Chapter 18

INFORMATION TECHNOLOGY FOR VISUALIZING THE EDUCATIONAL PROCESS OF MEDICAL STUDENTS

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INTRODUCTION

Nowadays, society actively demands from medical professionals not only high qualifications, but also creativity, creativity and competitiveness. Therefore, higher medical education should ensure the formation of professional competence of medical students and the development of their personality in general. The main principle of modern medical education is to form medical professionals capable of innovative activities, possessing skills of continuous professional growth, as well as to ensure transparency and clarity of the educational process for medical students to give them confidence in achieving results.

In the modern world, the key rule of education is also the development of digital competencies. The Law of Ukraine "On Education"[1] recognizes information and communication competence as one of the key competencies that a successful person needs in the modern world. Digital literacy, recognized by the European Union as one of the 8 key competencies for full life and work, enables people to acquire other necessary competencies faster and more efficiently.

According to the EU and Ukraine's education development strategy until 2030, all educational institutions should not only use digital tools in the traditional learning process, but also move to completely new digital learning models[2]. Moreover, these educational institutions should develop digital transformation programs to ensure competitiveness in education, research, and business at the national and international levels.

The digital transformation of educational institutions strengthens their competitive advantage in the markets of educational services, as it promotes new forms of integration both nationally and internationally. For example, it can lead to the creation of virtual universities that combine the resources of

[1] Закон України «Про освіту». *Відомості Верховної Ради (ВВР).* 2017. № 38-39. Ст. 380. URL: https://zakon.rada.gov.ua/laws/show/2145-19#Text.

[2] Education: Strategy of Ukraine 2030. URL: https://www.slideshare.net/UIFuture/2030-148758034.

higher education institutions from different regions or countries to jointly implement certain educational programs, especially in new technological environments.

To date, both medical students and teachers of medical schools do not always use digital resources in their activities. This reduces the quality of learning and work, limits opportunities and requires significant time to solve professional problems. This limited use of modern digital resources is primarily due to the lack of information about their availability and usefulness, as well as the lack of skills to work with them.

Since it is impossible for modern students to imagine their studies without digital technologies, and digital competence has become one of the key skills of the 21st century required for a successful career by 2030[3], and all future professions will be related to digital resources, medical university teachers should help students to use these tools in their studies. The process of digitalization, individualization, and intensification of medical students' learning involves the use of effective digital visualization tools. These tools simplify access to information, its systematization, compactness and conciseness, increase the logic of presentation and the effectiveness of its perception.

Thus, the task of digitalizing the educational process of medical students by visualizing it is relevant now. The aim of the study is to improve the efficiency of information perception by medical students through the design and use of information technology for visualizing the educational process.

1. Analysis of the use of visualization methods and tools in the educational process of medical students

Students of the new digital generation should actively participate in their own learning and make their own contribution to the learning process, instead of passively receiving and repeating information. Teachers of both general education and professional disciplines in medical higher education institutions should assist students in using a variety of tools and technologies aimed at deeper learning. Students who actively shape their educational concepts and not just consume information can absorb more information (Fig. 1), developing the skills necessary for lifelong learning, which is extremely important for future medical professionals. As B. Franklin said: «Tell me and I forget; teach me and I remember; involve me and I learn».

[3] Future Skills You'll Need In Your Career By 2030. URL: https://talent500.co/blog/future-skills-youll-need-in-your-career-by-2030/.

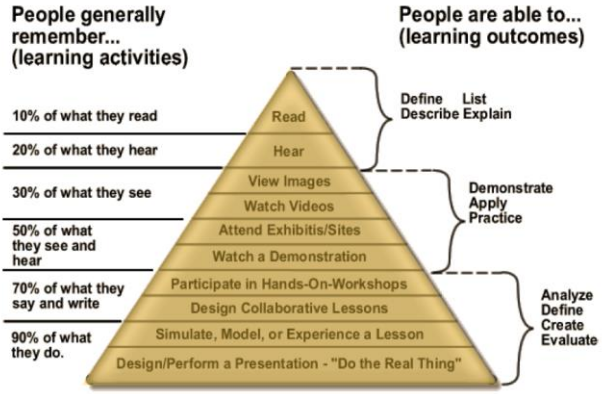

Fig. 1. Edgar Dale's experience pyramid[4]

Modern technologies are becoming extremely relevant in the modern educational environment. For example, Michio Kaku predicts that learning will soon be based solely on Internet technologies and devices such as Google Glasses, which allow you to instantly receive all the necessary information[5]. The fact that information technology is associated with entertainment and leisure for Generation Z (the post-millennial generation born in 1995-2012), which is the current student population, leads to great enthusiasm and enjoyment of learning with digital gadgets and information technology. Thus, it is very important that teachers use digital gadgets and information technologies, the concept of edutainment (education + entertainment)[6] to develop creative and critical thinking of medical students, creativity and perseverance, teamwork and problem solving, and their involvement in the educational process. Medical students rarely use available mobile devices for self-study and self-development due to lack of awareness and skills. However, the modern approach to learning is not just about "cramming" educational material, but about the ability to find and use information to solve practical problems – this is a key feature of the education of the future. The mental resource of students should be redirected from memorization to the

[4] Debunk This: People Remember 10 Percent of What They Read. URL: https://www.td.org/insights/debunk-this-people-remember-10-percent-of-what-they-read.

[5] Michio K. Physics of the Future: How Science Will Shape Human Destiny and Our Daily Lives by the Year 2100. New York: Doubleday, 2011. 416 p.

[6] Михалюк А. М. Edutainment як сучасна інноваційна технологія. Наукові записки Малої академії наук України. 2023. № 1(26). С. 72–79. URL: https://doi.org/10.51707/2618-0529-2023-26-09.

development of analytical skills, argumentation, informed decision-making and creativity[7].

Nowadays, almost every student in Ukraine owns a mobile device with Internet access. According to Ericsson ConsumerLab data for 2020, on average, every Ukrainian family has 2.5 such devices[8]. However, the results of a study of Ukrainians' digital literacy showed that currently 53% of the country's population is still below the level of basic skills – because most people use their devices mainly for entertainment, such as playing games or watching movies, or to quickly find ready-made solutions, answers to questions, etc. (Fig. 2). Most individuals still lack the skills to create their own digital content, even though they have expensive devices that allow them to write blogs, create infographics, books, and videos.

Digital Quotient (DQ) includes three levels: 1) digital citizenship – the use of information technologies in everyday life; 2) digital creativity – the ability to create one's own digital content; 3) digital entrepreneurship – the use of information technologies for professional activities. In view of the above, it can be assumed that the educational environment is currently developing mainly the first level of digital intelligence – digital citizenship. However, the need to develop digital creativity and digital entrepreneurship is obvious.

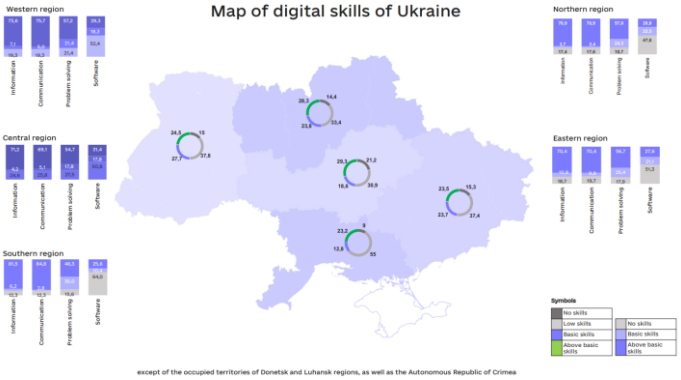

Fig. 2. Map of digital skills of Ukraine[9]

[7] Поморова О. В., Говорущенко Т. О., Побережний С. Ю., Магдін В. В. Трансфер знань та технологій на прикладі підтримки реалізації студентських стартапів. *Електротехнічні та комп'ютерні системи*. 2016. №22 (98). С. 384-391.

[8] Ericsson estimates USD 31 trillion 5G consumer market by 2030. URL: https://www.ericsson.com/en/press-releases/2020/11/ericsson-estimates-usd-31-trillion-5g-consumer-market-by-2030.

[9] Digital literacy of the population of Ukraine. URL: https://osvita.diia.gov.ua/uploads/0/588-the_first_in_the_history_of_ukraine_research_compressed.pdf.

The use of modern digital resources by both teachers and students has the following advantages: increased interest and attention to learning; acceleration and facilitation of the process of knowledge acquisition; promotion of analytical skills; increased cognitive and productive thinking; deeper understanding of the new essence of information; significant improvement in the quality of classes; simplification of the process of preparing for classes; increased professionalism and scientific development; increased efficiency of information handling; increased work's productivity and facilitating the solution of professional tasks.

Given the significant amount of information in the modern world and the need for its compact display, there is a need to visualize and systematize data to facilitate its perception. Positive aspects of data visualization in education include: improved understanding and interpretation of data; facilitating decision-making; increasing student engagement in learning; personalizing the learning process; increasing transparency and accountability[10].

Effective digital visualization tools play an important role in achieving competencies and skills. The use of such tools allows you to present large amounts of information in a concise and logical form, which helps to intensify learning. Today, there are a large number of digital visualization tools, which are presented in the "Periodic Table of Visualization Methods"[11].

The need for digitalization and visualization of educational content is due to the peculiarities of a modern university student who quickly perceives visual and graphic information, processes information quickly, but quickly switches attention and has a limited ability to assimilate large amounts of text.

Let's consider the organization of the educational process of medical students on the example of visualization of the educational component "Histology" of National Pirogov Memorial Medical University (Vinnytsya, Ukraine). The amount of information on this subject is constantly growing, which stimulates the introduction of new effective tools for learning the material. In accordance with the modern requirements for the training of future medical professionals, the learning process at the Department of Histology of National Pirogov Memorial Medical University is undergoing significant changes.

Mind maps, as an effective digital tool for visualizing concepts and structure, are widely used as a new form of educational content and a learning model for individualizing the educational process at the Department of

[10] Watts M. Harnessing the Power of Data Visualization in Education: Pros and Cons. URL: https://www.linkedin.com/pulse/harnessing-power-data-visualization-education-pros-cons-martin-watts/.

[11] A Periodic Table of Visualization Methods. URL: http://www.visual-literacy.org/periodic_table/periodic_table.html.

Histology of National Pirogov Memorial Medical University[12]. These are diagrams used to generate, represent, systematize and classify concepts, ideas and thoughts. Mind maps enable students to process and memorize large amounts of information, organize it and present it in the form of diagrams and structures[13].

These maps visually demonstrate the main idea, key elements, and the relationships between them, helping to improve comprehension. They are an effective way to attract attention, facilitate the assimilation of information, and deepen understanding of the material. Building mind maps helps to activate thinking and stimulates the generation of new ideas, which contributes to the development of logical and creative thinking[14].

To create mind maps, we use Canva, a free online graphic design platform. This platform allows you to quickly create interactive mind maps with the ability to add audio, video, images and hyperlinks to the map nodes that explain the concept of a node or branch of the map in more detail.

Students of National Pirogov Memorial Medical University majoring in 222 "Medicine" and 221 "Dentistry" use mind maps when studying histology to facilitate the assimilation and deepening of understanding of information, as well as to understand both individual facts and the relationships between them[15].

The example of a mind map created using the online platform Canva is shown in Fig. 3.

In addition to mind maps, the online service Mentimeter (www.menti.com) is also used to visualize content while studying microdissections and electrograms.

[12] Mind Maps. URL: https://learnenglishteens.britishcouncil.org/skills/reading/a2-reading/mind-maps.

[13] Improving Reading Comprehension Skills Using Multimedia Storytelling with Mind Maps for Students with Learning Disabilities in Thailand / P. Pannim et al. *International Journal of Emerging Technologies in Learning*. 2022. Vol. 17 (8). P. 97–111.

[14] What are mind maps and how to use them effectively. URL: https://vseosvita.ua/news/shcho-take-intelekt-karty-ta-iak-ikh-efektyvno-vykorystovuvaty-vchyteliu-37694.html.

[15] Hnenna V., Korol A., Voichur O., Hovorushchenko O., Popova V. Modeling and processing of information flows in the educational process of medical students using mind maps. *Computer systems and information technologies*. 2023. №4. Pp. 16-24.

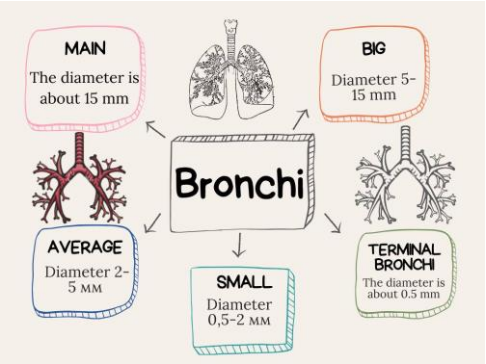

Fig. 3. Mind map "Bronchi"

The use of mind maps in the process of training medical specialists allows: developing information literacy through the use of digital technologies to organize and create their own digital content, which is part of digital creativity; promoting better understanding, interpretation and memorization of professional terms in both Ukrainian and English (or Latin) due to the bilingualism of mind maps, which is part of digital entrepreneurship; reducing the time required to memorize material by quickly processing large amounts of information and transferring it to long-term memory, which is also part of digital entrepreneurship; identify patterns and trends to make informed decisions in future professional activities, which is also part of digital entrepreneurship; structure and systematize knowledge, which helps to improve the quality of professional skills and abilities, as well as activate creative thinking, which is also part of digital entrepreneurship; stimulate independent thinking, interest in research, initiative and critical approach to solving problems, which is part of digital creativity; meet the personal educational needs of each student, which leads to individualization and personalization of the educational process; intensify, optimize, make the educational process more flexible and mobile, as well as develop associative thinking in medical students and identify knowledge gaps and educational gaps.

Thus, creating a modern and innovative educational environment involves creating optimal conditions for students' personal development, including the use of modern digital resources as a means of self-study. The introduction of digitalization and visualization into the educational process at the Department of Histology of National Pirogov Memorial Medical University through the creation of mind maps and the use of the online service Mentimeter leads to an increase in the efficiency, effectiveness and quality of learning. This is achieved by developing students' cognitive, productive and reproductive thinking, increasing their engagement and developing digital competence. In

addition, it helps to meet two important trends in education today – individualization and personalization of the learning process, as well as the development of soft skills in medical students.

2. Information technology for visualizing the educational process of medical students

Information is data, concepts and theoretical information that is stored, processed and transmitted to analyze various processes, objects and phenomena. Collected and structured information that has logical connections is a set of knowledge available for systematic study or familiarization. Information skills allow you to identify a problem, analyze existing methods of solving it, and develop your own strategies to overcome this problem.

Information processes are carried out with the help of information processors, which can be physical (such as devices) or biological (such as the human brain). These processors are integral parts of information systems. An abstract model of information processing includes four main components: processor, memory, receptors, and effectors (Fig. 4).

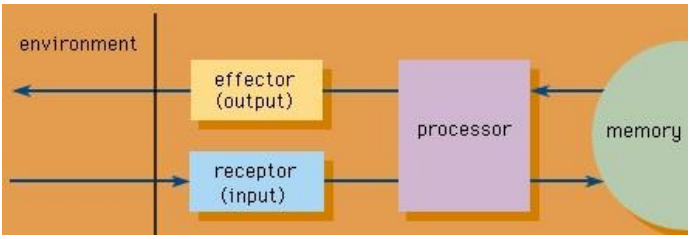

Fig. 4. Abstract model of information processing [16]

A processor, whether it is a device or a human brain, performs several important functions: processing basic information operations on symbolic expressions, temporarily storing input and output expressions in short-term memory, scheduling information processes, and changing the sequence of operations according to the content of short-term memory. Memory is responsible for storing symbolic expressions, including complex information processes. As for the other two components, the receptor and the effector, they are input and output mechanisms. The receptor receives symbolic expressions from the external environment for the processor, while the effector transmits the processed structures back to the environment. For example, humans

[16] Information processing. URL: https://www.britannica.com/technology/information-processing.

receive information through the senses, such as hearing for sounds, sight for images and texts, touch for shape and temperature, and smell for odors. These senses perceive energy phenomena such as sound waves, light waves, chemical and electrochemical stimuli, in other words, information in an analog format. Most of the information, over 60%, comes to us through sight and hearing, so a diverse presentation of information will make the process of its perception more efficient.

To identify and analyze a problem and existing methods of solving it, it is necessary to use a variety of information sources. The main sources of information for medical students are: the teacher of the educational component, who is a key source of information; various documents, such as textbooks, scientific articles, manuals, dictionaries, atlases, audiovisual materials, etc.; the material environment, which includes models, layouts and devices; experience and observation; environment (Fig. 5).

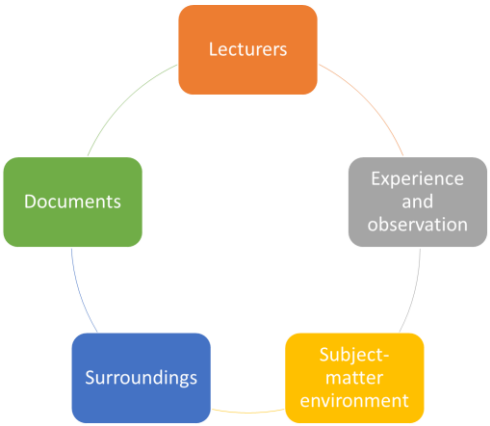

Fig. 5. Sources of information on the educational process of medical students

The means of finding the necessary information include communication methods (consultation with a teacher or practitioner, excursions, communication with classmates, etc.) and searching for documents on the Internet or in the library. The main requirement for the source of information is to meet the information needs of the person seeking this information.

Based on the use of these sources of information, the knowledge of medical students is formed (Fig. 6). Thus, the quality of students' knowledge largely depends on the characteristics of information sources. Insufficient, inaccurate, unreliable or contradictory information can lead to deficiencies in students' knowledge. Therefore, to ensure quality and complete education of

medical students, it is important to increase the consistency between information flows coming from information sources and information flows that students learn.

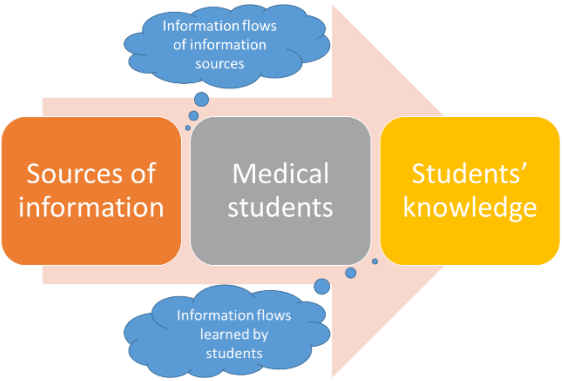

Fig. 6. Organization and content of information flows in the acquisition of knowledge by medical students

Based on empirical research conducted during the study of histology at National Pirogov Memorial Medical University, it was found that during traditional teaching, students learn only a small part of the educational material – about a quarter. In other words, the information flows that students learn in the process of traditional education make up only 25% of the total information they need to learn. It has also been empirically confirmed that the use of digitalization and visualization of educational material using mind maps almost triples this figure. Thus, the information flows that students assimilate through visualization (such as mind maps and the online service Mentimeter) account for at least 75% of the total information provided by information sources (Fig. 7).

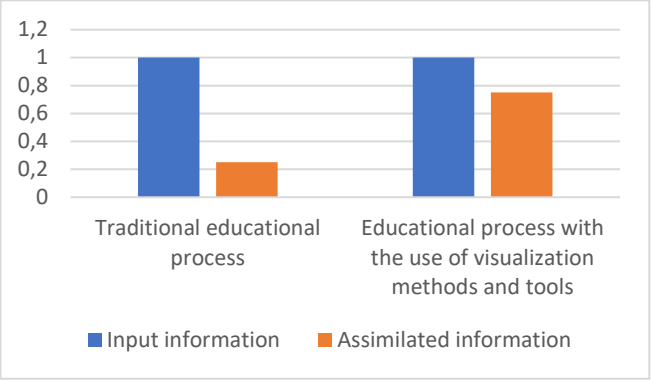

Fig. 7. Comparison of the level of information assimilation during the traditional educational process and the educational process using visualization methods

Taking into account the concept presented in the form of an abstract model of information processing (Fig. 4), as well as the organization and content of information flows during the acquisition of knowledge by medical students (Fig. 6), we can reproduce the process of processing these information flows using mind maps in the form of the model shown in Fig. 8.

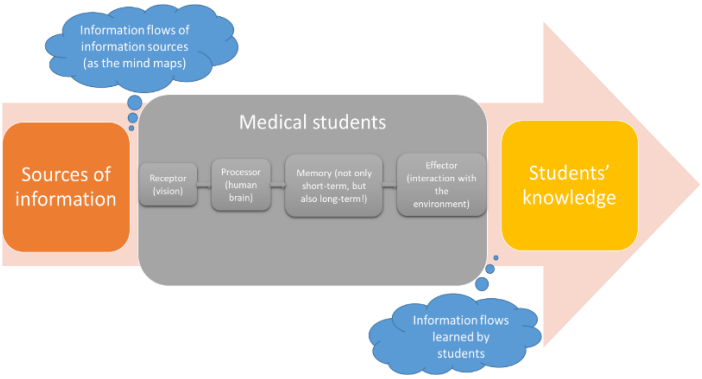

Fig. 8. Information model of knowledge formation of students of medical specialties with the help of mind maps

Given the above-mentioned urgency of the task of digitalizing the educational process of future doctors through its visualization, it is advisable to create and develop an information technology that will process the available

educational material presented in text format in the already mentioned sources of information and provide examples of ready-made mind maps and pages on the Menti platform based on this information.

This information technology will help save even more time for medical students, facilitate their learning, simplify preparation for classes, increase their productivity, and simplify and speed up the solution of professional problems.

This information technology can also be useful not only for preparing for semester control activities, but also for preparing for the Unified State Qualification Exam in the form of the Krok-1 Licensing Integrated Test Exam and the ESP Exam. In addition, the proposed information technology can also be useful for already working doctors, helping them to quickly obtain systematized information on any topic (for example, a certain topic from the educational component "Histology" that they studied in their first year of study).

Principles underlying the design and operation of information technology: the principle of development, which involves continuous improvement and expansion of technology capabilities; the principle of compatibility, which focuses on ensuring the compatibility of information technology with other systems and programs; the principle of efficiency, which aims to achieve maximum results with minimum resource expenditure; the principle of systematicity, which involves organizing information technology as a system with interconnected elements; the principle of automation of information flow processing, which is designed to ensure automatic processing and analysis of information; the principle of adaptability to new tasks, which provides for the ability of technology to respond to new requirements and tasks; the principle of stages, which determines the sequence and structure of the stages of development and implementation of information technology; the principle of openness of information, which provides for the availability of information to users and the possibility of exchanging it with other systems.

Taking into account the created information model of the formation of knowledge of medical students using mind maps (Fig. 8), let's develop a conceptual model of information technology for visualizing the educational process of medical students that will meet the above principles (Fig. 9).

On the basis of the developed information model of knowledge formation of medical students using mind maps (Fig. 8) and the conceptual model of information technology for visualization of the educational process of medical students (Fig. 9), let's develop the contextual diagram of information technology for visualization of the educational process of medical students (Fig. 10).

The developed contextual diagram of the information technology of visualization of the educational process of medical students reflects

information flows and stakeholders of the information technology of visualization of the educational process of medical students, makes it possible to understand the environment of the information technology of visualization of the educational process of medical students.

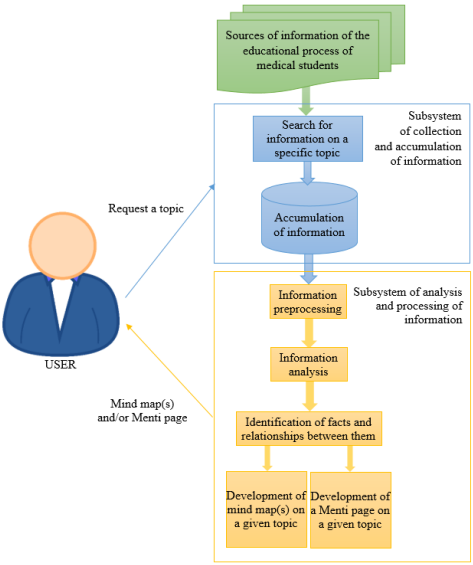

Fig. 9. Conceptual model of information technology for visualizing the educational process of medical students

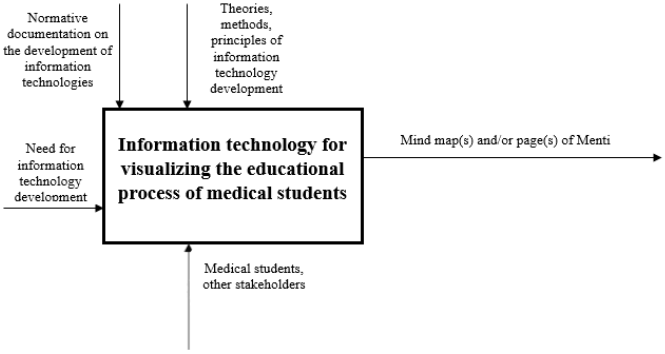

Fig. 10. Contextual diagram of information technology for visualization of the educational process of medical students

Obviously, the main goal of the developed information technology for visualizing the educational process of medical students is to automate (in order to simplify and speed up) the analysis of available information on a user-defined topic and to develop ready-made mind maps and Menti pages.

3. Results of using methods and tools of visualization of the educational process of medical students

In order to determine the usefulness and advantages of using mind maps for visualization of the educational process in the educational component "Histology", an anonymous survey of students majoring in 222 "Medicine" and 221 "Dentistry" of National Pirogov Memorial Medical University was conducted using the online service Mentimeter. Thus, students majoring in 222 "Medicine" and 221 "Dentistry" identified a number of advantages of mind maps, in particular, convenience, speed, ease of learning, structuredness, clarity, accessibility of information, aesthetics, interest, informativeness, and efficiency.

In addition, students were surveyed on whether, in their opinion, the mind maps provided them with the following in the study of histology and in preparation for the final classes/exam: facilitating the learning of educational content; deepening the understanding of educational content; demonstrating the relationships between facts; facilitating memorization and understanding of basic terms and concepts in English; systematizing, structuring and visualizing educational content; reducing the time spent on studying educational content; and meeting personal educational needs.

The results of the survey showed that students majoring in Medicine believe that mind maps provide the above opportunities by 81% (reducing the time to study the educational material) – 94% (demonstrating the relationship between facts) in the study of histology and by 82% (reducing the time to study the educational material) – 98% (systematization, structuring and visualization of educational content) in preparation for the exam in histology (Fig. 11).

The results of the survey also showed that students majoring in dentistry believe that mind maps provide these opportunities by 60% (reducing the time to study the educational material) – 80% (demonstrating the relationship between facts) in the study of histology and by 59% (reducing the time to study the educational material) – 86% (demonstrating the relationship between facts) in preparation for the final classes in histology (Fig. 11).

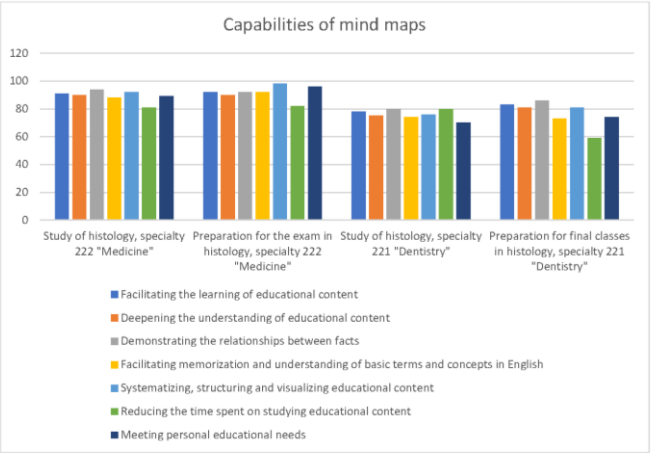

Fig. 11. Capabilities of mind maps in the study of histology and in preparation for the exam in histology according to students of specialty 222 "Medicine", as well as in the study of histology and in preparation for the final classes in histology according to students of specialty 221 "Dentistry"

In order to determine the usefulness of using the Mentimeter online service for visualizing the educational process in the educational component "Histology", an anonymous survey of students majoring in 222 "Medicine", 221 "Dentistry" of National Pirogov Memorial Medical University was conducted using the Mentimeter online service.

Thus, students were asked whether, in their opinion, the Mentimeter online service provided them with the following when studying microdissections and electrograms during the study of histology and in preparation for final classes/examination: usefulness in mastering educational content; visualization of educational content; feedback from the lecturer; satisfaction of personal educational needs.

The results of the survey showed that students majoring in Medicine believe that the Mentimeter online service provides these opportunities by 81% (satisfaction of personal educational needs) – 91% (feedback from the lecturer) when studying microdissections and electrograms in the study of histology and by 72% (satisfaction of educational needs) – 72% (feedback from the lecturer) when preparing for the histology exam (Fig. 12).

The results of the survey also showed that students majoring in Dentistry believe that the Mentimeter online service provides these opportunities by 65% (satisfaction of personal educational needs) – 82% (feedback from the

lecturer) when studying microdissections and electrograms in the study of histology and by 75% (usefulness in mastering educational content) – 95% (feedback from the lecturer) in preparation for the histology exam (Fig. 12).

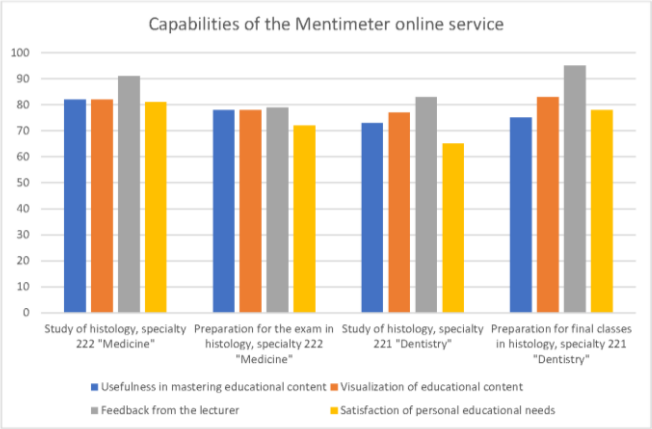

Fig. 12. Capabilities of the Mentimeter online service in the study of histology and in preparation for the exam in histology according to students of specialty 222 "Medicine", as well as in the study of histology and in preparation for the final classes in histology according to students of specialty 221 "Dentistry"

Thus, the anonymous surveys of students majoring in 222 "Medicine" and 221 "Dentistry" of the National Pirogov Memorial Medical University showed the high usefulness of mind maps and the Mentimeter online service for visualizing the educational process both during the study of the educational component "Histology" and in preparation for the final classes/exam on this educational component.

CONCLUSIONS

Nowadays, it is important to introduce digital technologies into the educational process of future doctors in order to facilitate their perception of information. Therefore, the main goal of our study is to improve the effectiveness of teaching medical students through the introduction and use of information technology to visualize the learning process.

In the course of our study, we analyzed the use of various visualization methods and tools in the educational process of medical students. This included an analysis of already known visualization methods and tools, as well

as consideration of the peculiarities of using these tools in teaching medical students.

An analysis of the organization and content of information flows in the process of teaching medical students was conducted. This study made it possible to develop an information model for the formation of knowledge in medical students using mind maps. The results obtained indicate that in order to achieve maximum coincidence between the information flows coming from information sources and those assimilated by students, the process of digitalization and visualization of educational material is quite appropriate.

On the basis of the developed information model of knowledge formation of medical students, a conceptual model and contextual diagram of information technology for visualizing the educational process of medical students have been developed, which aims to automate (in order to simplify and accelerate) the analysis of available information on a user-defined topic and the development of ready-made mind maps and Menti pages.

Thus, the anonymous surveys of students majoring in 222 "Medicine" and 221 "Dentistry" of the National Pirogov Memorial Medical University showed the high usefulness of mind maps and the Mentimeter online service for visualizing the educational process both during the study of the educational component "Histology" and in preparation for the final classes/exam on this educational component.

SUMMARY

Digitalization, individualization and intensification of the educational process of medical students requires the use of effective digital visualization tools. Therefore, the task of digitalizing the educational process of medical students through its visualization is currently relevant. The purpose of the study is to increase the efficiency of information perception by medical students through the design and use of information technology for visualizing the educational process of medical students. The object of research is the process of visualizing the educational process of medical students. The subject of the study is the methods and tools of visualizing the educational process of medical students. Objectives of the study: to analyze and model the information flows of the educational process of medical students; to design information technology for visualizing the educational process; to analyze the results of visualization. As a result of the study, all the tasks were fulfilled, in particular, the information technology for visualizing the educational process of medical students was designed, which aims to automate the development of mind maps and Menti pages.

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