physical processes into logical sequences. For example, when studying mechanics, students can create a mind map that illustrates the movement of an object from point A to point B, including all the intermediate steps and forces involved.

3. Relationships and connections: Mind mapping helps to show the relationships between different aspects of a physical process. Students can use branches and connections to show how different physical quantities affect each other.

4. Examples and exercises: It is important to give students the opportunity to use mind mapping to solve specific physical problems and exercises. For example, students

can create a mind map to solve a problem about the movement of a body in an arc trajectory.

Creating mind maps is an interesting and exciting process. Moreover, thanks to programs for creating mind maps and online resources, the work will not take much time. Mind maps in physics lessons can be used at different stages of the lesson.

The use of mind mapping techniques to visualize physical processes is becoming an important element of physics education. It helps students better understand, memorize, and apply physical concepts. At the same time, mind mapping supports the development of critical thinking, creativity, and independent learning skills. Physics teachers can use this tool to facilitate the learning process and create a more effective and interactive learning environment.

It is important to use knowledge maps when summarizing and analyzing the material to create a generalized map, which can be the final work in the study of the section.

To intensify learning and cognitive activity, it is advisable to ask students to create mental maps related to the theoretical material they have studied. This practice develops students' memory, attention span, and interest. A mind map encourages learning in a way that connects all the blocks of material studied in class. After making mind maps, students should comment on their actions and try to use the map to reveal the essence of the topic. Even if students don't know how to use online services to create mind maps, you can teach them to draw them by hand on separate pieces of paper, in a notebook, or on the board. Drawing mind maps by hand stimulates thinking and encourages students to make non-standard decisions, create their own symbols and labels, and customize the scheme.

Using the mind mapping technique in physics classes has proven to be very useful and practical.

Below are some examples that illustrate how this tool can enhance physics learning:

- Visualizing complex concepts. Physics often contains abstract or complex concepts that are difficult to understand. Mind mapping allows you to create

visualizations of these concepts, which makes them easier for students to grasp. For example, creating a mind map to understand Archimedes' Law helps students more easily visualize the force of water lifting.

- Organization of the material. Physics involves a lot of theory and formulas. mind mapping helps to structure this material into a logical hierarchy, where the central idea can be a physical process and the branches of sub-items can be subtopics or different aspects.
- Active learning. Mind mapping supports active learning as students create visualizations and participate in the process on their own. They actively explore and analyze the material, which contributes to better learning.
- Increased motivation. Creating creative interactive mind maps can be a fun task for students, which increases their motivation to learn physics.

Implementing the mind mapping technique in physics lessons requires preparation and careful design. Here are some pedagogical recommendations:

- Preparing students. Begin by teaching students the basics of mind mapping, including creating a central idea and adding branches of sub-issues.
- Interactivity. Encourage students to actively participate in creating mind maps in class. Give them opportunities to discuss and share their visualizations.
- Application in different tasks. mind mapping can be used not only to study theoretical materials, but also to solve problems, laboratory work or projects.
- Open dialog. Teachers can openly discuss with students the advantages and limitations of using mind mapping in teaching, which will help them understand how this method is suitable for a particular class.

The use of mind mapping in physics lessons is a powerful tool for improving the quality of learning and increasing students' interest in the subject. It helps visualize complex concepts, organize material, and develop students' active skills. It is important to consider pedagogical recommendations for the successful implementation of this method and achievement of positive results in physics teaching.

Information about the content of the educational material studied in class is displayed by students in graphic images and in short notes, which are not the subject

of special memorization, but contribute to the restoration of the content of the studied educational material in the memory of students. Note-taking is carried out in the process of presenting educational material by the teacher and may be accompanied by the creation of mental maps.

The units of content of a school physics course are its components - physical phenomena, quantities, laws, etc. [104].

The content of each of these components is revealed through a system of statements about its essential features (structural elements), which can be contained in one or more textbook paragraphs, not necessarily placed directly after each other. Knowledge of a component is the knowledge of the complete system of its essential features (a block of structural elements or simply a block).

There are relations of sequence, intersection, and absorption between blocks and their structural elements. The essence of these connections is as follows: you cannot use those concepts that have not been revealed and realized by students. If only a part of the essential features of a concept is introduced, then the limits of its application should be taken into account when using it; for groups of questions of the school curriculum in physics that relate to specific components, there are similar sets of essential features; there is a hierarchy between the blocks, and the block of a higher rank includes some statements that generalize the content of other blocks of a lower rank.

The content of the unit is studied and mastered by students in the system of lessons - a cycle of the educational process, which has a structure consisting of the following elements: formulation of the educational problem and motivation of the next activity; forecasting the next activity - finding out what should be the end result of this activity; consistent introduction of essential features as the results of solving cognitive tasks; generalization and systematization of what has been learned; demonstration of the method of solving an educational (typical) task that specifies the educational problem.

All information related to the introduction of a unit of educational content is divided into educational and didactic material. Educational material is a statement about the essential features of what is being studied. Didactic material is the

information that helps to learn and master the educational material. Didactic material reflects the justification and illustrations, explanations of individual statements about essential features [104].

An example of an outline created during the study of the topic "Current Force" in grade 9 (Figure 2):

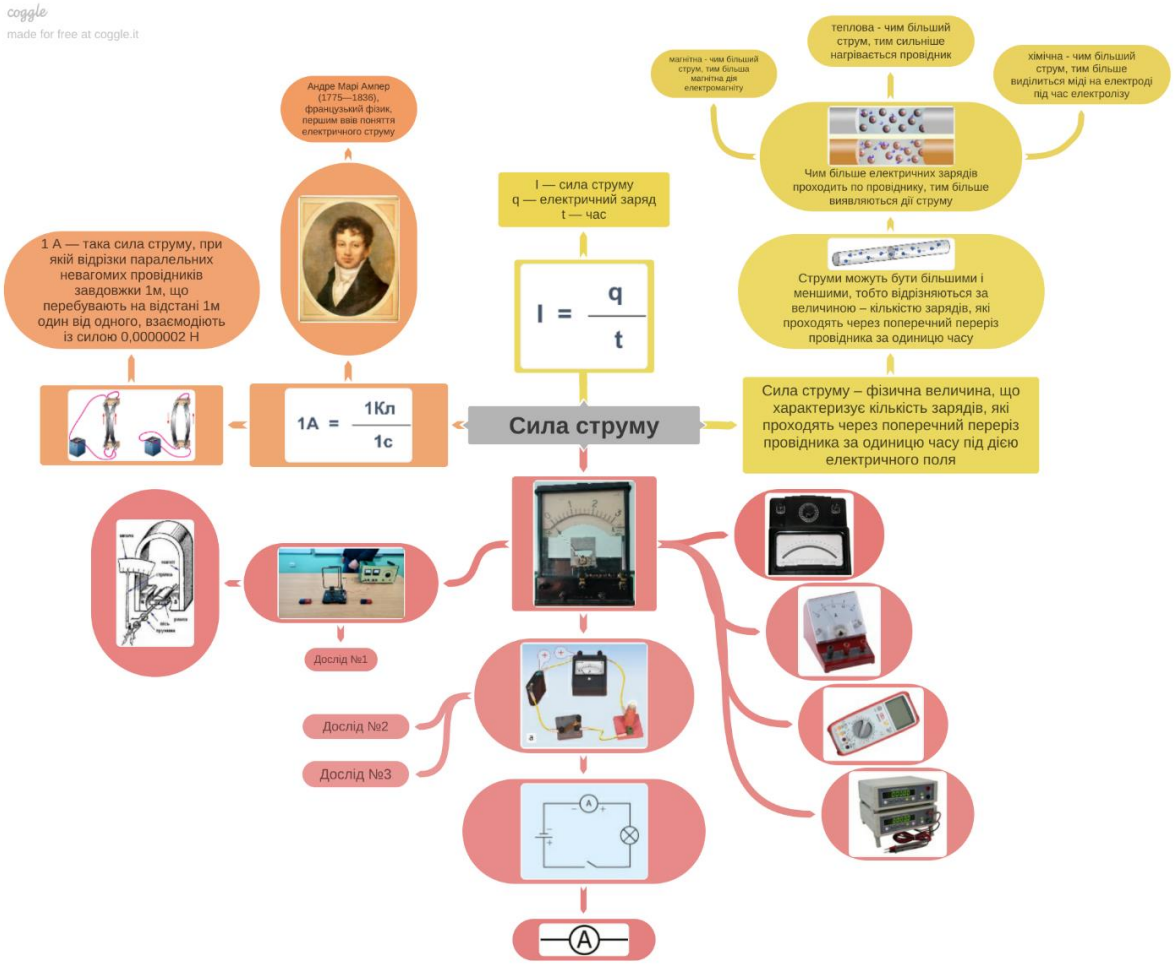

Figure 2. Students' synopsis on the topic "Power of current" in the form of an mind map, created with the help of the online service Coogle.

Working notes are used as a basis for reproducing what you have previously learned in the process of introducing new things and applying what you know to solve cognitive and practical problems. Full notes are used during homework to prepare for the next lesson.

The preparation and use of notes that correspond to the integrative model of the educational process are aimed at achieving the following goals:

1) to create in the minds of students a holistic view of the components of the content of the school physics course that correspond to the structural elements of

scientific physical knowledge; to overcome the disadvantage of traditional structuring of educational content - fragmentation of students' knowledge;

2) developing students' ability to substantiate, explain, illustrate individual statements, and draw conclusions; focusing students' activities on reproducing what they have learned to develop these skills in contrast to the traditional reproduction of textbook texts studied during homework;

3) development of graphic skills, which involves students' mastery of conventional images of physical objects defined by state standards;

4) rationalization of the processes of learning and reproduction of educational material;

5) reducing the overloading of students' memory with information that needs to be stored in long-term memory, since the result of studying a component of the content of a school physics course is knowledge of a system of statements about its essential features (there are relatively few such statements).

The use of multimedia and computer technologies allows us to modernize the processes of creating and using notes in physics lessons.

The notes made using mind mapping technology have peculiarities compared to those made by the teacher on a traditional blackboard and by students in their notebooks [105].

Entries of complete sentences and key (anchor) words, dynamic and static images of physical objects in mind maps can be mutually transformed.

The images of physical objects and their associated keywords reflect the justification of the relevant statements about the essential features of the subject matter being studied. To this end, images in a synopsis can be static or dynamic, reflect real or model imaginary physical objects, and be formed in stages or in full.

The notes can reproduce the content of textbook paragraphs and illustrations to them, as well as the content of educational and didactic material proposed by the teacher, which is an alternative to the first.

Individual fragments of the outline or a complete system of them are created after the introduction of the relevant educational material and commented on by the teacher.

The reproducible notes are commented on by the students.

Expandable notetaking is an approach that allows students to create compact but flexible notes that can be easily expanded and improved over time. This method fits perfectly with the mind mapping technique and becomes part of active learning in physics at school. Here is more about this approach:

1. Creating a basic outline. The student begins to create a basic outline where he/she records the main concepts, laws, examples and proofs from the physics course. This initial outline should be concise, retaining only the basic and key ideas that are necessary to understand the topic.

2. Use mind mapping. When creating a basic outline, a student can use the mind mapping technique to graphically represent the connections between concepts, laws, and examples. He creates a graphic diagram that shows the logical connections and hierarchy of information.

3. Allocate space for expansion. When creating a basic outline, it is important to leave room for further expansion. The student can add comments, hints, or blank sections that are left open in advance to be filled in with more detailed information.

4. Constant updating and supplementation. The learner regularly reviews his or her outline and adds new knowledge or extends it with more detailed examples. For example, they may add more formulas, graphs, experimental data, or their own reflections.

5. Connection to previous and subsequent topics. Each outline should also include connections to previous and subsequent topics. This helps the student understand how the topic fits into the overall context of the physics course.

6. Use of interactive tools. To facilitate the expansion of the outline, the learner can use interactive tools such as online databases, digital note-taking applications, etc. This will allow you to store additional material and resources.

7. Regular review and repetition. To truly consolidate knowledge and develop understanding, a learner should regularly review and revise their notes, expanding on them and adding new information.

Using this approach allows students to not only create a compact and easy-to-use

outline, but also to develop critical thinking, improve their ability to connect different concepts, and retain and expand knowledge throughout their schooling and beyond.

One of the conditions for the educational process to be aimed at the development of students' personalities is that it should be a process of consistent problem solving.

A feature of the modern educational process in physics is the conscious participation of students in the use of previously introduced concepts of the components of the content of the school course in physics and methods of educational activities at all stages. Therefore, the study of any new component of the content of the school physics course, which is carried out in the cycle of the educational process, involves not only the identification, generalization, systematization of its essential features, but also the formation of students' ability to use this knowledge in specific situations.

The contribution of solving practical problems to the formation of physical concepts is as follows: 1) the range of physical objects that correspond to the introduced concept is expanded; 2) the introduced concept is included in the general system of knowledge in this subject, because in the process of solving such problems, connections are established between the components of the content of the school physics course - their essential features, symbols.

To focus students' attention on the logic of solving typical problems, to develop their skills in organizing learning activities related to the application of the introduced concept to specific situations, it is advisable to use the technology of mental maps as a means of managing this part of independent work.

In preparation for a practical lesson, students solve typical problems on a given topic while simultaneously using the instructions on the monitor screen.

The text of the task, instructions with two answers to each of them, and comments on the implementation of the instructions appear on the monitor screen in sequence.

The instructions in their entirety reflect an algorithmic prescription. At the same time, they have certain features.

Algorithmic instructions for students should be concise and contain a relatively small number of actions. But each action should be as elementary as possible, i.e., such that almost all students can perform it.

For example, students receive instructions on the monitor screen in the form of an expanded branch of a mental map that can combine several actions performed one after the other.

Solving problems in physics requires both a deep understanding of physical principles and the ability to apply this knowledge to specific situations. To effectively solve physics problems and create algorithmic prescriptions for typical tasks, you should follow these steps:

1. Understand the physical principles. First, it is necessary to thoroughly understand the physical principles that apply to the problem at hand. This includes an understanding of the fundamental laws of physics, such as Newton's laws, conservation laws, work, energy, and other relevant concepts.

2. Identify known and unknown quantities. You need to clearly define what quantities you know and what you don't know. This helps to separate the data you need to use to solve the problem from the result you are trying to find.

3. Establishing a relationship between quantities. Knowledge of physical laws allows you to establish a mathematical relationship between different quantities in a problem. This relationship can be expressed in the form of equations or formulas, and it is used to solve the problem.

4. Algorithm development. At this stage, you create an algorithm for solving the problem. You write out the sequence of steps needed to calculate an unknown quantity based on known data and physical laws. The algorithm can include mathematical operations, formula conversions, work with units of measurement, etc.

5. Substitution of values and calculations. Now you have all the necessary elements to solve the problem. By substituting the known values into the algorithm and performing the necessary mathematical operations, you find the value of the unknown quantity.

6. Checking the result. After calculations, it is important to check the result. This

may include assessing the logicality of the result, checking the units of measurement, comparing with common sense, etc.

7. Create algorithmic prescriptions. If you are faced with typical tasks that have similar structures, this can be a great help. You can create algorithmic instructions that describe the general process of solving such problems. This will simplify and speed up solving similar problems in the future.

8. Exercises and improvements. Problem solving is a skill that improves over time. The more you practice solving different types of physics problems, the more you become proficient in this process.

With the help of algorithmic prescriptions, students can learn to systematically approach problem solving, develop analytical and logical thinking, and confidently cope with various types of physical tasks.

If an essential feature is introduced by means of, for example, one of the verbal teaching methods, then its formulation in relation to the demonstration experiment can be considered as a "hypothesis" that needs to be confirmed. In this case, based on the formulation of the statement about the essential feature, it is determined how to reproduce this subject of knowledge, an experiment is planned and conducted, and the results obtained are compared with the "hypothesis".

Thus, a physical experiment always reflects the general structural elements of volitional, conscious, purposeful activity - awareness of the purpose of the activity, drawing up its plan, implementation of this plan, and work with the result.

Of course, in each specific case, individual actions of the specified plan can be combined and, conversely, expanded by introducing new actions, for example, consideration of an example, installation, their structure, principle of operation, if they were not previously known to students.

A laboratory experiment in physics plays an important role in learning scientific concepts, developing practical skills, and testing theoretical predictions. In a laboratory experiment, students or researchers conduct specially designed measurements and investigations to obtain data and study certain phenomena. Here is a general outline of how to report and calculate errors in a laboratory experiment:

1. Introduction:

- Description of the purpose of the study and scientific hypothesis.

- Definition of the goals and objectives of the laboratory experiment.

2. Experimental part:

- Description of the special equipment used during the study.

- Measurements and data recording.

- Description of the research methodology and the use of measuring instruments.

3. Data processing:

- Calculations made based on the data.

- Inclusion of graphs, tables, formulas.

- Calculation of statistical parameters such as mean and standard deviation.

4. Analysis of results:

- Comparison of the results with theoretical predictions.

- Estimation of deviations and measurement errors.

5. Errors and uncertainties:

- Consideration of errors and uncertainties that occur during measurements.

- Calculation of systematic and random errors.

6. Conclusions:

- Summarizing the results of the study and answering the questions posed.

- Analysis of the results and justification of the conclusions of the scientific work.

7. An example of an error calculation scheme:

- Calculating the relative error: $\frac{\Delta x}{x} = \left(\frac{\Delta A}{A} + \frac{\Delta B}{B} + \cdots\right)$ is the sum of the relative errors of all the values that affect the result.

- Calculating the absolute error: $\Delta X = \Delta x \cdot X$, where ΔX is the absolute error, Δx is the relative error, and X is the measured value.

- Calculate the standard error of the mean value: $S\bar{x} = \frac{\Delta x}{\sqrt{N}}$, where S$\bar{x}$ is the standard error of the mean value, Δx is the relative error, and N is the number of measurements.

Laboratory experiments and reports include detailed data analysis and processing,

error calculation, and measurement accuracy assessment, which contributes to the development of scientific thinking and compliance with scientific methodology standards.

Systematizing and summarizing what you have learned is an important part of the learning process. This process helps students organize their knowledge, draw conclusions, and understand the connections between different parts of the material. Here are some key aspects of systematizing and summarizing what you have learned:

1. Organization of information. Systematization is the organization of the acquired knowledge in a logical order. This can include creating tables, graphs, charts, diagrams, schemes, or using other methods to present information.

2. Grouping by similar characteristics. Similar concepts or elements can be grouped into categories or groups. For example, learned theorems in mathematics can be divided into groups according to their properties.

3. Creating concept maps. Use mind mapping or other graphic techniques to create diagrams that show the connections between concepts and ideas. This contributes to a better understanding of important connections.

4. Conclusions and analysis. During systematization, students usually draw conclusions based on the material they have learned. They answer the questions "What have we learned?" and "How does this relate to other knowledge?"

5. Application in practice. Systematization not only helps in understanding information, but also makes it useful for solving problems and making decisions. Students should make themselves aware of how the knowledge they have learned can be applied in practice.

6. Review and update. Learning is an ongoing process. Once knowledge has been systematized and summarized, it is important to review and refresh it from time to time to keep the memory fresh.

Systematization and summarization help learners to better understand, remember, and apply learning material, as well as stimulate critical thinking and the development of analytical skills. This is an important aspect of learning that helps to create the basis for further knowledge acquisition and development.

Frontal and group questioning, or fill-in-the-blank memory mapping is a teaching method that helps learners actively interact with the learning material and test their knowledge at the same time. This method can be useful for learning a variety of subjects, including physics. Here's how it works and how to use it:

1. Create memory cards. Begin by creating memory maps where you note key concepts, formulas, or facts related to a particular topic in physics. Mind maps can be created on paper, a whiteboard, or even electronically using specialized software.

2. Group or frontal discussion. Divide students into groups or discuss the material together. This can be a group project or a frontal lesson where you explain and discuss the topic with the whole group.

3. Empty spaces. During a group discussion or lecture, use memory cards with some concepts or quotes missing. Students need to fill in the blanks using their knowledge.

4. Feedback. After students have filled in the gaps on the flashcards, give them feedback. Compare their answers with the correct answers and explain any errors or inaccuracies.

5. Review and summarize. To reinforce learning, review the important concepts and facts printed on the memory cards and summarize the topic. You can ask students how confident they feel about the material and decide if additional study is needed.

6. Practical application. At the end of the questioning and discussion, emphasize how this knowledge can be applied in practice in different physics situations.

Using this method helps to stimulate active learning, promotes interaction between students and teachers, and allows you to check the level of learning. Memory maps and fill-in-the-blank activities create opportunities for more effective understanding and memory of important concepts in physics and other subjects.

The mind mapping technique has become an important tool for improving physics teaching and developing the pedagogical process. Its use is aimed at facilitating the perception of complex physical concepts, stimulating active learning, and developing students' creative skills. However, this technique has the potential for further expansion and improvement.

1. Study the impact of mind mapping on students' academic performance.

One of the main prospects is to conduct detailed research to determine the impact of mind mapping on students' academic performance in physics. This could include comparing the performance of students who use this method with those who do not. Research could also investigate how mind mapping affects students' ability to solve complex physics problems and understand concepts.

2. Development of specialized mind mapping tools for physics.

Another perspective is the development of specialized mind mapping tools and programs that would be designed specifically for physics. These tools may include ready-made templates for creating diagrams and schemes for various physical concepts, as well as built-in functions for inserting formulas and graphs. The development of such tools can greatly facilitate the process of creating mind maps and make it more accessible to teachers and students.

3. Use of mind mapping for individualized learning and work with gifted students.

Mind mapping can be an effective tool for individualized learning and development of gifted students in physics. Prospects include the creation of individual mind maps for each student, where they can explore in depth specific topics of interest. It is also possible to consider creating specialized mind mapping tasks and projects for gifted students.

4. Integration of mind mapping into online learning and distance education.

As modern education is increasingly moving towards online and distance education, it is important to consider the possibilities of integrating mind mapping into these processes. The development of online platforms that support the creation and collaboration of mind maps can help teachers and students use this tool effectively, even when they are at a great distance from each other.

Another interesting area of research is to study the effectiveness of mind mapping in combination with other teaching methods and tools. For example, one could consider how the use of mind mapping in conjunction with interactive simulations of physical phenomena can improve understanding and memorization of material.

The first step to successfully using the mind mapping technique in teaching

physics is to prepare the teaching material. Here are some of the steps you can take:

1. Setting goals. First, you need to determine which physical concepts or topics you want to study using mind mapping. Will it be learning the laws of motion, optics, electricity, or other aspects of physics?

2. Structuring the material. Consider the material to be studied and divide it into logical parts or concepts. Ask yourself: "How can this material be structured to make it easier for students to understand?"

3. Create key concepts. Identify the main key concepts and terms that should be included in the mind maps. These will serve as the central nodes on the mind map.

4. Graphic design. Plan how you will visualize these concepts on mind maps. Use diagrams, colors, symbols, arrows, and other graphic elements to increase understanding and memorization of information.

The practical implementation of MIND Mapping in physics lessons can be divided into several steps:

1. Introduction to the concept of MIND Mapping. At the beginning of the school year or at the beginning of a new topic, give a short lecture or training on what MIND Mapping is and how it can be used to organize knowledge.

2. Create collaborative MIND MAPs. Begin by creating shared MIND MAPs on a whiteboard or projector with the class. You can start with a central idea and add sub-ideas as you discuss the material with students.

3. Individual mind maps. Distribute the task of creating individual mind maps among students. Each student should create their own visualization of a specific physical concept or topic they are studying.

4. Presentation and discussion. Students can present their mind maps in front of the class. This not only allows them to demonstrate their understanding of the material, but also facilitates discussion and exchange of ideas.

5. Use mind maps as a review tool. After completing a topic, students can use their mind maps to review and consolidate knowledge before tests or exams.

- Creating mind maps is an interesting and exciting process that your students will enjoy. However, we must admit that you will have to spend a lot of effort and

time working on the map - we have already talked about this in a separate article.

It is important to consider online services designed specifically for creating mind maps. Let's look at some of them.

Freemind is one of the most well-known and popular free programs for creating mind maps. It is very easy to work with, although you shouldn't expect to create masterpieces. The graphic elements offered by the program are not of very high quality, so it is better to attach your own, but Freemind does a good job of highlighting semantic blocks and designing simple diagrams. Students study this program in 7th grade computer science classes. Advantages:

- Intuitive operation.
- Availability of all the tools needed to build a map.
- Ability to save ready-made mind maps in any convenient format (PNG, JPEG, XML, HTML, XHTML, etc.).
- Support for different styles of structures and diagrams.
- Ability to link to external sources.

XMind is a great program that can be used to create handy mind maps and Fishbone diagrams, as well as to conduct brainstorming sessions. XMind has a nice interface, and it's very easy to understand the controls. And best of all, it's free.

Advantages:

- Creation of various types of schemes.
- Beautiful design, colorful layout - background for the entire map or for individual blocks, a large selection of styles, lines, colors, icons, and shapes.
- Many different tools and functions (setting any font parameters, editing and spell checking, external links, etc.)
- Several users can work on one mind map at once.
- Compatible with the Microsoft Office suite of programs.

Bubble is a handy online resource that allows you to quickly and easily develop bright mind maps. The resource is conditionally free: you can create 3 mind maps for free, but you will have to pay for more. However, it will be enough to familiarize students with the very principle of working with maps.

Advantages:

- Work in online mode.
- Easy navigation.
- Access for several participants at once.
- The ability to import the finished map to your website or blog.
- The language of the resource is English, but the interface is very simple and implemented with the help of graphic images.

The iMindMap service was created by the same famous author of the mind mapping methodology, Tony Buchanan, and therefore automatically deserves attention. Of course, the program is fully compliant with mind mapping technology, but you can use it for free for only 30 days. Then it is only possible to either delete or buy.

Advantages:

- It works in four modes: mind mapping, brainstorming, and capturing thoughts and ideas.
- It has about 130 types of styles.
- There are tools necessary for convenient work (spell checking, the ability to take notes and set your own formats, etc.)
- You can add audio files and images. "
- Exports files in PDF, SVG, 3D images, web pages, PowerPoint presentations, and archives them to a gif file.

Mind42 is a free online program that allows you to create a simple but clear mind map without any hassle. This is a great option if you are just starting to teach students how to create mind maps.

Advantages:

- Possibility of group work.
- User-friendly interface.
- Integrated image search via Google.
- Ability to take notes.
- Compatible with similar programs.

Since mind mapping helps to visualize and organize information, it is ideal for teaching the topic of gravity in physics class. Let's take a look at an example of how this technique can be implemented in the classroom by creating a mind map:

Lesson topic: Gravity

The order of using mind mapping:

1. Introduction (15 minutes): Begin the lesson with a brief introduction explaining that you are going to be learning about gravity. Provide background and motivation for the topic.

2. Creating a shared mind map (15 minutes): As a group, work with students to create a mind map on the board or overhead projector. Ask students to name the key words and concepts they associate with gravity and add them to the picture.

3. Individual mind maps (20 minutes): Give students a piece of paper and colored pencils and ask each student to create their own mind map on the topic of "Gravity." Give them a free hand but remind them of the importance of including the main concepts and ideas.

4. Presentation and discussion (15 minutes): Ask students to present their mind maps to the class. They can talk about the concepts they have chosen and how they visualized them. After each presentation, discuss the map and the importance of the material presented.

5. Wrap up the lesson (10 minutes): Summarize the lesson, emphasizing the main ideas and key concepts that have been learned. Give students independent study and review tasks, such as additional exercises or reading.

Using the mind mapping technique helps students structure information and store it in an easily accessible and visually appealing format. This approach makes learning physics more interactive and understandable.

The general description of the results of the study "Implementation of the mind mapping technique in teaching physics with a focus on the topic 'Gravity'" indicates how the use of this technique affects the learning process and students' understanding of the topic "Gravity". The study included an analysis of the psychological and pedagogical aspects, advantages and disadvantages of using mind mapping in physics

teaching, as well as the study of practical experience in using this technique and recommendations for its further improvement.

The study showed that the use of mind mapping techniques improves students' perception and understanding of the material. Visualizing concepts helps retain information and improves memory. Students are more engaged in the lesson and can create their own connections between concepts.

Using mind mapping allows you to structure information, emphasize the main ideas, and show the connections between them. Students create their own cards, which helps to individualize learning. In addition, this technique increases creativity and analytical skills.

Disadvantages of using the mind mapping technique: Some students may find it difficult to create mind maps or perceive them as an additional learning burden. It is important to provide support and instructions on how to create mind maps.

Practical experience has shown that students have experienced improvements in organizing and learning the material. They learn new concepts more easily and retain information better.

The analysis of the impact of mind mapping on the level of students' learning of physics reveals important aspects that can improve the learning process and students' understanding of physics. The study shows that the use of mind mapping allows you to structure information, improves perception, and promotes knowledge retention.

One of the key aspects that affect the effectiveness of mind mapping in physics teaching is the psychological component. The use of graphic diagrams helps students visualize and analyze information. They can see the relationships between different concepts and structure the material in the form of a tree or network. This contributes to a better perception and assimilation of the material.

Students feel more confident in their own knowledge because they create mind maps on their own, which increases their engagement in learning and self-discipline. Graphical representation of information can also make it easier to memorize and apply knowledge in practice.

Research has shown that students who use mind mapping show improved learning

compared to traditional teaching methods. They are more likely to show a deeper understanding of concepts and can answer questions and solve problems more easily.

Recommendations for practice:

1. Preparation of educational material: Teachers should create or provide students with ready-made mind maps for learning the material. This can greatly facilitate the learning process.

2. Lesson organization: The use of mind mapping can be integrated into the structure of the lesson, where students first create their cards and then discuss them with the teacher and classmates.

3. Support for students: Teachers should provide support to students, especially in the initial stages of using mind mapping. Trainings and practical exercises can help students learn the technique.

This study has identified both positive and negative aspects of using mind mapping in physics education and provided specific recommendations to address the identified problems.

The positive aspects include:

1. Improving the perception and understanding of the material. The use of mind mapping allows students to better structure and visualize physical concepts, which makes them easier to understand and memorize.

2. Development of creative and critical cognitive skills. Creating your own MIND MAPs helps to develop students' creativity and analytical skills.

3. Individualization of learning. Each student can create their own mind map based on their needs and learning styles.

4. Retention of knowledge. Students who use mind mapping retain information in their memory for a longer period due to the active use of information during the creation of maps.

However, the study also revealed some problems:

1. The difficulty of creating mind maps. Some students may face difficulties in creating graphic diagrams, especially at the initial stages of using the methodology.

2. Lack of prepared teaching material. Teachers do not always have access to

ready-made mind-maps or adequate training to create them for lessons.

3. The need for trainings for teachers. Teachers need preparation and training to effectively use mind mapping techniques in the classroom.

Given the identified problems, we recommend:

1. Preparation of educational material. Develop ready-made educational material in the form of mind maps for teachers and students to facilitate their use.

2. Organization of trainings. Conduct trainings for teachers on the proper use of mind mapping and preparing students for this methodology.

3. Supporting students. Provide students with instructions and support when creating mind maps.

In general, the use of mind mapping has great potential to improve physics education at school, but it requires a systematic approach, training, and support from teachers and students.