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ABSTRACT

of the dissertation for the degree of Doctor of Philosophy

TEACHING NETWORK TECHNOLOGIES IN THE TRAINING OF INFORMATICS TEACHERS

Speciality: 5801.01 – "Theory and methodology of training and education (methodology of teaching informatics)"

Field of science: Pedagogy

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GENERAL DESCRIPTION OF THE RESEARCH

Relevance and the degree of research of the topic: One of the primary demands of the modern era is to raise a young generation capable of mastering skills to utilize new technologies. Not only computer science teachers but also primary, secondary, or higher education teachers of any discipline must be proficient in accessing their personal electronic accounts, uploading instructional materials to educational portals, and assessing laboratory and practical assignments of students. Furthermore, all teachers must be capable of using modern search engines to gather necessary materials from the Internet to prepare lessons and presentations on any given topic, embed these materials into presentation slides, and subsequently animate them.

Network technologies emerge as the most essential and integral component of new innovative and interactive technologies. Modern educators, including computer science teachers, must properly organize online classes by utilizing Internet teleconferencing services. They must also be capable of organizing online discussions in teleconferencing software such as Zoom, Microsoft Teams, and others, while effectively engaging students in these discussions. All these evident facts further substantiate the distinct relevance of the topic "Teaching Network Technologies in the Training of Computer Science Teachers." It can be asserted with confidence that this relevance continuously amplifies over time because the new generation utilizes new technologies with great proficiency, thereby demanding teachers to possess new, innovative knowledge, skills, and abilities.

The process of integrating informatics into education has been characterized by the application of new information technologies to the instructional process. Under the conditions of changing content and structure of informatics education in higher and secondary schools, the analysis of the professional activity of computer science teachers proves that the problem of training high-quality computer science teachers possesses paramount importance and is growing day by day.

Alongside teaching informatics as a fundamental science to students and undergraduate students, a modern computer science teacher must concurrently pay special attention to the user-oriented aspects of informatics. In this regard, they must perfectly know and teach software designed for working with text, audio, and video, as well as be competent in developing software and multimedia applications. Additionally, a modern computer science teacher must prepare students and undergraduates for olympiads and conferences at a high level. Consequently, future computer science teachers studying at higher education institutions must develop not only general cultural and professional competencies but also subject-specific competencies, including proficiency in programming, network technologies, and multimedia systems.

Apart from electronic textbooks, great importance is also attached to video lessons. Unlike traditional textbooks, television, and motion pictures, video files are highly effective for the repetition and explanation of educational materials, creating a systematic transition from simple to complex concepts. By reviewing video clips, future computer science teachers become more deeply engaged in the teaching process and acquire new skills by solving the interactive tasks embedded within those videos.

The structure of a video lesson is meticulously designed by the author, remaining compact and structured from simple to complex. All information is maximally clear and comprehensible, and the presenter acts as an educator with extensive work experience who possesses a comprehensive knowledge of the subject's teaching methodology.

The application of video lessons yields the following results:

- enhancing the visual clarity of the educational process;
- ensuring the vitalization of teaching;
- saving time;
- increasing the quality and effectiveness of the educational process;
- deepening interdisciplinary connections;
- increasing the activity of creative performance;

- optimizing the search for vital and significant information sources.

In the process of designing a lesson based on the use of interactive technologies, the teacher implements the following objectives:

1) selects the primary targets subject to comprehensive monitoring;

2) forms the initial structure of the educational process;

3) identifies and selects optimal forms, methods, and teaching tools;

4) determines methods for the prompt elimination of errors that may occur in the educational process.

Modern information and communication technologies possess highly powerful interfaces for conducting teleconferences with audio and video content. For this very reason, future informatics teachers must acquire deep knowledge in this field to use information and communication technologies effectively and purposefully. Such competencies require skills and habits in utilizing electronic educational resources (EER).

In the process of using electronic educational resources, each resource must individually solve specific tasks of the educator, and the implementation of each resource must be carried out in a methodologically correct and well-founded manner.

Wireless technologies emerge as a particularly noteworthy type of distance technologies. The Microsoft Teams software can be cited as the most widespread service for implementing distance learning technologies. The analysis of pedagogical practice shows that informatics teachers, in most cases, build their online platforms based on Moodle and use a popular method based on CMS (content management systems) for website development.

As one of the most widespread CMS platforms on the Internet, the WordPress platform can be highlighted, which provides the teacher with the following opportunities:

– installation of free plug-ins that optimize the website's application across various mobile devices;

– addition of interactive elements to text, images, and videos;

– integration of interactive videos, simulators, and tests developed in other applications;

– provision of online exchange of ideas between learners and the teacher through various network services, such as the VKontakte API;

– the ability to work in parallel with various Internet services.

During the research process, the practical application experience of methods and tools used by advanced teachers in teaching the computer networks course, as well as the level of students' knowledge and skills, were studied.

The research aims to develop a methodology geared toward innovative approaches to training in practical sessions of the Network Technologies course, and toward developing the creative qualities of students' thinking activities.

In the dissertation work, the necessity of using practical approaches to training in the teaching of the Network Technologies course– which holds a special place in ensuring the scientific and methodical preparation of future informatics teachers in higher pedagogical schools– has been theoretically and practically substantiated. All tasks put forward regarding the problem of the research have been resolved, and the following main results have been achieved:

1. The subject of Network Technologies is of crucial importance in ensuring the scientific and methodical preparation, in other words, the professional training of future informatics teachers at the bachelor's level in higher pedagogical educational institutions. Alongside the general educational significance of studying the course itself, its primary objective is to provide the scientific foundation for the concepts studied in the secondary school informatics course and to instill the necessary practical skills for delivering them to pupils.

2. Prior to our study, it was shown that the level of development of students' knowledge and skills in the Network Technologies course was low, which generally leads to a decline in students' scientific and methodical preparation and, consequently, in the level of overall professional training.

3. As a result of the analysis of pedagogical-psychological literature, the characteristics of the student age period were determined, and difficulties associated with students' adaptation to changing conditions during the transition from school education to higher education institutions were noted. Based on the analysis of educational-methodical literature and the specific research conducted, it was determined that studying the Network Technologies course, especially its practical topics, creates greater difficulties, which is also linked to several objective reasons.

Regarding the degree of research on the topic, it should be noted that Russian scholars, including V.A.Sukhomlin[1], V.G.Olifer[2], and others, have addressed the solution to this problem. When analyzing their research papers, we have once again been convinced that the competence-based approach in education is currently not only a means of equipping future specialists with profile-oriented competencies, but also a means of fundamentalizing education in terms of core knowledge. More specifically, the competence-based approach shapes[3] the overall performance capabilities of the future professional.

Object of the research: Training of future informatics teachers through the instruction of network technologies.

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[1] Sukhomlin, V. A., & Andropova, E. V. (2013). Diversifikatsiya programm professional'noy podgotovki v mezhdunarodnykh obrazovatel'nykh standartakh v oblasti informatsionnykh tekhnologiy [Diversification of professional training programs in international educational standards in the field of information technology]. *Vestnik Moskovskogo Universiteta. Seriya 20. Pedagogicheskoe Obrazovanie*, (1), p. 75.

[2] Olifer, V. G., & Olifer, N. A. (2023). Komp'yuternye seti. Printsipy, tekhnologii, protokoly [Computer networks. Principles, technologies, protocols] (6th ed.). Piter. p. 142.

[3] Baydenko, V.I. (2005). *Kompetentnostnyy podkhod k proektirovaniyu gosudarstvennykh obrazovatel'nykh standartov vysshego professional'nogo obrazovaniya (metodologicheskie i metodicheskie voprosy): Metodicheskoe posobie* [Competence-based approach to designing state educational standards of higher professional education (methodological and methodical issues): A methodical manual]. Research Center for Problems of Quality in Specialist Training.methodical manual]. Research Center for Problems of Quality in Specialist Training. p. 45.

Subject of the research: Development of a teaching method aimed at forming the competence of future informatics teachers through the instruction of network technologies.

The aim and objectives of the research: To develop a methodology for utilizing specialized software for the effective teaching of network technologies in informatics teacher training. This includes the technology of working with virtual machines and environments within the framework of a competence-based approach. The following objectives have been set in the research:

a) The first group of objectives aims to substantiate the selection of teaching content aligned with network technologies; to analyze scientific and methodical literature for this purpose; and to select and clarify the basic concepts of the subject area as a science. Specifically, to clarify concepts such as information and network technologies, computer networks, information-educational environments, training-computer networks, and others.

b) The second group aims to develop technological tasks for selecting elements of the methodical system to study network technologies.

c) The third group aims to test the proposed approach to methods and training through tasks of an experimental nature.

Methodological basis of the research: This consists of the dialectical theory of cognition, and the collection of principles, methods, theoretical propositions, and tools applied for the study, comprehension, and transformation of pedagogical facts, phenomena, and processes.

Research methods:

- theoretical analysis of psychological, pedagogical, methodical, and scientific literature related to the research problem;
- interviews and discussions with teachers;
- utilizing computer systems to eliminate difficulties arising during the solution of problems related to any given subject;
- conducting integrated mathematics and informatics lessons by utilizing computer network technologies;
- conducting theoretical and practical sessions in informatics by using the developed methodology;

- observing the learning activities of students majoring in informatics teacher education at the university level and providing them with recommendations during this process;

- conducting interviews with students and recording these discussions.

Propositions presented for defense:

1) To theoretically and practically substantiate the teaching of computer networks and network technologies to students in university teaching majors through new innovative methods;

2) To prove the necessity of structuring the forms of training organization based on an active approach and modular technology;

3) To emphasize that the use of virtual simulator programs as specialized software playing the role of the primary teaching tool is of utmost importance.

Scientific novelty of the research: This consists of a new methodical and technological approach to teaching network technologies in informatics teacher training. This is based on a set of professional teaching tasks in the field of computer network administration and reflects the structured activity of a specialist in this field.

Theoretical and practical significance of the research: The method proposed by the author has been substantiated through a methodical system established within the framework of the dissertation research in the process of teaching network technologies in informatics teacher training. Thus, a concept of professional competence in the field of network administration has been formulated. During this process, the purposeful objectives method was utilized.

Approbation and implementation of the research work: Presentations were delivered at several international and republican scientific conferences regarding the results of the research. Articles and abstracts have been published in journals recommended by the Supreme Attestation Commission.

Name of the organization where the dissertation work was performed: The dissertation work was performed at the Department of Informatics and Algebra of Ganja State University.

The dissertation consists of an Introduction, 2 chapters encompassing 10 sections, a Conclusion, a Bibliography, and Appendices. The Introduction comprises 13 pages and 24,469 characters; Chapter I comprises 55 pages and 94,478 characters (Section 1.1 – 16 pages, 27,209 characters; Section 1.2 – 10 pages, 16,041 characters; Section 1.3 – 9 pages, 15,957 characters; Section 1.4 – 7 pages, 10,970 characters; Section 1.5 – 15 pages, 24,301 characters); Chapter II comprises 56 pages and 77,527 characters (Section 2.1 – 16 pages, 19,372 characters; Section 2.2 – 9 pages, 13,916 characters; Section 2.3 – 11 pages, 14007 characters; Section 2.4 – 8 pages, 9,068 characters; Section 2.5 – 16 pages, 21,079 characters); the Conclusion comprises 4 pages and 6,208 characters. Excluding the Bibliography and Appendices, the total volume of the dissertation is 202,682 characters.

MAIN CONTENT OF THE RESEARCH

In the "**General Description of the Research"** section of the dissertation, the relevance of the topic and its degree of development are substantiated, and its object, subject, aim, and objectives are defined. The methodological basis of the research, the propositions presented for defense, the scientific novelty, and the theoretical and practical significance of the study are highlighted. Information regarding the approbation and implementation of the research work, the name of the organization where the dissertation work was performed, the individual volume of the structural parts of the dissertation, and its total volume in characters is presented.

In the **"Introduction"** section, the relevance of the research is substantiated; the object and subject, the aim and objectives, the hypothesis, the methodological basis, the research methods, and the propositions presented for defense are indicated; and the scientific novelty of the work is explained. Additionally, the scientific novelty of the research, the level of study of the problem, its theoretical and practical significance, and the propositions presented for defense are elaborated upon, along with brief information regarding the implementation of scientific results and the approbation of the work.

Chapter I is titled "Theoretical Foundations of Teaching Network Technologies Based on a Computerized Approach in Informatics Teacher Training."

The first paragraph of this chapter is titled ***"Computer Network and Network Technologies as a Basic Section of the Informatics Subject."*** In this paragraph, the concept of a "computer network" is provided, the purpose of computer networks is examined, and the directions of modular technology for the propedeutics of modern network technologies are reviewed. The concept of "network topology" is given in the first paragraph, and bus, ring, star, hierarchical, fully connected, and hybrid topologies are presented as types of topologies. At the end of the first paragraph, three main components of network technologies are noted: hardware, software, and information components. For the propedeutics of modern network technologies, the use of the following modular technology is considered appropriate:

1. The Internet and its possibilities of use. What is the Internet? (The Internet and standards, Internet service provider). ISP (provision of Internet services to a finite number of users, hierarchy of the Internet network, use of various tools for creating an Internet map). Formatting of pages, their organization into blocks, etc.

2. Support service.

Technical specialists of the support service (organization of the ISP support service, duties of technical specialists of the Internet service provider, communication with customers). The OSI model. Troubleshooting at the Internet service provider level.

3. Planning network upgrades.

Documenting the characteristics of the existing network (physical and logical topology, documenting network requirements). Planning (stages of network modernization, physical medium, cabling). Operation of network equipment.

4. Configuration of network equipment.

5. Routing.

Application of routing protocols (foundations of routing, routing protocols, configuration of the RIP protocol).

6. Services provided by Internet service providers.

Introduction to the services offered by the ISP (Customer requirements, reliability, and availability). Protocols ensuring the functionality of ISP services (TCP/IP protocols, transport layer protocols, differences between TCP and UDP, supporting multiple network services). Domain Name Service (DNS).

7. Obligations of providers.

The second paragraph of chapter I is called ***"Purpose of educational computer networks, design, creation and level of their use". This*** paragraph considers the concept of "educational computer network" as a computer network used in the educational process and gives the main tasks of using educational computer networks in educational institutions. The process of building a network in educational institutions is divided into 4 stages: task analysis, physical structure design, infrastructure design and deployment. At the task analysis stage, both the physical and logical structure of the network is analyzed, and then at the second stage, the physical structure of the network is designed. At the second stage, depending on the requirements for the network, the composition of the network equipment, as well as the number and characteristics of computers, are determined. At the final stage, the deployment stage, the connection lines are arranged, the equipment is installed and configured. Then, the main characteristics and comparative analysis of the network standards IEEE 802.3 (Ethernet), IEEE 802.5 (Token-Ring), IEEE 802.12 (AnyLAN), Datapoint (Arcnet), ISO 9314 (FDDI) are carried out.

The third part of chapter I The paragraph is entitled ***"Levels of use of educational computer networks in educational institutions"***. This paragraph considers the concept of "information-educational environment" and its constituent components (information, hardware, regulations). Then, 2 levels of use of educational computer networks in educational institutions are given: user and IT specialist levels. The user level includes those persons who participate in the implementation of the educational process, that is, they carry out their professional, educational and educational duties from the computer network of the educational institution (in short, teachers).

The IT specialist level includes highly trained personnel who are able to provide services to and manage the computer network of an educational institution. Network administrators at this level must be able to perform the functions of strengthening and configuring network workstations, creating and supporting user budgets, supporting system performance, installing software on workstations, and providing assistance to users. The International Organization for Standardization (ISO) has divided network administration and management into five main areas:

1) troubleshooting management,
2) configuration management,
3) resource utilization management,
4) production management,
5) security management.

The tasks performed by a training computer network administrator are similar to those performed by the administration of any computer network. Therefore, most of the issues solved using information and communication technologies in educational institutions, especially those related to the management of the educational computer network, fall not on the IT specialist, but on the informatics teacher. The functions that the informatics teacher must perform in the field of managing the educational computer network are as follows:

a) independently design and ensure the operational maintenance of the local computer network of the educational institution;

b) ensure full use of network resources, be able to assess the quality of hardware for the corporate computer network and the Internet;

c) be able to assess the quality of software tools that provide the use of network technologies in training;

d) assist the school administration in using local and corporate computer networks and Internet resources at school;

d) have knowledge of the architecture of computer networks and network resource management technology;

e) have the skills to protect information on the Internet and local computer networks.

The fourth paragraph of Chapter I is called ***"Specifically competent characteristics of an informatics teacher in the field of computer network management"*** and the main ideas of the competent approach are expressed here as follows:

a) competence combines the intellectual and habit segments of education;

b) competence covers not only the cognitive and operational-technological parts, but also motivational, ethical, social and behavioral components. It includes the results of training (knowledge and skills), value system, habits, etc.;

c) competence means acquired knowledge, skills, experience, knowledge of how to behave in a specific situation;

d) The content of the concept of "competence" includes the content interpretation of education that is formed "as a result";

e) competence occurs not only as a result of the learning process at school, but also under the influence of the environment surrounding the individual, that is, it is formed both in formal and informal settings, outside of formal education.

The specialization of an informatics teacher is formed on the basis of State standards of higher educational institutions for vocational education. According to this standard, the training of future teachers in the "informatics" specialty includes computer networks, the Internet and multimedia.

The content of the subject includes the section "Computer Networks". The parts of the block it organizes are: Fundamentals of network technologies; Local area networks; Computer network equipment; Programming of network applications; Information protection in networks. A modern computer science teacher should have the following special competencies in creating an information and educational environment of an educational institution for pedagogical purposes:

a) architecture of computer networks and design of training computer networks;

b) management of computer networks and operation of training computer networks;

c) provision of services to the training computer network and use of their resources in the training process and in the management of education;

d) knowledge of the characteristics of training computer networks, expansion of their resources when organizing the training process and managing education;

Chapter I, paragraph 5 is called ***"The concept of teaching network technologies to future computer science teachers"***. This paragraph includes the following as the most important features of a promising education system:

a) fundamentalization of education. This should fundamentally change the quality of education;

b) the preventive nature of the entire education system, its orientation to the problems of the future post-industrial civilization, to the creative abilities of man;

c) the accessibility of the education system to all inhabitants of the planet through the wide use of information and communication technologies and the possibilities of distance learning.

This paragraph gives the main terms of information technologies, including network technologies: the concepts of specification, standard, protocol, profile.

The concept of training of a network technology specialist includes the skills of managing:

1) management of an educational computer network. This includes design, configuration and maintenance;

2) management of the development of the information and educational environment (system) of the educational institution.

This paragraph proves the importance of such professional skills as design, configuration, network maintenance and management of future computer science teachers in network technologies. The basic components of network technologies are determined and the management of training computer networks in educational systems of various levels is determined. The main approaches to training are selected: activity and competence. A

universal approach is accepted as the most cost-effective method for students to fulfill their professional duties.

The second chapter of the dissertation is called **"Methodology of teaching the subject of network technologies through practical tasks"**.

Paragraph 1 of this chapter is devoted to ***"Classification of network technologies and practical training of management functions in the educational process"***. This paragraph lists the following as the functions of computers connected to the network:

1) ensuring network availability

2) managing information transfer between computers connected to the network

3) providing various services to network users

Classifications of network technologies are given according to the rules of transmission and the scale of the network. In point-to-point network technology, two network nodes are connected directly and without an intermediary, while in point-to-multipoint technology, one central node is connected to more than one node at the same time. Depending on the scale of the network, VPN, PAN, WAN, MAN, LAN types of networks are noted.

VPN (Virtual Private Network) securely connects two computers connected to the Internet. In this case, data is encrypted and confidentiality is ensured.

PAN (Personal Area Network) type has a very small coverage area, supports a distance of about 10 meters and provides communication between personal devices such as tablets, smartphones, smart watches, headphones and other computers.

MAN (Metropolitan Area Network) is a type of network on a large city or regional scale and is created as a result of connecting several local networks over a larger area via a high-speed connection. At the end of the paragraph, the sequence of wired and wireless network connections of computers in Windows 10 and Linux operating systems, the procedure for assigning IP addresses, is explained.

The second paragraph of Chapter II is entitled ***"Types of Internet resources and current problems of information security"***. This paragraph first gives the types of Internet resources:

1) websites
2) social networks
3) blogs
4) portals
5) Internet services

To ensure the security of information in computer networks, it is necessary to protect the network from cyber threats. Cyber threats or cybercrime are crimes committed over the Internet or other networks. The source of cyber threats is Trojan viruses, including spyware, adware, and remote control utilities. The most convenient way to protect against these threats is antivirus programs.

The third paragraph of Chapter II is called ***"Implementation of consistency and systematicity in the preparation of lectures on the subject of network technologies and multimedia"***. This paragraph, in turn, is divided into the following subparagraphs:

2.3.1. Methodological approach to teaching the topic of the concept and classification of computer networks

2.3.2. Methodological approach to teaching the topic of cables and devices used in the network

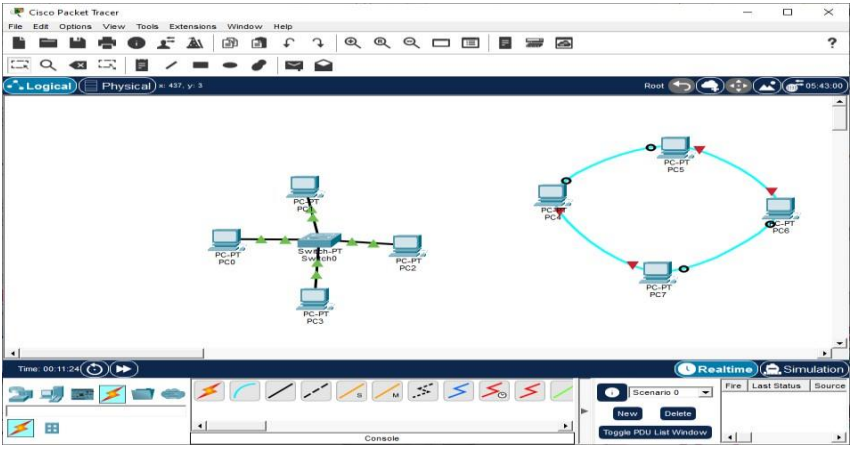
2.3.3. Methodological approach to teaching the topic of technologies used in local networks

2.3.4. Methodological approach to teaching the topic of dividing local networks into segments

2.3.5. Methodological approach to teaching the topic of global networks and their classification

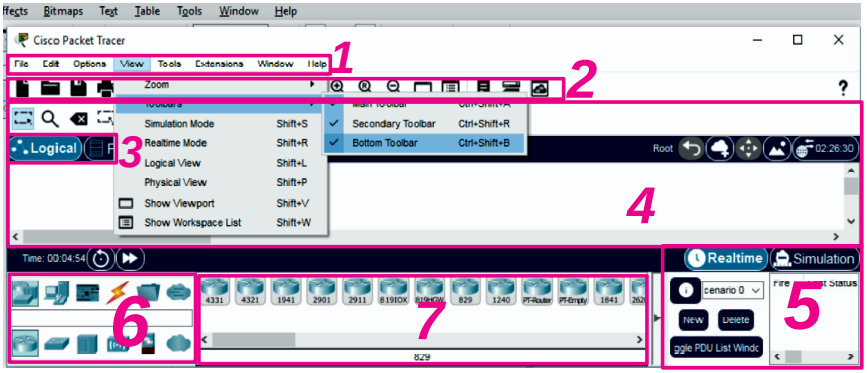
In subparagraph 2.3.1, a methodological justification of the concept of a computer network and the classification of networks is provided: what a computer network is, what components it consists of, according to what criteria and into what types it is divided should be consistently analyzed. The reasons for the purpose of connecting computers to the network and the joint use of which resources (files, printers, modems, magnetic disks and other equipment) are considered. Subparagraph 2.3.2 provides a methodological

justification of the principles for selecting cables used in network construction, the appropriate selection of communication devices depending on the purpose, goals and tasks of the network, and the rules for connecting computers to these devices. Subparagraph 2.3.3 provides a comparative explanation of the names and areas of use of LAN, i.e. local area network technologies (Ethernet, Token Ring, Arcnet) in a separate table, and their topology, cable system, price, maximum throughput, reliability, scalability, convenience and repairability. Subparagraph 2.3.4 provides a methodological justification of the reasons for dividing the local area network into segments, and the rules for setting up network equipment and connections between them in each separate segment. This subsection explains the standard toolbars[4] that are part of the main window of the virtual simulator program Cisco Packet Tracer and the functions of the buttons on those toolbars.



Picture 2.3.4.1. Network sharing in Cisco Packet Tracer

[4] [5] Gafarov, A.A. Gelecek informatika muellimlerine lokal shebeke khellerinin CISCO PACKET TRACER simulyatorunda oyredilmesi [Teaching local network technologies to future informatics teachers in CISCO PACKET TRACER simulator] // AMEA Gence Bolmesi, "Kheberler mecmuesi" (Pedagoji elmler seriyasi) [ANAS Ganja Regional Division, "Collection of News" (Pedagogical sciences series)]. Ganja, – 2022. No. 1 (4), – pp. 25-31.

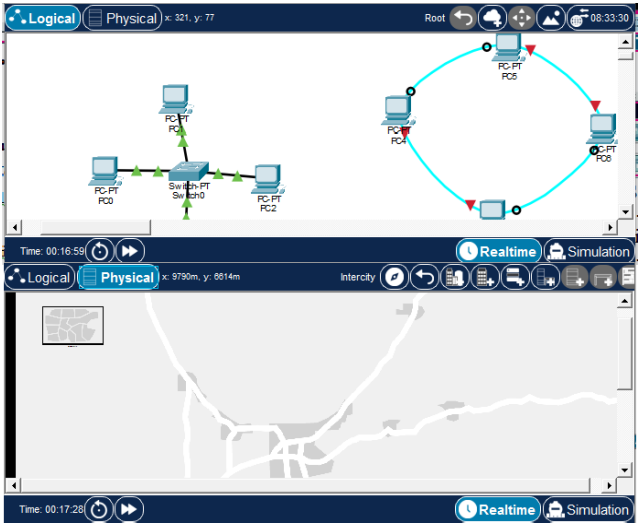


Picture 2.3.4.2. Cisco Packet Tracer interface

Part 1 contains the Menu commands (File, Edit, Options, View, Tools, Extensions, Help).

Part 2 is called the main toolbar and contains the following tools: Copy, Paste, Undo, Redo, Zoom, Drawing Palette

Part 3 (Logical/Physical) Provides switching between Logical/Physical operating modes.



Picture 2.3.4.3: Logical/Physical operating modes in Cisco Packet Tracer

Part 4 is the Workspace section. It is in this area that network equipment is placed and installed on the network.

Part 5 is the section called Realtime / Simulation, which provides a switch between Realtime Mode and Simulation Mode.

Part 6 is called the Network Components Box. This box is where we select devices and connections to place in the workspace.

Part 7 is called the Device Type Selection Box. This box contains the types of devices and connections available in the Packet Tracer.

By performing several practical tasks on the purpose of these commands, the teaching of the topic can be concluded.

Subparagraph 2.3.5 justifies the methodological sequence in which global networks and their classification should be conveyed to students. This paragraph explains the time frame and sequence in which the services offered by the leading provider companies AzTelekom, AiləNet, Azerin, Intrans, AzEuroTel are explained.

The fourth paragraph of Chapter II is dedicated to **"Methodology of preparing practical lessons of the subject of Network Technologies and Multimedia"**. In this paragraph, first, the methodology of connecting four computers to a Switch (converter) via an automatic cable and exchanging packets between computers is given, then in the next part of the lesson, students are given the task of setting up a network between two personal computers and two laptops, checking and discussing the errors made, and at the end of the lesson, they are instructed to set up a relatively complex network (Intranet).

The fifth paragraph of Chapter II is entitled **"Pedagogical experiment and analysis of its results"**. This paragraph emphasizes the need to conduct a pedagogical experiment in order to raise the quality of teaching of the subject of Networking in the specialties of "Mathematics Teacher", "Informatics Teacher", "Mathematics and Informatics Teacher" of higher education institutions to a higher level and to form innovative thinking in students.

The experimental research, spanning the years 2018–2023, consisted of three phases: **the first phase, having a determining nature**, covered the years 2018–2019; the **second phase, having a**

formative (instructional) nature, covered the years 2019–2022; and the **third phase, being a summative (verification) experiment**, covered the years 2022–2023. The experimental research was conducted at the Faculty of Mathematics and Informatics of Ganja State University.

During the conduct of the research, questionnaire surveys and interviews were initially carried out with teachers instructing the relevant subject to verify the knowledge level of first-year students in teaching majors regarding the hardware and software of local and global network technologies; it was determined that the instruction of these topics is conducted using outdated methods.

To analyze the educational experiment, a non-control group (one-way or one-sided) experimental method was used, which is widely explained in the pedagogical literature.

In this determining phase of the research, 3 levels of knowledge development were identified corresponding to the partial-search and research levels of cognitive activity: descriptive, applied, and creative.

To determine the level of knowledge development among university students, the calculation of their level coefficient was carried out according to the following formula:

$$S_m = \frac{n}{n_0} \leq 1$$

In this formula, n_0– is the number of total questions, and n is the number of correctly and completely answered questions.

Taking into account the above, the calculation of the entered coefficient is carried out according to the formula $S_m = \frac{n+n_1}{n_0} \leq 1$ (where $n_1 = n_{incomplete} \cdot 0.8$, where n- the number of complete and correct answers, $n_{incomplete}$- the number of correct but incomplete answers, n_0- the number of total questions).

As a result of the experiment, if $S_m \leq 0.5$, knowledge is formed at the descriptive level; if the calculated coefficient satisfies the condition $0.5 \leq S_m \leq 0.8$, then at the applied level, and finally, if the condition $S_m \geq 0.8$ is satisfied, knowledge is considered formed at the creative level.

The level of formation of initial knowledge and skills of the students participating in the experiment was evaluated as the numerical average of the indicators in the form of a total coefficient $S_{initial} = 0.65$.

This result indicates that the students' level of assimilation of new material is satisfactory, but sufficient (in other words, not at a high level).

136 students participated in the experiment, and these students were divided into groups according to the levels of knowledge formation as follows: 50 people (36.8%) at the level of description, 77 people (56.6%) at the level of application, 9 people (6.6%) at the level of creativity. The indicators of the level of preparation of students in the first academic year of the organized defining experiment are given in the table below:

Table 2.5.1

Number of students involved in the experiment	Level of knowledge formation					
136	Description		Application		Creativity	
	count	%	count	%	count	%
	50	36,8	77	56,6	9	6,6

At the decisive level of the conducted pedagogical experiment, the following results were obtained:

- Very few students have creative thinking and cannot consciously apply this thinking to the necessary extent and direction;

- The ability of students studying at the university to solve non-standard, highly creative tasks requiring high creativity is not that high, and this fact indicates that these students are unprepared for their future professional activities;

- The teaching of network technologies, which is given special importance in the preparation of informatics teachers, should be carried out at a qualitatively new level.

To solve this issue, the application of new innovative and at the same time interactive technologies in order to form creative thinking in students is extremely crucial. At the same time, when teaching network technologies, it is necessary to apply the principle of a modular approach so that it is possible to identify the topics that the student knows poorly and instill in him new knowledge, skills and habits on these topics. The second phase of the research covers the years 2019–2022 and has a **formative (instructional) nature**. In the years 2019–2022, the new topics were added to the syllabi of teachers instructing Computer Networks and Network Technologies in the majors of Informatics Teacher Education, Mathematics Teacher Education, and Mathematics-Informatics Teacher Education.

In the **educational stage** of the pedagogical experiment, educational and research work was carried out based on the principle of a modular approach to teaching network technologies to third-year students of the specialties of Informatics Teacher, Mathematics Teacher, as well as Mathematics and Informatics Teacher, using new innovative teaching methods, including interactive hardware and software tools. It was considered extremely important for future computer science teachers to master the rules for connecting computers and other technical equipment in a local network, the standards for sending and receiving information packets between network nodes, and to use them in their further professional activities, using a virtual simulator program in lectures and especially in laboratory lessons.

A number of such laboratory works were given to the students and successfully completed by them.

At the end of the pedagogical experiment, after the completion of the teaching of all the topics provided for in the syllabus according

to the subject program of computer networks, a **final testing stage** was set to evaluate the new knowledge, skills and habits formed in the students, and new tasks were given to the participants in the experiment in accordance with the criteria of the program and syllabus.

As an indicator of the effectiveness of innovative training, indicators of the level of knowledge formation and the number of students moving from a low level to a high level were considered. 4 topics were selected using the selection method, 5 tasks were assigned to each topic. In order to examine the quality of the implementation of the testing work in the conducted study, the knowledge coefficient of the students was formed according to three indicators: correct and complete answers, correct and incomplete answers, incorrect (wrong) answers. The table below shows the results of the testing work on the topics assigned in the research process.

Table 2.5.2

Indicators of completion of interim inspection work on topics (in people and %)

Inspection performance indicator	Topic 1	Topic 2	Topic 3	Topic 4
correct and complete	10 (7.4%)	12 (8.8%)	14 (10.3%)	15 (11.0%)
correct and incomplete	85 (62.5%)	79 (58.1%)	84 (61.8%)	84 (61.8%)
incorrect (wrong)	41 (30.1%)	45 (33.1%)	38 (27.9%)	37 (27.2%)

At the end of the educational experiment, the coefficient of the level of knowledge formation was $S_{final} = 0.76$. The distribution of students participating in the study by levels was carried out as follows: 35 people (25.7%) were assigned to the description level, 87 people (64%) to the application level, and 14 people (10.3%) to the creative level, and is reflected in the following table:

Table 2.5.4

Number of students involved in the experiment	Level of knowledge formation					
136	Description		Application		Creativity	
	count	%	count	%	count	%
	35	25,7	87	64,0	14	10,3

According to the analysis of the results, 5 students moved from the application level to the creative level, and 15 students moved from the description level to the application level.

The pie charts reflecting the situation before and after the pedagogical experiment can be given as follows:

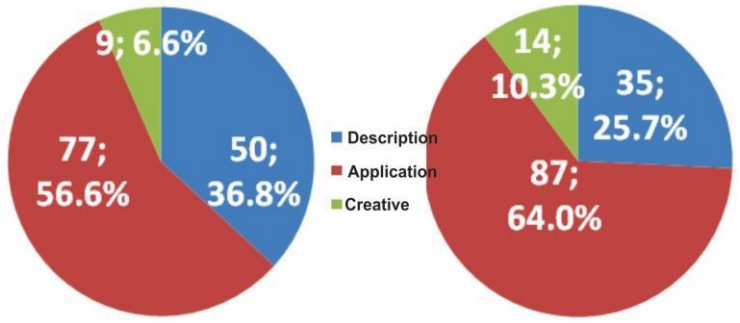


Figure 2.5.8. Situation before and after the pedagogical experiment

Taking into account all the above, we conclude that teaching the subject of computer networks with a new, differential and modular approach based on innovative methods allows to

significantly increase the knowledge and skills of students.

All the issues and obligations envisaged by the study have been fully resolved and the **following results** have been obtained:

1. The subject of computer networks is extremely important in the scientific and methodological provision of the training of informatics teachers studying at the undergraduate level of universities [3;4;7].

2. Students studying in teaching specialties of higher education institutions have a great interest in modern technologies [10;11].

3. In the scientific work, the characteristics of the undergraduate age period have been clarified using pedagogical and psychological literature and the difficulties of adaptation to differential innovations related to the transition from secondary school education to higher education have been noted [5;6].

4. The conducted research and analysis of the existing educational and methodological literature have led to the conclusion that the teaching of practical topics of network technologies in the training of informatics teachers is associated with many objective problems [8;9].

5. Surveys and studies conducted among university teachers allow us to conclude that almost the majority of teachers recognize the importance of new innovative methods in training and emphasize the necessity of new interactive teaching tools in conducting practical classes [10].

6. Research conducted in the training of informatics teachers at universities shows that new practical approaches should be used to clearly and unambiguously teach network technologies to students [1;2].

7. It has been proven that by using differentiated teaching methods and interactive tools, it is possible to increase the efficiency and informativeness of the lesson, as well as to instill new knowledge, skills and habits in students in the subject of computer networks [6;7].

8. In addition to all the directions provided for in the study, the ways of how, with what subtleties and in what sequence each topic is delivered were considered. At the same time, the effectiveness of

new teaching methods was based on modern literature and Internet resources [10;11].

9. The experimental part of the pedagogical research proved a significant increase in the effectiveness of teaching as a result of the use of innovative and interactive teaching technologies, a modular differential approach, proposed in the training of computer science teachers in teaching network technologies [6;7].

10. All the goals of the study were achieved. The conducted research is of decisive importance both theoretically and practically [12].

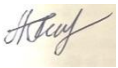
It is known that network technologies are developing day by day, new hardware and software complexes are emerging, and new discoveries and innovative steps must be taken to keep up with this development. Thus, in the future, it is necessary to develop this methodological approach, perfect it, and adapt it to constantly updated requirements.

The main results of the dissertation are reflected in the following publications of the applicant:

1. Gelecek informatika muellimlerine komputer shebekesi khellerinin oyredilmesi yollari [Ways of teaching computer network technologies to future informatics teachers] // AMEA Gence Bolmesi, "Kheberler mecmuesi" (Pedagoji elmler seriyasi) [ANAS Ganja Regional Division, "Collection of News" (Pedagogical sciences series)]. Ganja, – 2021. No. 1 (1), – pp. 69-75.
2. Gelecek informatika muellimlerine muasir shebeke khellerinin tedrisinde modullu yanashma [Modular approach in teaching modern network technologies to future informatics teachers] // AMEA Gence Bolmesi, "Kheberler mecmuesi" (Pedagoji elmler seriyasi) [ANAS Ganja Regional Division, "Collection of News" (Pedagogical sciences series)]. Ganja, – 2021. No. 1 (2), – pp. 76-83.
3. Metody obucheniya budushchikh prepodavateley informatiki mul'timediynym i setevym tekhnologiyam [Methods of teaching multimedia and network technologies to future

informatics teachers] // Istoricheskaya i sotsial'no-obrazovatel'naya mysl' [Historical and Social-Educational Idea]. Scientific journal, Krasnodar, – 2021. Vol. 13, No. 4, – pp. 124-137.
4. Informatika muellimliyi hazirliginda lokal shebekelerde istifade edilen kheller movzusunun tedrisine metodik yanashma [Methodical approach to the teaching of the topic of technologies used in local networks in the training of informatics teachers] // AMEA Gence Bolmesi, "Kheberler mecmuesi" (Pedagoji elmler seriyasi) [ANAS Ganja Regional Division, "Collection of News" (Pedagogical sciences series)]. Ganja, – 2022. No. 1 (3), – pp. 47-54.
5. Gelecek informatika muellimlerine lokal shebeke khellerinin CISCO PACKET TRACER simulyatorunda oyredilmesi [Teaching local network technologies to future informatics teachers in CISCO PACKET TRACER simulator] // AMEA Gence Bolmesi, "Kheberler mecmuesi" (Pedagoji elmler seriyasi) [ANAS Ganja Regional Division, "Collection of News" (Pedagogical sciences series)]. Ganja, – 2022. No. 1 (4), – pp. 25-31.
6. Interaktiv simulyatorda shebekelerin tedrisi [Teaching networks in an interactive simulator] // Riyaziyyatın fundamental problemleri ve intellektual khellerin tehside tetbiqi. II respublika elmi konfransinin materiallari [Fundamental problems of mathematics and application of intellectual technologies in education. Materials of the II Republican Scientific Conference], Sumqayit State University, Sumqayit, – 2022. No. 10, – pp. 189-190.
7. Simulyatorun interfeysinde shebekelerin emulyasiyasi [Emulation of networks in the interface of the simulator] // "Elektroenergetikanin muasir problemleri ve inkishaf perspektivleri" Beynelxalq Elmi-Texniki Konfransinin Meruze Materiallari ["Modern problems and development prospects of power engineering" Materials of the International Scientific-Technical Conference], "Azerbaijan Caspian Shipping" CJSC, Baku, – November 17-18, 2022. – pp. 609-611.

8. Technique of teaching of computer networks with application of program // 5th International E-Conference on Mathematical Advances and its Applications: Abstract book, Istanbul, – May 11-14, 2022. – p. 34.
9. Primenenie CISCO PACKET TRACER v prepodavanii lokal'nykh setey [Application of CISCO PACKET TRACER in teaching local networks] // "Rossiyskaya nauka v sovremennom mire": Materialy XLVI Mezhdunarodnoy nauchno-prakticheskoy konferentsii. Sbornik statey ["Russian science in the modern world": Materials of the XLVI International Scientific and Practical Conference. Collection of articles], Moscow, – May 31, 2022. – pp. 173-176.
10. Metodika prepodavaniya setevykh tekhnologiy s primeneniem programmy CISCO PACKET TRACER [Methodology of teaching network technologies using the CISCO PACKET TRACER program] // Tsifrovaya transformatsiya obrazovaniya: sostoyanie i perspektivy: Materialy I Mezhdunarodnoy nauchno-prakticheskoy konferentsii [Digital transformation of education: status and prospects: Materials of the I International Scientific and Practical Conference], Dagestan State Pedagogical University, Makhachkala, – July 1 - July 3, 2022. – pp. 56-59.
11. Sovremennye metody obucheniya budushchikh uchiteley informatiki peredovym setevym tekhnologiyam [Modern methods of teaching advanced network technologies to future informatics teachers] // Pedagogicheskoe Obrazovanie. Mezhdunarodnyy nauchno-issledovatel'skiy zhurnal [Pedagogical Education. International Research Journal], Belgorod, – 2023. Vol. 4, No. 6, – pp. 189-193.
12. Methods of teaching wireless network technologies using Cisco Packet Tracer simulator // Pedagogicheskoe Obrazovanie [Pedagogical Education]. – 2026. Vol. 7, No. 5. – pp. 81–86. DOI: 10.62257/2712-9950-2026-7-5-81-86 (Co-authors: Babaeva S.E.; Applicant's contribution: 50%).



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