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Training pre-service mathematics teacher to use mnemonic techniques

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Abstract. The article reveals the issue of the appropriateness of training pre-service mathematics teachers to use the techniques of mnemonics in professional activities. This issue is caused by the intensification of the educational process, when the amount of information accumulated by mankind is many times greater than the amount of knowledge that can be learned by a particular person. It is established that in the process of teaching mathematics, mnemonics should be used as a way of perceiving new information due to the formation of associative connections using special methods and techniques. The expediency of training pre-service mathematics teachers to use various methods of mnemonics ("Binding", "Transformation", "Amplification") is substantiated. A positive attitude of mathematics teachers towards the use of mnemonics techniques was revealed, as well as a low level of students' understanding of the advisability of using mnemonics techniques in professional activities. The classification of software used to create visual models is presented. A training was developed and introduced into the practice of university education on the development of mnemonic techniques for the presentation of educational mathematical material. The prospects of scientific research through the development of methodological support for the training of pre-service mathematics teachers to use the techniques of mnemonics in professional activities are determined.

1. Introduction

Modern youth is developing in an environment saturated with powerful and intense information flows. The amount of information accumulated by mankind is many times greater than the amount of knowledge that can be acquired by a specific person. The constant increase in information, combined with high competition and the demands of society, leads to an intensification of the educational process. On the other hand, the intensification of the educational process leads to a number of problems in the mental and somatic health of students. In such conditions, the problem of the cognitive load of the subjects of training appears, which consists in the fact that a person can achieve the optimal level of assimilation of material only if there is an adequate load on the subject's memory.

In the process of teaching mathematics, only memory has a special load. The success of training depends on the level of development of mnemonic processes that ensure the memorization, preservation, and reproduction in the brain of information obtained during human interaction with the outside world. Therefore, the introduction of effective approaches to memorizing a variety of mathematical information


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can partially solve the problem of cognitive load. As one of such approaches, we consider the use of mnemonics as a way to improve new information by creating associative relationships using special methods and techniques.

The disappointing results of External Independent Evaluation in mathematics in recent years, the results of the international study of the quality of education PISA – 2018 [11], which determine the level of mathematical literacy of Ukrainian students as such, which are lower than average, clearly demonstrate the level of mathematical preparation of school students. For today's mobile and computerized students, the assertion that mathematics is the queen of all sciences, which develops their thinking, is no longer an authority. School teachers need updated methodological tools that will make students interested in mathematics. Therefore, there is a need for a certain reboot, modernization of the existing system of methodological training of pre-service mathematics teachers at universities.

The basis for the implementation of our work was the results of scientific research on the mathematical preparation of students at the university by a number of authors: Mogens Allan Niss and Tomas Højgaard [10], Todd R. Kelley and J. Geoff Knowles [6], Xueli Wang [18], Barbara Jaworski [5], Kateryna Vlasenko, Olena Chumak, Iryna Lovianova, Daria Kovalenko and Nataliia Volkova [17] as well as the authors of this study ([1], [15]), which disclose the theoretical and methodological foundations for the implementation of mathematical education at the university.

The issue of using mnemonics in the educational process is presented in the works of several authors. (Thomas E. Scruggs and Margo A. Mastropieri [14], Jerome A. Yesavage, Javaid I. Sheikh, Leah Friedman and Elizabeth Tanke [19], Franziska R. Richter, Avi J. H. Chanales and Brice A. Kuhl [12]), in particular in the process of studying mathematics (Susan Peterson Miller and Cecil D. Mercer [8], Peter M. Nelson, Matthew K. Burns, Rebecca Kanive and James E. Ysseldyke [9], Emmanuel Manalo, Julie K. Bunnell and Jennifer A. Stillman [7]).

In the above-mentioned works, it is proved that mnemonic techniques are used to improve the assimilation of complex information that does not have established logical connections between its elements from the point of view of the person who remembers it. Such information requires long-term storage and subsequent reproduction, for example, a sequence of numbers, phone numbers, historical dates, formulas. It is established that the use of mnemonics improves the volume and accuracy of memorization and development of cognitive processes, increases the duration of storage and the quality of reproduction of acquired information.

At the same time, our studies made it possible to argue that the issue of training pre-service mathematics teachers for the use of mnemonic techniques and methods has not been the subject of special studies yet.

The aim of research: to reveal the content of training future mathematics teachers to use mnemonic techniques in professional activities.

2. Research methods

The achievement of the research objective was facilitated by the use of a set of appropriate methods: analysis of scientific literature in order to establish the state of development of the problem being studied, determining the categorical-conceptual apparatus of the study; synthesis, generalization, systematization for the theoretical justification of the appropriateness of training pre-service mathematics teachers to use the of mnemonic techniques and methods in professional activities; empirical: diagnostic (conversation, questionnaire), statistical (McNemar's test) to assess the appropriateness of using mnemonic techniques in teaching mathematics.

The experimental base of the study is the institutions of general secondary education in Kiev, Sumy, Dnipro and Irpin, A. S. Makarenko Sumy State Pedagogical University, Borys Grinchenko Kyiv University, Alfred Nobel University (Dnipro).

3. Results and discussion

The process of memorizing educational material is more intensive provided that subjects are engaged in active thinking, using their operations of comparison, analysis, synthesis, classification, generalization.

Effective in the study of mathematics is the timely use of memos, tables, instructions, visual supports that help students gradually, without overload, to perceive and remember significant objects.

An essential characteristic of the process of memorization is a measure of understanding the memorized. Therefore, meaningful and mechanical memorization is usually emphasised.

Mechanical memorization – memorization without awareness of the logical connection between the various parts of the material (memorization of historical dates, statistics, etc.). The basis of mechanical memorization is related associations. One part of the material binds to the other only because it follows it in time. To establish such a connection, it is necessary to repeat the studied material several times.

Comprehended memorization is based on an understanding of the internal logical connections between the individual parts of the material. Two positions, one of which is derived from the other, are remembered not because they follow each other in time, but because they are logically connected. Therefore, meaningful memorization is associated with thinking processes and relies mainly on generalized relationships between parts of the material at the level of the second signaling system.

In the process of training pre-service mathematics teachers, it is worth paying attention to the comprehended memorization of the material studied. To do this, it is necessary to divide its semantic group into parts with the separation of the main and essential in each of its parts. In addition, it is necessary to find and highlight semantic support points in each part, that is, thoughts, expressions and images that define the essence of this part and the oral or written formulations of this essence in the form of short headings for each part. Finally, it is necessary to establish links between the selected parts and understand the logical sequence of their location, to draw up a general plan for the location of educational material.

In order to comprehensive memorize educational material, methods and techniques of mnemonics are determined. The work of G. A. Chepurnoi and L. V. Bura on educational mnemonics as a technology of effective assimilation of information became a reference point for us [2].

Link Method is a method of combining information units by creating associative links between them.

The method consists of the following techniques: *Storytelling Technique* (using stories), *Mnemonics* (using music, rhyme, chants, poems, songs, counting out rhymes, etc.), *Sequential Associations* (sequential associative connections are created), *Bonding Method* (combining information units into a single holistic image with preservation of the main features and functions), *Synthesis Method* (information units are combined into a single integrated image with a common associative connection), *Key Letters Method* (an associative connection is created between the first letters of words, you need to remember, and the first letters of words of a specially created sentence), *Logical Questions Method* (an additional logical associative connection is created between images remembered through answers to the main questions – What? How? Why? etc. about the relationship between them).

Consistent Associations Technique. When studying the construction rules for remembering the order of changing the name of a function, one can suggest the following association: the angles $\frac{\pi}{2}$, $\frac{3\pi}{2}$, are located on the vertical axis, therefore, we shake our heads in the affirmative, that is, we change the function, the angles π, 2π are located on the horizontal axis, therefore shake our head negatively, that is, we do not change the function.

Key Letters Method. In the study of the topic *Disclosure of brackets. Similar terms and their construction* it are worthwhile to draw the attention of students to the sign that appears before the brackets. If there is a *minus*, then we change all signs to the opposite, if *plus*, then leave the expression unchanged, for example:

- – (a + b) – «**M**inus» – **M**iniaiemo znaky (in Ukrainian), ***M****inus* – **Ch**ange the signs; in Ukrainian, the words *minus* and *change* begin with the letter ***m***;
- + (a + b) – «**P**ljus – **P**erepysujemo bez zmin (in Ukrainian), ***P****lus* – **R**ewrite without changes; in Ukrainian, the words *plus* and *rewrite* begin with the letter ***p***.

Transformation Method is a method of primary processing of information, which turns information that is difficult to perceive into convenient for efficient reproduction.

The method consists of the following techniques: analogy (between the informational units of the memorable find common signs, properties, qualities, development trends, etc.), transformation (the objects of the memorable are transformed into others in value and in order to facilitate memorization), pictograms (abstract or such information must be remembered, schematically depicted by simplified drawings, pictograms), a stenographer (text information that is memorized is recorded using separate key letters, special characters and a number of abbreviations), phonetic association (a consonant word or part of it is selected to memorize an unfamiliar word, which associatively associated with the meaning of the original word), neologism (to improve the memorization of information (words, letters, symbols) new words, terms, concepts, phrases are created), digital image (digital information when memorizing is associated with certain images or systems about times), digital – letter code digits of numbers in letters to compose specially selected words for the purpose of their further memorization), individual association (for information that is memorable, associative connections are found with individually known data, events, information), regularity (for remembering information, certain logical, mathematical or other regular relationships are found and rules)

An example of receiving a *Neologism* is shown in figure 1.

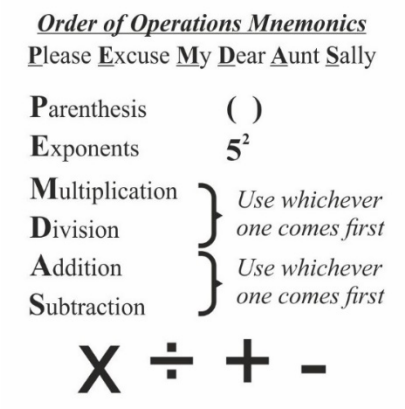

Figure 1. Neologism Technique.

Analogy Technique. When solving mathematical work word problems, students have more complications than when solving motion word problems. The analysis of complications showed that students do not understand the content of the concept of *productivity*. Let us draw an analogy between the values of the motion problems and work motion word problems.

As a result of the analogy between the values, the term "productivity" and its load become clear to students (see Table 1).

Table 1. Analogy Technique.

Dimensions of motion problems	Dimensions of work problems
S – speed of movement – is the distance an object travels per unit of time	P – work speed – the amount of work per unit of time
T – time	T – time
D – distanse	V_p – the amount of work to be done
Key formula:	Key formula:
$D = S \cdot T$	$V_p = P \cdot t$

The *Amplification* method is a method of increasing the efficiency of perception, preservation and reproduction of created associative connections and images formed by the methods of *transformation* and *binding*.

The method consists of the following techniques: *modality, character, personification, hyperbole, comedian, fiction, stereo, color accent, visualization, interpretation, emotional accent*. Examples of the use of some techniques are shown in figures 2a, 2b, 3a, 3b.

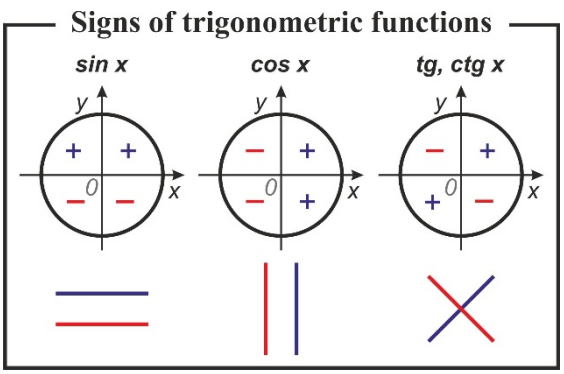

Figure 2a. Visualization technique "Signs of trigonometric functions".

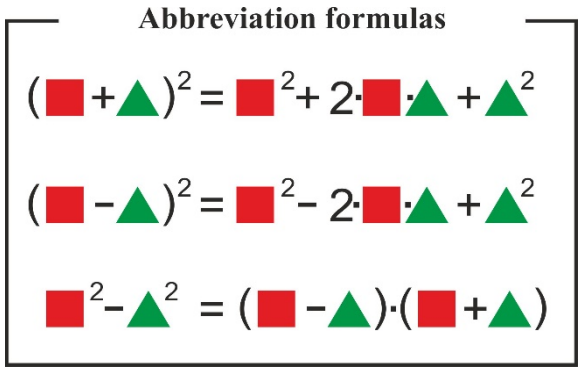

Figure 2b. Visualization technique "Abbreviation formulas".

To confirm the appropriateness of mastering the techniques of mnemonics, future teachers conducted a pedagogical observations. During March – May 2019, we conducted a survey of 32 working mathematics teachers in Kiev, Sumy, Dnipro and Irpin. 52 students of the specialties "Mathematics" and "Secondary Education (Mathematics)" of the A. S. Makarenko Sumy State Pedagogical University and Borys Grinchenko Kyiv University, as well as individual students of the Alfred Nobel University (Dnipro) also acted as respondents. The results of the survey of teachers were distributed as follows: 87% of teachers noted the feasibility of using mnemonic techniques, and their answers to the most effective were distributed differently (choosing one of three, figure 4).

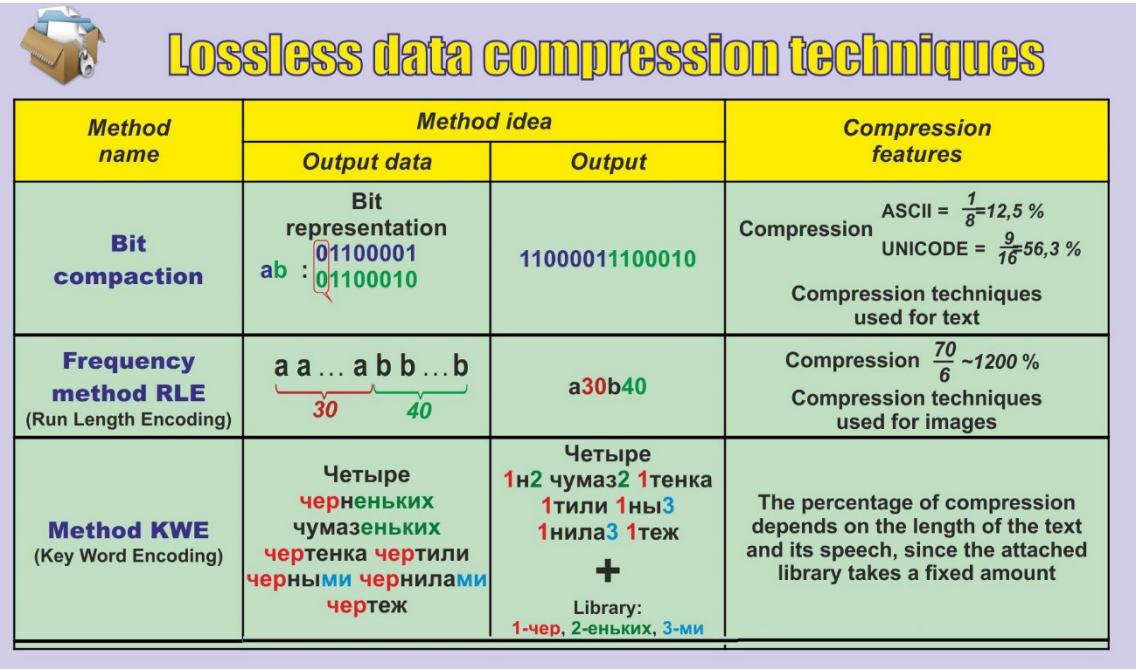

Figure 3a. Color accent technique.

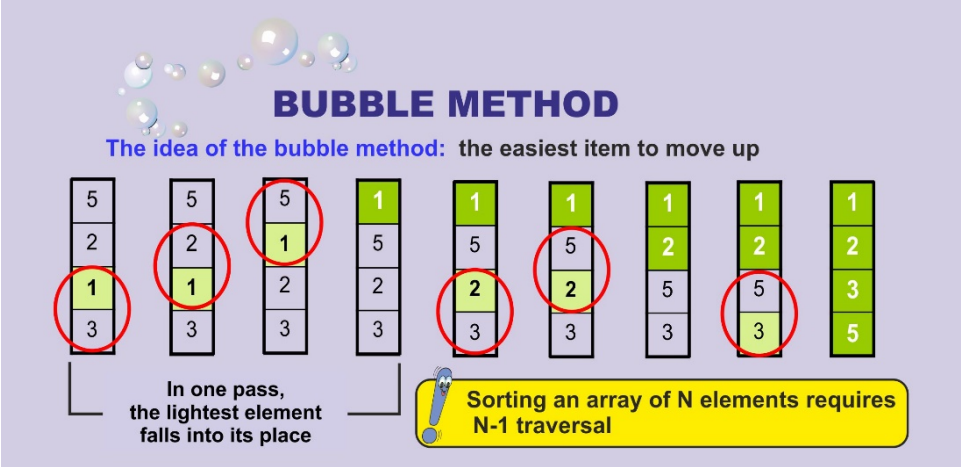

Figure 3b. Color accent technique.

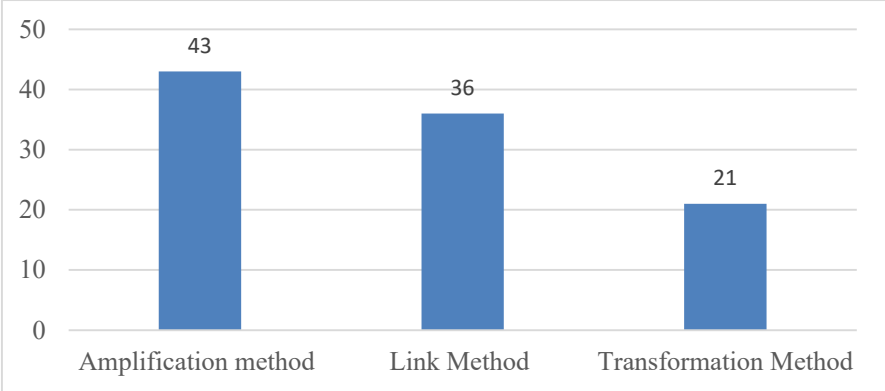

Figure 4. The opinion of teachers regarding the most effective mnemotechnical method (in%).

Moreover, among the receptions, visualization, color accent, comedian, analogy and plot were noted to a greater extent (figure 5). The remaining 17 methods that we proposed for evaluation are of poor popularity among teachers of mathematics.

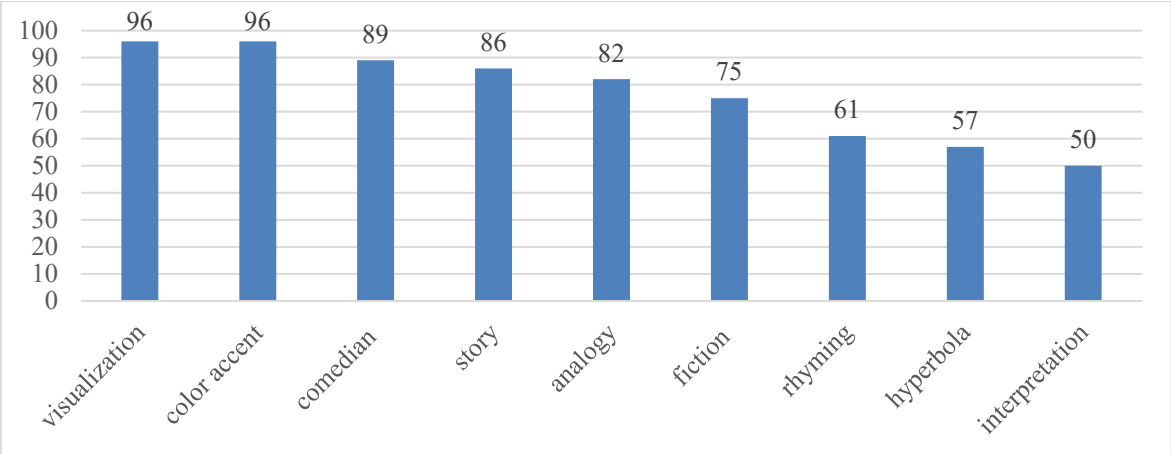

Figure 5. Teachers' opinion on the effectiveness of the mnemonic method (in %).

Unfortunately, the number of students who believe that it is advisable to use the mnemonic techniques of is a little, only 38%. This clearly demonstrates the importance of improving university training in this regard.

Based on the teachers' opinion that the *Amplification* method and the *Visualization* method are the most effective, which contribute to the meaningful memorization of educational material through its structuring and compaction, we drew attention to the software tools used to create visual models. Their study was implemented as part of the work of scientific student groups of the A. S. Makarenko Sumy State Pedagogical University. Conventionally, software can be divided into four groups:

1) office software products with Smart objects;
2) mindmapping programs;
3) services for creating scribing presentations;
4) programs for creating infographics.

We describe these groups. So, the office software package (MS Word, MS Excel, MS Power Point) is offered with the function of constructing Smart objects that allow you to efficiently create mnemovisual models in the form of a list, connection, matrix, process, cycle, hierarchy, pyramid (figure 6).

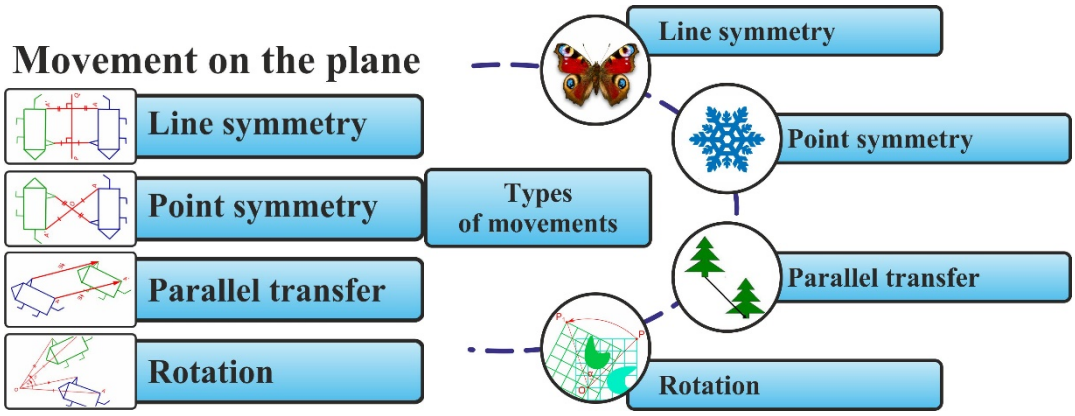

Figure 6. Mnemovisual models created using Smart objects.

Mindmapping is a technology that allows you to efficiently restore information (past), generate and capture New Ideas (future), draw conclusions and establish connections between them by building mind maps. Mind maps is the development of Tony Busan, a British psychologist who began developing the concept of smart cards back in the 70s of the twentieth century. Interesting ideas and technologies for creating smart cards in the process of teaching mathematics are presented in the works of modern scientists: Pui Kun Choo, Zhi Ning Lou, Bradley A. Camburn, Kristin L. Wood, Ben Koo and Francois Grey [3], Halyna I. Ivanova, Olena O. Lavrentieva, Larysa F. Eivas, Iuliia O. Zenkovych and Aleksandr D. Uchitel [4], Riccardo Solmi [16].

To build intelligence cards use the program X-Mind, Free-Mind, Coggle, Mind-Meister and others. Such programs help to fix ideas, organize them into various diagrams, use these diagrams together with other users. The mentioned programs allow you to build intelligence cards (figure 7), Ishikawa diagrams (fishbone diagrams or cause-effect diagrams), tree diagrams, logic diagrams, tables.

The main areas of application of intelligence cards in the professional activities of mathematics teachers include: creating lesson plans of any type; planning educational activities; algorithms for solving problems; study of new educational material; consolidation and verification of the studied material; systematization and repetition of the studied material in preparation for the state final certification, external independent evaluation.

Both scribing technique is used to activate the cognitive and mnemonic activity of subjects of learning, and to visualize the educational process. Scribing is a mnemonic technology for the

visualization of educational material, which provides the display of key moments of its content (properties of the learning object, its internal and external connections) by using simple graphic elements (drawings, pictograms, symbols, words, circuits, diagrams) sequentially created on the screen in according to the oral presentation (or audio). The appearance of scribing is associated with the British artist Andrew Park, who proposed this technology to popularize scientific knowledge. Sudeep Sarkar notes that this way of presenting information has become more productive for explaining to the audience, because it uses the *parallel effect* when the audience simultaneously hears and sees about the same thing, while the graphic series is fixed on key moments of the audio sequence [13].

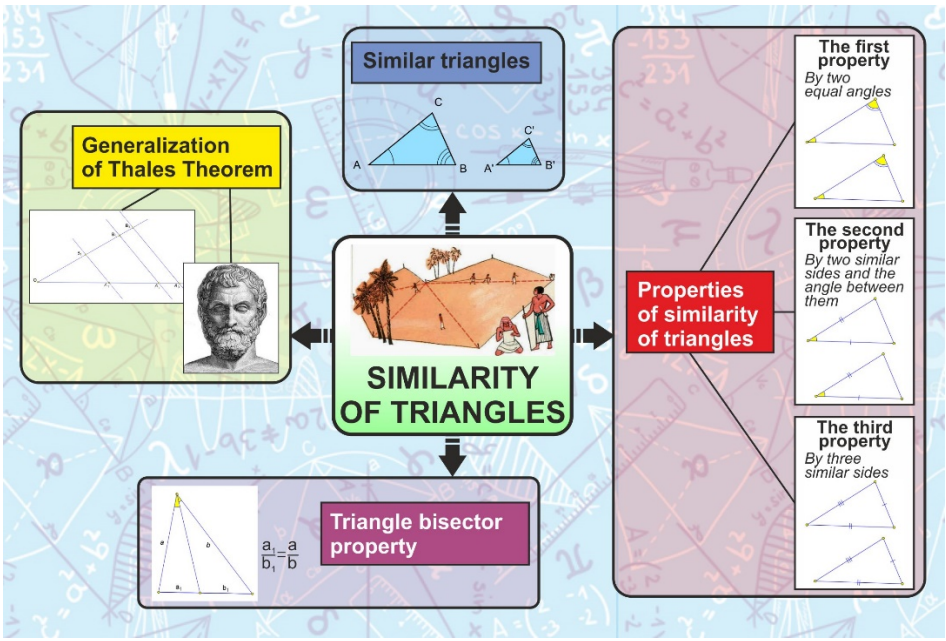

Figure 7. Memory card for the theme "Similar triangles".

Among a large number there are several useful for creating scribing presentations such as: Sparcol Video Scribe (www.sparcol.com, figure 8), Pow Toon (www.powtoon.com), Go Animate (www.goanimate.com), Plotagon (www.plotagon.com).

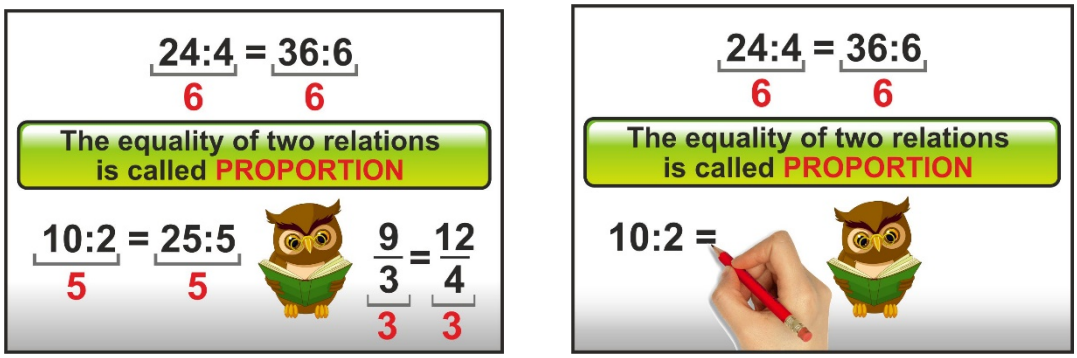

Figure 8. Scribes for the theme of Proportion.

In accordance with infographics, the technology of educational material is presented in the form of statistical graphs, maps, charts, diagrams, tables that "explain". Educational visibility is used not only for illustration, but also as an independent source of knowledge (figure 9). Resources for creating infographics include: Infogr.am, Easel.ly, Vizualize.me, Venngage more.

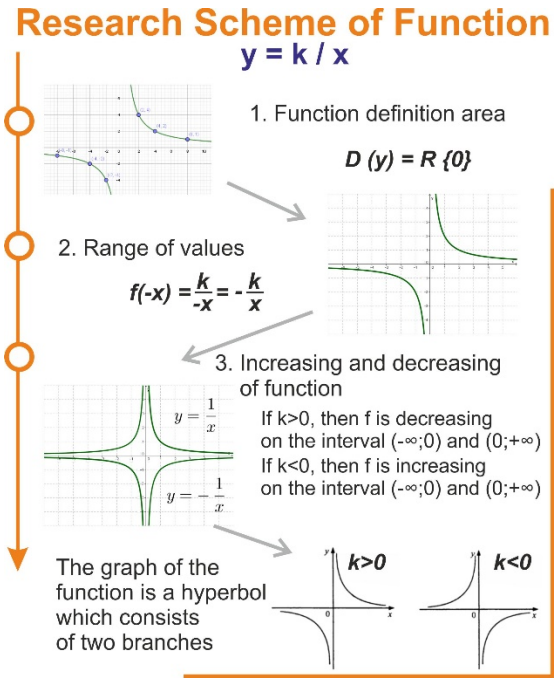

Figure 9. Infographics on function research.

During September – November 2019, at the A. S. Makarenko Sumy State Pedagogical University with various groups of students specializing in secondary education (mathematics), we conducted trainings on the development of mnemonic methods for presenting educational mathematical material. The training lasting 3 hours was aimed at training future mathematics teachers to use of mnemonic techniques in professional activities, the result was achieved through acquaintance with the existing mnemonic techniques and the formation of these skills to implement them using specialized software environments. More details are presented in table 2.

At these trainings, students had the opportunity not only to develop their own products to accompany professional activities, but also to evaluate the development of other students, to analyze their effectiveness taking into account their own educational experience and practical activities. During the organization of the experiment, we are primarily interested in efficiency and, in connection with this, before the start of training, a survey was conducted on the appropriateness, in the opinion of students, of using mnemonics. Then, a survey was again conducted on the appropriateness of using mnemonic methods. A total of 41 students took part in the survey. Since students' answers may or may not have changed, the McNemar's test was used to confirm the effectiveness of the training. The results of the first and second surveys are shown in table 3.

The statistical hypothesis was constructed: the special course does not affect the students' opinion on the appropriateness of using mnemonic techniques in teaching mathematics. For the McNemar's test with $n = 2 + 10 = 12$, the statistic value is $T = \min\{2, 12\} = 12$, therefore, according to the hypothesis acceptance rule, we have $0.019 < 0.025$. Therefore, the null hypothesis must be rejected and an alternative hypothesis should be adopted on the effectiveness of training for future teachers to master mathematics techniques of mnemonics.

4. Conclusions and prospects for further research

In the process of analysis of scientific literature, it was found that the level of development of mnemonic processes that ensure the memorization, preservation and reproduction of information in the brain depends on the success of training, in particular, mathematics. In order to introduce effective ways to memorize a variety of mathematical information, mnemonics are considered as a way of perceiving new information due to the formation of associative connections using special methods and techniques. The

expediency of preparing pre-service mathematics teachers to use the methods of mnemonics: *Binding*, *Transformation*, *Amplification*, as well as appropriate techniques.

Table 2. Detailing the content of the training on the development of mnemonic techniques.

The number of hours	Contents	Training methods	Learning tools	Expected learning outcomes
0,25	Memory. Mechanical and meaningful memorization	Verbal methods (story, conversation)	Presentation	An idea of the mechanisms of human memory, knowledge of the types of memorization of educational information; development of teacher professional competence
0,75	Educational mnemonics as a technology for the effective assimilation of information. Mnemonics and their corresponding mnemonic techniques	Verbal methods (story, conversation), visual methods (demonstration, display), Interactive methods (brainstorming)	Presentation	Knowledge of the methods and techniques of mnemonics: Link Method (techniques: Sequential Associations, Key Letters Method), Transformation Method (Analogy technique), Amplification method (techniques: modality, character, personification, hyperbole, comedian, fiction, stereo, color accent, visualization, interpretation, emotional accent); development of teacher professional competence
0,5	Specialized software for supporting mnemonic techniques	visual methods (demonstration, display)	Presentation, specialized software: 1) office software products with Smart objects; 2) mind mapping programs; 3) services for creating scribing presentations; 4) programs for creating infographics	The concept of specialized software groups for supporting mnemonic techniques, knowledge of specialized software (including freeware) and its computer tools for supporting mnemonic techniques; development of teacher professional competence
1,5	Development of copyright materials for mnemonic support	Interactive methods (brainstorming, case-method)	Power Point, X-Mind, Free-Mind, Pow Toon Easel.ly	Knowledge of specialized software examples, knowledge of software tools (MS Power Point, X-Mind, Free-Mind, Pow Toon, Easel.ly), the ability to use specialized software tools to accompany mnemonic techniques; ability to analyze created products; development of teacher professional competence

Table 3. Distribution of students' answers before and after the training.

Survey results	Effective	Ineffective	
Effective	23	2	25
Ineffective	10	6	16
	33	8	41

According to the results of a survey conducted by experts, a positive attitude of mathematics teachers to the use of mnemonic techniques was established and the most popular of them were identified. At the same time, a low level of students' understanding of the appropriateness of using the mnemonic techniques in professional activities was recorded, which requires the development of appropriate pedagogical tools (methods, technologies, etc.) to train pre-service mathematics teachers for use mnemonics.

The classification of software tools used to create visual models is presented: office software products with Smart objects; mining mapping programs; web resources for creating scribing presentations; programs for creating infographics.

A training was developed for mastering of mnemonic techniques for the presentation of educational mathematical material and introduced into the training process for future teachers of mathematics. The effectiveness of the training was confirmed using the McNemar's test.

We see the prospects for further scientific research in the development of methodological support for training pre-service mathematics teachers to use the mnemonic techniques in professional activities and introduction of mnemonics in the practice of university training of future teachers.

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