https://doi.org/10.31891/csit-2023-4-3
UDC 004.9: 004.04: 004.67

Valentyna HNENNA, Anatolii KOROL
National Pirogov Memorial Medical University
Oleg VOICHUR
Khmelnytskyi National University
Olha HOVORUSHCHENKO, Viktoriia POPOVA
National Pirogov Memorial Medical University

MODELING AND PROCESSING OF INFORMATION FLOWS IN THE EDUCATIONAL PROCESS OF MEDICAL STUDENTS USING MIND MAPS

The fundamental principle of medical education today should be the formation of a highly qualified competitive medical professional who can conduct innovative activities and has the skills of continuous professional development, as well as increasing the transparency and clarity of the educational process for students and building confidence in achieving effective results. The creation of a modern innovative educational environment involves ensuring optimal conditions for the development and self-development of a student, which can be created, among other things, through the use of modern digital resources by both lecturers and students. Thus, the task of digitalizing the educational process of medical students is currently relevant. The purpose of this study is to model and process the information flows of the educational process of medical students.

Digitalization and visualization of the educational process at the Department of Histology of National Pirogov Memorial Medical University (Vinnytsya, Ukraine) by developing mind maps revolutionizes education, improves the teaching process, significantly increases the efficiency, effectiveness and quality of the educational process through the development of cognitive, productive, reproductive thinking in students, compliance with the intellectual capabilities of higher education students, increasing the level of involvement of students, developing digital competence in students, and so on.

The modeling and processing of information flows of the educational process of medical students has shown that students' knowledge is largely determined by the characteristics of information sources, and in order to maximize the coincidence of information flows of information sources and information flows learned by students, it is worthwhile and expedient to digitalize and visualize educational content using mind maps. It has been empirically confirmed that the use of mind maps in the study of the educational component "Histology" has increased the coincidence of information flows of information sources and information flows learned by students from one quarter to three quarters.

Keywords: digitalization of the educational process, visualization of the educational process, mind maps, modeling of information flows, processing of information flows.

Валентина ГНЕННА, Анатолій КОРОЛЬ
Вінницький національний медичний університет ім. М. І. Пирогова
Олег ВОЙЧУР
Хмельницький національний університет
Ольга ГОВОРУЩЕНКО, Вікторія ПОПОВА
Вінницький національний медичний університет ім. М. І. Пирогова

МОДЕЛЮВАННЯ ТА ОПРАЦЮВАННЯ ІНФОРМАЦІЙНИХ ПОТОКІВ ОСВІТНЬОГО ПРОЦЕСУ ЗДОБУВАЧІВ МЕДИЧНИХ СПЕЦІАЛЬНОСТЕЙ З ВИКОРИСТАННЯМ КАРТ ДУМОК

Основоположним принципом медичної освіти сьогодення має стати формування висококваліфікованого конкурентоспроможного фахівця медичної галузі, який може вести інноваційну діяльність та володіє навичками безперервного професійного розвитку, а також підвищення прозорості та зрозумілості освітнього процесу для здобувачів та формування у здобувачів впевненості у досягненні ефективних результатів. Створення сучасного інноваційного освітнього середовища передбачає забезпечення оптимальних умов для розвитку й саморозвитку людини, що навчається, які можуть бути створені в тому числі й за допомогою використання сучасних цифрових ресурсів як викладачами, так і здобувачами освіти. Отже, наразі актуальною є задача діджиталізації освітнього процесу здобувачів медичних спеціальностей. Метою даного дослідження є моделювання та опрацювання інформаційних потоків освітнього процесу здобувачів медичних спеціальностей.

Діджиталізація та візуалізація освітнього процесу на кафедрі гістології Вінницького національного медичного університету ім. М. І. Пирогова шляхом розроблення карт думок революціонізує освіту, удосконалює процес викладання, значно підвищує ефективність, результативність та якість освітнього процесу завдяки розвитку в здобувачів пізнавального, продуктивного, репродуктивного мислення, відповідності інтелектуальним можливостям здобувачів вищої освіти, підвищення рівня залученості здобувачів, розвитку цифрової компетентності у здобувачів, а також за рахунок задоволення двох стійких трендів освіти сьогодення – індивідуалізація і персоналізація освітнього процесу та формування soft skills у здобувачів вищої освіти.

Моделювання та опрацювання інформаційних потоків освітнього процесу здобувачів медичних спеціальностей показало, що знання студентів значною мірою визначаються характеристиками джерел інформації, а для максимізації співпадіння інформаційних потоків джерел інформації та інформаційних потоків, засвоєних здобувачами, варто і доцільно діджиталізувати та візуалізувати освітній контент з використанням карт думок. Емпірично підтверджено, що використання карт думок при вивченні освітнього компоненту «Гістологія» дозволило підвищити співпадіння інформаційних потоків джерел інформації та інформаційних потоків, засвоєних здобувачами, з однієї чверті до трьох чвертей.

Ключові слова: діджиталізація освітнього процесу, візуалізація освітнього процесу, карти думок, моделювання інформаційних потоків, опрацювання інформаційних потоків.

Introduction

Modern education in general and medical education in particular aims to develop the personality and form the professional competence of future specialists. Society is a customer for a qualified, creative, competent specialist who is competitive in the national and European labor market.

The fundamental principle of medical education today should be the formation of a highly qualified, competitive medical professional who can conduct innovative activities and has the skills of continuous professional development, as well as increasing the transparency and clarity of the educational process for students and building confidence in achieving effective results.

Students of the new digital generation should actively participate in their own education and contribute to learning, rather than passively receive and repeat information. Lecturers of both general education and professional training components in medical higher education institutions should be aware of new trends and teaching methods to increase their effectiveness. Lecturers should help students use a variety of tools and technologies aimed at more in-depth learning. Students who do not just absorb information but actively build their own educational concepts develop skills that enable lifelong learning, which is a necessary reality for future healthcare professionals. As B. Franklin said: "Tell me and I forget; teach me and I remember; involve me and I learn".

The key to learning in the modern world is the development of digital competencies. The Law of Ukraine "On Education" considers information and communication competence to be one of the key competencies that every person needs to be successful in the modern world. The EU has recognized digital literacy (digital competence, digital skills) as one of the 8 key competencies for full life and work. Digital competence is unique in that it enables people to acquire other competencies faster and more efficiently. According to the EU and Ukraine's education development strategy, by 2030, all educational institutions should move not only to digital tools in the traditional educational process, but also to completely new digital learning models [1]. In addition, educational institutions should develop digital transformation programs to ensure the competitiveness of educational, research, and business activities at the national and global levels. The digitalization of educational institutions enhances their competitive advantages in the markets of educational services, as it promotes new forms of integration at both the national and international levels, for example, it allows the creation of virtual universities, which involve the pooling of resources of higher education institutions located in different regions (countries) for the joint implementation of certain educational programs, primarily in new technological environments.

Modern technologies are more relevant than ever in the modern educational environment - for example, Michio Kaku predicts that education will soon be based solely on Internet technologies and gadgets such as Google Glasses, which will soon be transformed into tiny lenses that will allow you to instantly download all the necessary information [2]. The fact that information technology is associated with entertainment and leisure for Generation Z, which represents the current student population, leads to high enthusiasm and enjoyment of learning with digital gadgets and information technology. Therefore, it is now very important for lecturers to use digital gadgets and information technologies to engage medical students, develop their creative and critical thinking, creativity and perseverance, teamwork and problem solving. Today, students should not be forced to simply "cram" the educational material, but should be taught to find the necessary information and use it to solve practical problems, which is a sign of the education of the future. And the freed-up mental reserve should be reoriented to develop the ability to analyze, argue, make the right decisions, and create.

Today, almost every student in Ukraine has a mobile device with Internet access (according to Ericsson ConsumerLab 2020 [3], every Ukrainian family has 2.5 devices with Internet access), but according to the results of a study of digital literacy of Ukrainians [4], another 53% of the population of Ukraine is currently below the "basic level" mark, as they use the available devices mainly for games and watching movies, to find ready-made solutions to tasks. The map of digital skills of Ukraine is shown in Fig. 1 [4].

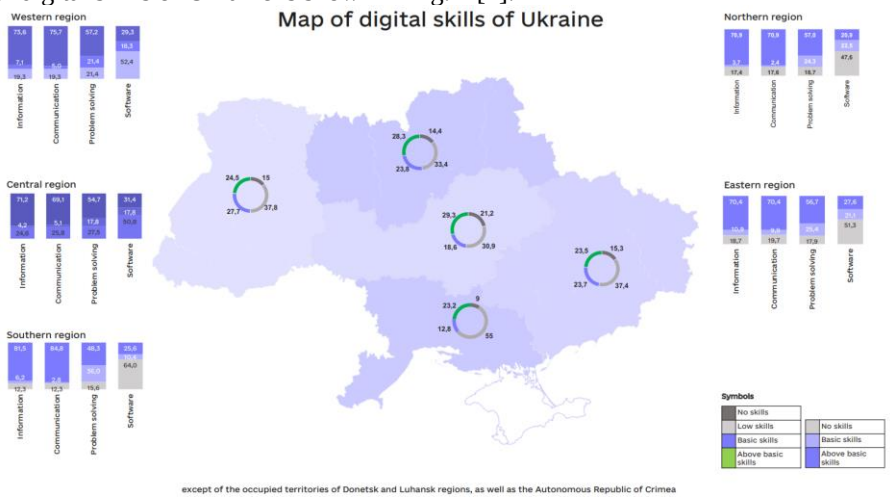

Fig. 1. Map of digital skills of Ukraine [4]

Medical students also make little use of the available mobile devices for self-education and self-development due to inability and ignorance of such opportunities. At present, even students who are considered "digital natives" are actually far from producing their own digital content – while they own their own expensive devices with the ability to write blogs, create infographics, books, and videos.

Consequently, both students and lecturers do not always use digital resources in their activities, which reduces the quality of their learning and work, limits and requires significant time to solve professional problems. This partial use of modern digital resources is primarily due to the lack of information about the availability and usefulness of digital resources, as well as the lack of skills to work with them.

Digital intelligence (DQ – Digital Quotient) includes three levels [1]: 1) digital citizenship – the use of IT in everyday life; 2) digital creativity – the creation of one's own content; 3) digital entrepreneurship – the use of IT for professional activities. Given the above, it can be concluded that currently only the first level of digital intelligence – digital citizenship – is developed in the educational environment, but the need to develop digital creativity and digital entrepreneurship is obvious.

The use of modern digital resources by lecturers and students will lead to:

1) increase of attention and interest in learning;
2) accelerating and facilitating the assimilation of knowledge;
3) development of analytical skills;
4) development of cognitive, productive thinking;
5) deeper understanding of the essence of new information;
6) promoting significant and lasting changes to improve the quality of classes;
7) simplification of preparation for classes;
8) increase of professional and scientific level;
9) increase of the efficiency of work with information;
10) increase in productivity, facilitation and acceleration of solving professional problems.

Since today's students cannot imagine their lives without digital technology, given the growth of information and the fact that digital competence has become one of the 10 key competencies of the 21st century, which is included in the Future skills you'll need in your career by 2030 [5], and all professions of the future are somehow related to digital resources, lecturers should help students use this toolkit in a new, creative and personalized way.

Thus, the task of digitalizing the educational process of medical students is *currently relevant*. Therefore, *our study is devoted* to the modeling and processing of information flows in the educational process of medical students.

Features of the organization of the educational process of medical students using mind maps

Taking into account the above requirements for the training of future specialists, including specialists in the medical field, the educational process at the Department of Histology of National Pirogov Memorial Medical University (Vinnytsia, Ukraine) is currently changing radically – it is being digitalized, individualized and intensified through the use of effective digital visualization tools that provide easier access to information, compact and concise presentation of information, systematization of information, increasing the logic of its presentation and effective teaching.

The educational component "Histology" consists of such sections as: cytology, embryology, general and special histology, and the amount of information for each section is constantly growing, which constantly motivates the introduction of new effective tools for the perfect and effective assimilation of information.

Given the huge amount of information in the modern world and the need for compact means of displaying it, when working with information, there is a need to visualize and systematize it to increase convenience and ease of perception [6].

Positive aspects of data visualization in education [6]:

1) improved understanding and interpretation of data;
2) enhanced decision-making;
3) increased student engagement;
4) personalized learning;
5) increased transparency and accountability.

Negative aspects of data visualization in education [6]:

1) privacy and security concerns;
2) data quality and accuracy;
3) overreliance on data;
4) accessibility and equity.

Effective digital visualization tools play an important role in the acquisition of competencies and programmatic learning outcomes by students. By using visualization tools, large amounts of information can be presented in a concise and logical manner, thereby contributing to the intensification of learning. Currently, there are a huge number of digital visualization tools that are presented in the "Periodic Table of Visualization Methods" [7].

An effective digital tool for visualizing the concept and structure, a new form of educational content and a new digital learning model that is actively used to individualize the educational process at the Department of Histology

of National Pirogov Memorial Medical University (Vinnytsia, Ukraine), are mind maps – diagrams used to generate, present, systematize and classify concepts, ideas, thoughts [8, 9].

Mind maps enable students in distance and classroom learning to process and record a significant amount of information, assimilate it and organize it in the form of schemes and structures. The construction of mind maps is based on associative connections, which is characteristic of long-term memory. Mind maps are used to visualize thinking, develop creative thinking, brainstorm, stimulate imagination, and solve problems, etc. Mind maps are new forms of educational content that attract the attention of the audience, provide flexibility of educational content, facilitate the assimilation of educational content by students, deepen the understanding of educational content by students, and demonstrate not only facts but also the relationships between them [8, 9].

To build the mind maps, the free online graphic design platform Canva is used, which allows us to quickly create interactive mind maps with audio, video, images, and hyperlinks to map nodes that explain the concept of a node or branch of the map in more detail.

Students of specialties 222 Medicine and 221 Dentistry at National Pirogov Memorial Medical University (Vinnytsia, Ukraine) develop mind maps when studying histology to facilitate learning and deepen understanding of educational content, as well as to understand both facts and interdependencies between them.

Examples of mind maps developed using the online platform Canva are shown in Fig. 2-Fig. 5.

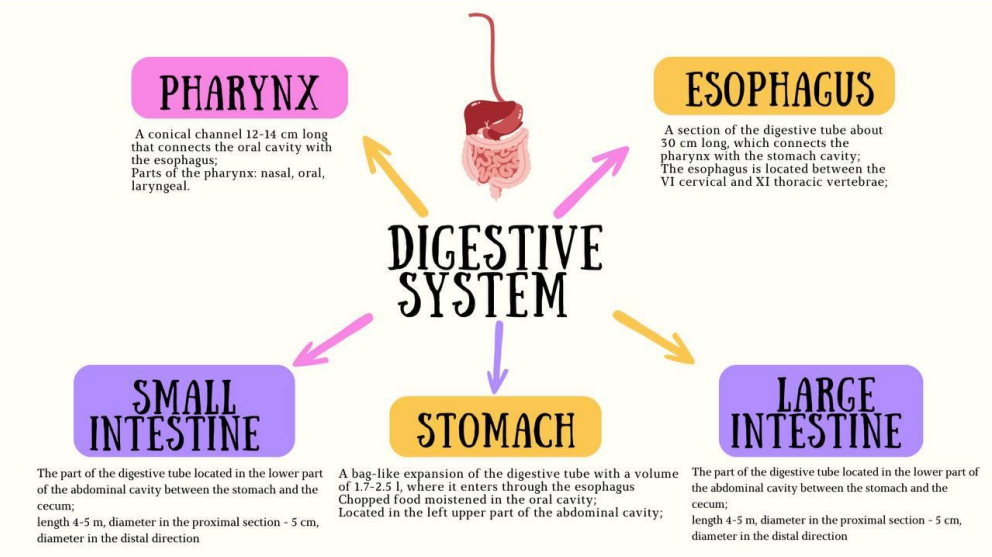

Fig.2. Mind map "Digestive system"

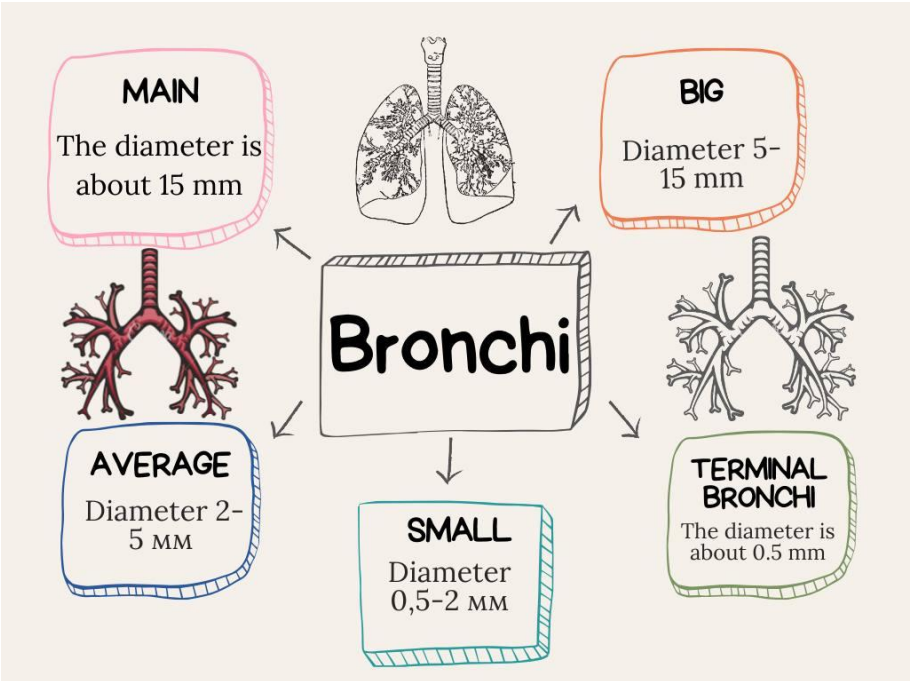

Fig.3. Mind map "Bronchus"

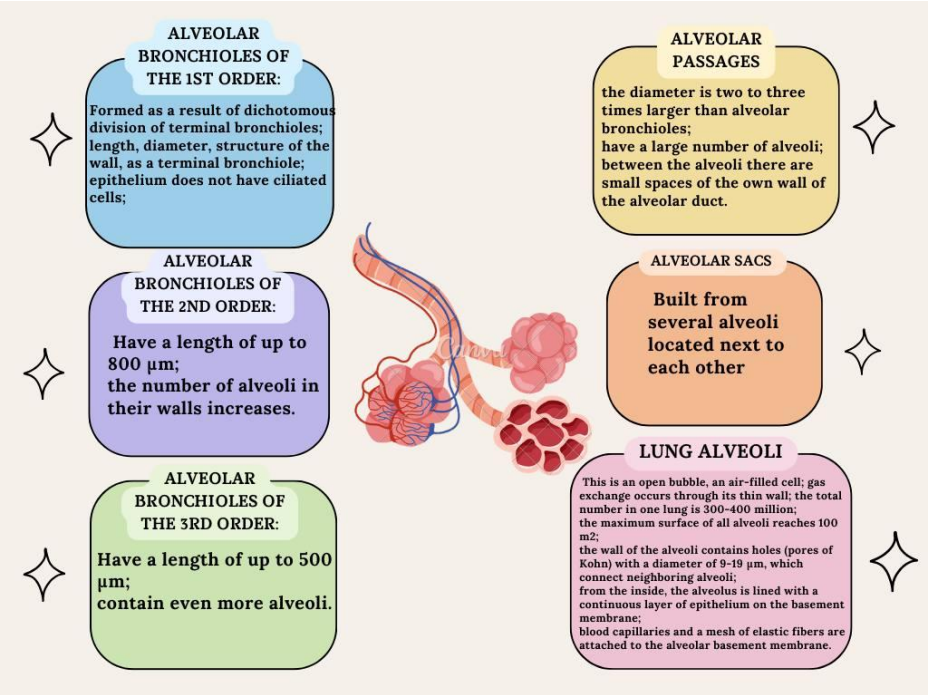

Fig.4. Mind map "Lungs"

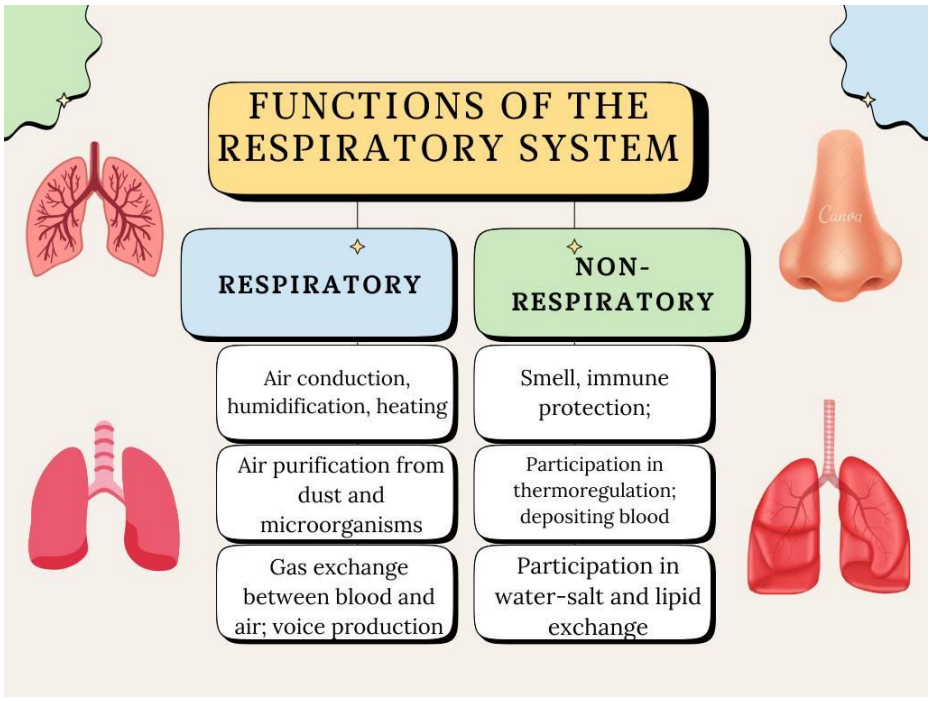

Fig.5. Mind map "Functions of the respiratory system"

The use of mind maps in the training of medical professionals provides:

- development of information literacy through the confident use of digital technologies to systematize information and the ability to create their own digital content (digital creativity)
- facilitating the understanding, interpretation and memorization of basic professional terms in both Ukrainian and English (or Latin) due to the bilingualism of mind maps (digital entrepreneurship);
- reducing the time for memorizing material due to the rapid processing of large amounts of information and the transfer of information into long-term memory and knowledge (digital entrepreneurship);
- identifying patterns, trends and deviations, which contributes to making more informed decisions based on evidence in future professional activities (digital entrepreneurship);
- structuring and systematization of students' knowledge, improving the quality of professional skills (digital entrepreneurship);
- formation of all levels of digital intelligence (DQ – Digital Quotient) in students and lecturers;
- facilitating preparation for the Unified State Qualification Exam in the form of the Krok-1 Licensing

Integrated Test Exam and the ESP Exam;

- development of self-control skills, timely identification of mistakes, their elimination and even prevention of their occurrence;
- stimulating the development of independent thinking, intellectual activity and creative approach to problem solving;
- meeting personal educational needs of each applicant, activation of individual learning and cognitive activity of applicants, adaptation of learning strategies, and as a result – individualization and personalization of the educational process of medical students by leveling the difference in perception and processes of information assimilation by applicants, analysis of the pace of mastering the material;
- promoting the development of curiosity and research interest, formation and development of initiative, creativity, visual and critical thinking, which are effective intellectual tools that will allow medical students to become specialists of the future;
- intensification, optimization, mobility and flexibility of the educational process, development of associative thinking in applicants, identification of gaps in applicants' knowledge and educational gaps.

The need for digitalization and visualization of educational content is due to the peculiarities of the modern higher education student's thinking – the ability and readiness to perceive visual and graphic information, the inability to perceive large amounts of textual information, fast information processing and short attention span. Digitalization and visualization of the educational process at the Department of Histology of National Pirogov Memorial Medical University (Vinnytsia, Ukraine) by developing mind maps revolutionizes education, improves the teaching process, significantly increases the efficiency, effectiveness and quality of the educational process through the development of cognitive, productive, reproductive thinking in students, compliance with the intellectual capabilities of higher education students, increasing the level of involvement of students, developing digital competence in students, and so on.

Modeling and processing of information flows in the educational process of medical students using mind maps

Information is a message, value, theoretical data that are objects of storage, processing and transmission and are used in the process of analyzing certain processes, objects and phenomena. Information organized in accordance with certain logical relationships is called a body of knowledge that must be obtained through systematic familiarization or study [10].

The ability to process information makes it possible to identify the problem (the essence of the contradiction), analyze the known ways and means of solving it, and generate one's own proposals and ways to solve the problem.

Information processes are performed by information processors, either physical (a device) or biological (the human brain). An abstract model of information processing includes four main elements: processor, memory, receptor, and effector (Fig. 6). A processor (a device or a human brain) performs several functions: performing elementary information processes on symbolic expressions; temporary storage of input and output expressions in short-term and/or long-term memory; scheduling the execution of information processes; changing the sequence of operations according to the contents of short-term and/or long-term memory. The memory stores symbolic expressions, including those representing complex information processes. The other two components, the receptor and the effector, are input and output mechanisms whose functions are, respectively, to receive symbolic expressions from the external environment for the processor and to transmit the processed structures back to the environment (a person receives information from his or her senses – sounds through hearing; images and text through sight; shape, temperature, and sensations through touch; smells through the sense of smell; the carriers of information signs perceived by the senses are energy phenomena – sound waves, light waves, chemical and electrochemical stimuli, i.e. information in analog form) [10]. More than 60% of information comes to us through sight and hearing. Sight and hearing are the most powerful and effective channels for transmitting and receiving information, which is why the more diverse the presentation of information, the more effective the process of its assimilation.

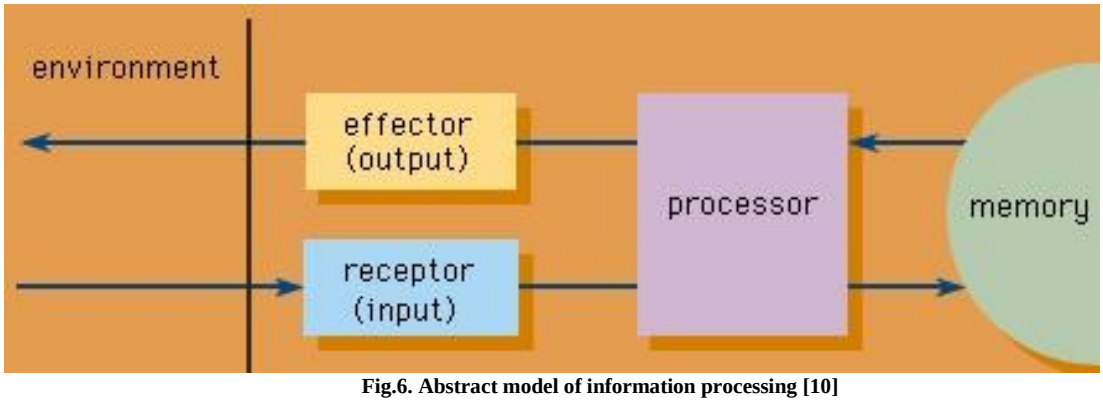

Fig.6. Abstract model of information processing [10]

To identify and study the problem and known means of solving it, certain sources of information are needed. The main sources of information of the educational process of medical students are: the lecturers of the educational components (a key link in the system of information sources); documents (textbooks, manuals, notes, scientific articles, reference books, dictionaries, encyclopedias, maps, atlases, albums, manuscripts, videos, presentations, etc.); subject-matter environment (models, layouts, devices); experience and observation; surroundings (Fig. 7). Accordingly, the ways to find the necessary information are: communicative (classes, consultation of a lecturer-practitioner, industry expert, excursion, consultation of classmates, etc.), search for documents on the Internet or in a library catalog. The main requirement for an information source is to meet the information needs of the person who accessed it.

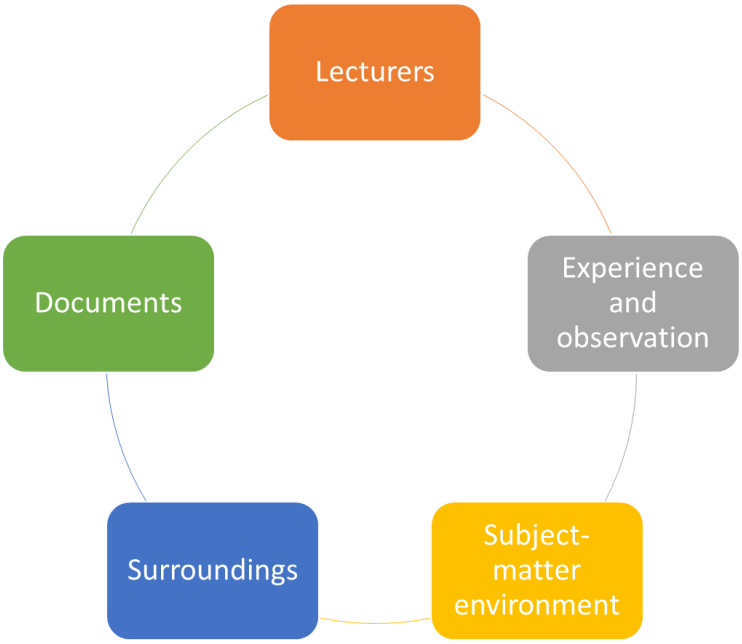

Fig.7. Sources of information of the educational process of medical students

Based on the above sources of information, the knowledge of medical students is formed (Fig. 8). Thus, students' knowledge is largely determined by the characteristics of information sources. If the source of information is insufficient, or it is inaccurate, unreliable, ambiguous or contradictory, there is a high probability that all these shortcomings will be reflected in the knowledge of students.

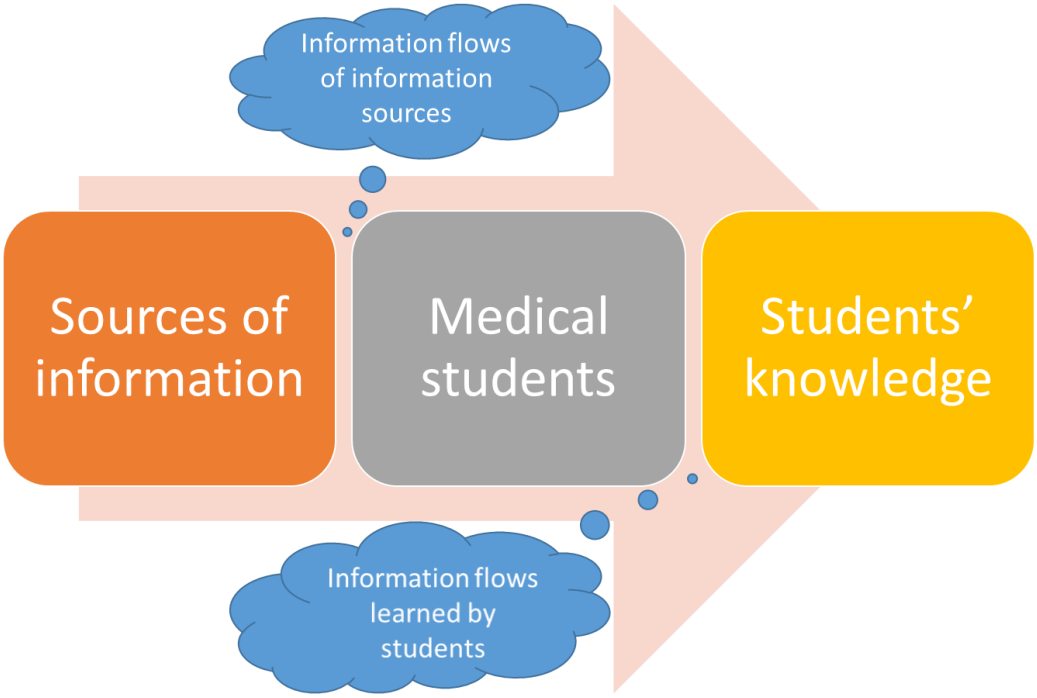

Fig.8. Structure and content of information flows in the formation of knowledge of medical students

Therefore, in order to ensure high-quality and complete knowledge of medical students, it is necessary to maximize the coincidence of information flows of information sources and information flows learned by students. As empirically confirmed during the teaching of histology at the National Pirogov Memorial Medical University (Vinnytsia, Ukraine), in the process of traditional education, students learn no more than a quarter of the proposed educational material, that is, the information flows learned by students in the process of traditional education are 1/4 of the information flows of information sources. When teaching histology at National Pirogov Memorial Medical University (Vinnytsia, Ukraine), it has also been empirically confirmed that digitalization and visualization of educational content using mind maps can increase this indicator by 2-3 times due to an increase in the efficiency of visual perception of the material, acceleration of the transfer of information into long-term memory and knowledge, and active participation in managing the presentation of educational content, that is, information flows learned by students when using visualization tools (mind maps) make up at least 2/4-3/4 of the information flows of information sources. Thus, it is the representation of information flows of information sources in a visual form (in particular, in the form of mind maps) that allows to increase the coincidence of information flows of information sources and information flows learned by students.

Taking into account the abstract model of information processing (Fig. 6), as well as the structure and content of information flows in the formation of knowledge of medical students (Fig. 8), let"s present the process of processing information flows in the educational process of medical students using mind maps in the form of such information model – Fig. 9.

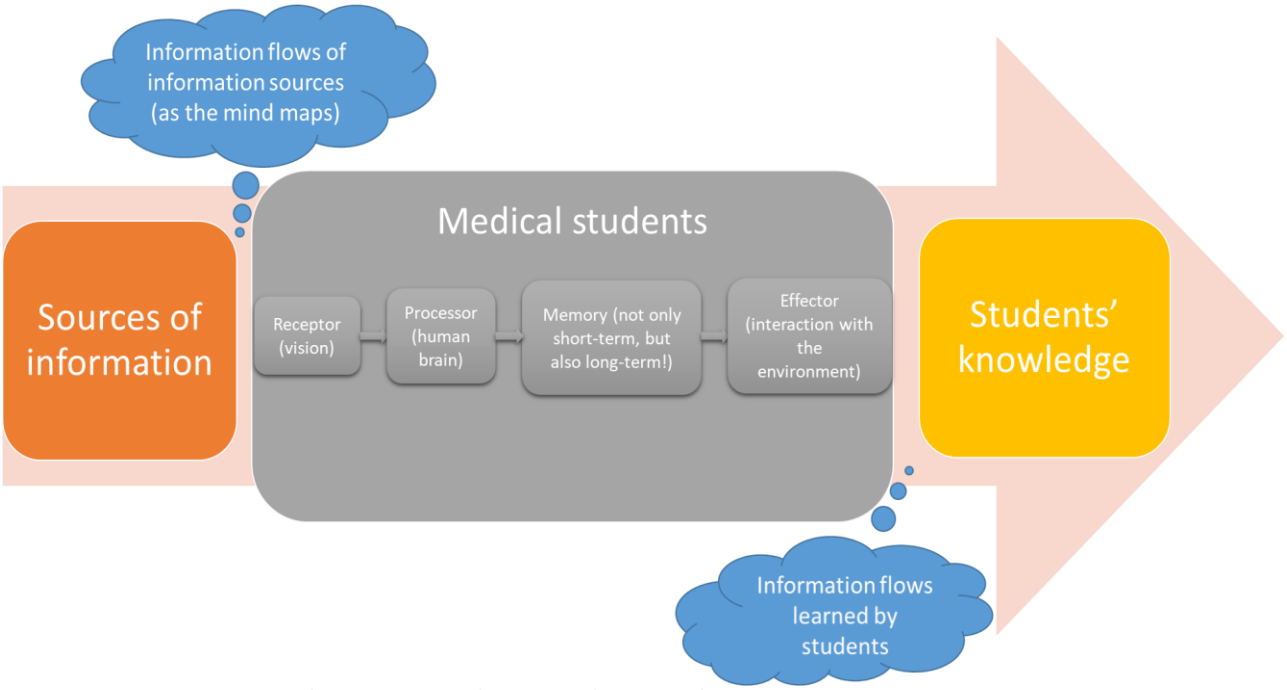

Fig.9. Information model of knowledge formation of medical students using mind maps

Thus, the modeling and processing of information flows of the educational process of medical students has shown that students' knowledge is largely determined by the characteristics of information sources, and in order to maximize the coincidence of information flows of information sources and information flows learned by students, it is worthwhile and expedient to digitalize and visualize educational content using mind maps. It has been empirically confirmed that the use of mind maps in the study of the educational component "Histology" has increased the coincidence of information flows of information sources and information flows learned by students from one quarter to three quarters.

Conclusions

The fundamental principle of medical education today should be the formation of a highly qualified competitive medical professional who can conduct innovative activities and has the skills of continuous professional development, as well as increasing the transparency and clarity of the educational process for students and building confidence in achieving effective results. The creation of a modern innovative educational environment involves ensuring optimal conditions for the development and self-development of a student, which can be created, among other things, through the use of modern digital resources by both lecturers and students. Thus, the task of digitalizing the educational process of medical students is currently relevant. The purpose of this study is to model and process the information flows of the educational process of medical students.

Digitalization and visualization of the educational process at the Department of Histology of National Pirogov

Memorial Medical University (Vinnytsya, Ukraine) by developing mind maps revolutionizes education, improves the teaching process, significantly increases the efficiency, effectiveness and quality of the educational process through the development of cognitive, productive, reproductive thinking in students, compliance with the intellectual capabilities of higher education students, increasing the level of involvement of students, developing digital competence in students, and so on.

The modeling and processing of information flows of the educational process of medical students has shown that students' knowledge is largely determined by the characteristics of information sources, and in order to maximize the coincidence of information flows of information sources and information flows learned by students, it is worthwhile and expedient to digitalize and visualize educational content using mind maps. It has been empirically confirmed that the use of mind maps in the study of the educational component "Histology" has increased the coincidence of information flows of information sources and information flows learned by students from one quarter to three quarters.

References

1. Education: Strategy of Ukraine 2030. URL: https://www.slideshare.net/UIFuture/2030-148758034.
2. K. Michio. Physics of the Future: How Science Will Shape Human Destiny and Our Daily Lives by the Year 2100. New York: Doubleday, 2011. 416 p.
3. 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.
4. 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.
5. Future Skills You'll Need In Your Career By 2030. URL: https://talent500.co/blog/future-skills-youll-need-in-your-career-by-2030/
6. M. Watts. 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/.
7. A Periodic Table of Visualization Methods. URL: http://www.visual-literacy.org/periodic_table/periodic_table.html.
8. Mind Maps. URL: https://learnenglishteens.britishcouncil.org/skills/reading/a2-reading/mind-maps.
9. 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, no. 08. P. 97–111.
10. Information processing. URL: https://www.britannica.com/technology/information-processing.

Valentyna Hnenna **Валентина Гненна**	PhD in Medical Sciences, Associate Professor, Associate Professor at the Histology Department, National Pirogov Memorial Medical University (Vinnytsya, Ukraine) https://orcid.org/0000-0002-0058-8399 e-mail: valentina.gnenna@gmail.com	Кандидат медичних наук, доцент, доцент кафедри гістології, Вінницький національний медичний університет ім. М. І. Пирогова
Anatolii Korol **Анатолій Король**	PhD in Medical Sciences, Associate Professor, Head of the Histology Department, National Pirogov Memorial Medical University (Vinnytsya, Ukraine) e-mail: histology@vnmu.edu.ua	Кандидат медичних наук, доцент, завідувач кафедри гістології, Вінницький національний медичний університет ім. М. І. Пирогова
Oleg Voichur **Олег Войчур**	PhD Student, Lecturer of Computer Engineering & Information Systems Department, Khmelnytskyi National University https://orcid.org/0000-0001-8503-6464 e-mail: ovoichur@gmail.com	Аспірант та викладач кафедри комп'ютерної інженерії та інформаційних систем, Хмельницький національний університет
Olha Hovorushchenko **Ольга Говорущенко**	Student of National Pirogov Memorial Medical University (Vinnytsya, Ukraine) https://orcid.org/0000-0001-6583-5699 e-mail: govorusenkoo@gmail.com	Студентка Вінницького національного медичного університету ім. М. І. Пирогова
Viktoriia Popova **Вікторія Попова**	Student of National Pirogov Memorial Medical University (Vinnytsya, Ukraine) https://orcid.org/0009-0007-6823-4849 e-mail: vikapopova3794@gmail.com	Студентка Вінницького національного медичного університету ім. М. І. Пирогова