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Professionally oriented network course as the basis for developing the computational thinking of future engineers

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Abstract. *Problem statement.* The need to study and use network technology competencies to improve the general education and professional level is becoming a prerequisite for training the next generation of advanced engineers. To effectively use computer devices and digital tools, computational thinking is required. The study aimed at substantiating the effectiveness of using a professionally oriented network training course for the development of computational thinking of future engineers. *Methodology*. To obtain theoretical generalizations, an analysis of scientific works on the problem of defining the phenomenon of "computational thinking" and the use of network educational resources in the training of specialists in engineering and technical specialties was carried out. Computational thinking is determined as a mental process of a set of actions: mobilizing an image system of objects and their interconnections from human memory; formulating the problem taking into account uncertainties; creating a solution algorithm; and implementing it effectively using digital tools. 68 bachelors were involved in the study in the direction of training 23.03.03 "Operation of transport-technological machines and complexes", profile "Automobiles and automotive industry". All are first-year students of the Russian State Agrarian University – Moscow Agricultural Academy named after K.A. Timiryazev. The online training course "Computer science and networks" is used, developed by E. V. Shchedrina, presented on the Moodle platform, and has registration certificate no. 24877 dated August 28, 2021. To diagnose and assess the maturity of computational thinking, the author's testing materials are used: 30 questions following the work program of the discipline. Pearson's chi-square test was applied as a statistical processing method. *Results*. When working with the materials of a network course in the discipline "Computer Science and Networks," a new generation engineer performs a sequence of actions characteristic of computational thinking: analyzes the text of a professionally oriented problem (formulates the task as a computational problem), decomposes the problem, composes and implements the algorithm, performs its analysis and evaluation. The conditions that influence the formation of computational thinking are generalized: obtaining relevant scientific and theoretical facts, patterns, and information on innovative methods and means; their reasoned choice, effective implementation at a high technical level; and analysis of the result and its practical application. Statistically significant differences were determined in the qualitative changes that occurred in the system of training specialists for high-tech production. *Conclusion*. The positive aspects of using a professionally oriented network course for the development of computational thinking of engineers are highlighted (for example, to gain experience in formulating a problem taking into account the uncertainty of the future, students analyze a corporate network, determine a subnet mask for different conditions, etc.). Options for the practical application of the research results are proposed: in the work of the All-Russian network project for variety testing "Malaya Timiryazevka", and in the activities of the Center for Pre-University Training and the Digital Department of the academy.

Keywords: digital technology, information interaction, new generation engineer, network educational program, computer network, distance course

Author's contribution. The authors contributed equally to this article.

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Профессионально ориентированный сетевой курс как основа формирования вычислительного мышления будущих инженеров

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Аннотация. *Постановка проблемы.* Потребность изучать и использовать возможности сетевых технологий для повышения общекультурного и профессионального уровня становится условием подготовки высококвалифицированных инженеров нового поколения. Для эффективного использования компьютерных устройств, цифровых инструментов необходимо вычислительное мышление. Обосновывается эффективность применения профессионально ориентированного сетевого учебного курса для развития вычислительного мышления будущих инженеров. *Методология.* Для получения теоретических обобщений выполнен анализ научных работ по проблеме определения феномена вычислительного мышления, использования сетевых образовательных ресурсов в подготовке специалистов инженерно-технических специальностей. Вычислительное мышление рассматривается как процесс, который включает в себя последовательное выполнение ряда действий: извлечение из памяти человека системы представлений об объектах и связей между ними; формулирование проблемы с учетом неопределенности; разработка алгоритма решения и его эффективная реализация с помощью цифровых инструментов. К исследованию привлечено 68 бакалавров по направлению подготовки 23.03.03 «Эксплуатация транспортно-технологических машин и комплексов» направленность «Автомобили и автомобильное хозяйство». Все обучающиеся – студенты первого курса Российского государственного аграрного университета – МСХА имени К.А. Тимирязева. Используется сетевой учебный курс «Вычислительная техника и сети», разработанный Е.В. Щедриной, представленный на платформе Moodle и имеющий свидетельство регистрации № 24877 от 28.08.2021 г. Для диагностики и оценки сформированности вычислительного мышления применяются материалы авторского тестирования: 30 вопросов в соответствии с рабочей программой дисциплины. В качестве метода статистической обработки использован критерий хи-квадрат Пирсона. *Результаты.* При работе с материалами сетевого курса по дисциплине «Вычислительная техника и сети» инженер нового поколения выполняет последовательность действий, характерных для вычислительного мышления: анализирует текст профессионально ориентированной задачи (формулирует задание как вычислительную проблему), осуществляет декомпозицию проблемы, составляет и реализует алгоритм, выполняет его анализ и оценку. Сформулированы условия, которые влияют на развитие вычислительного мышления: получение актуальной научно-теоретической информации, закономерностей и данных о инновационных методах и средствах; осознанный выбор этих методов и средств с учетом их эффективности на высоком техническом уровне, анализ полученных результатов и их практическое применение. Определены статистически достоверные различия в качественных изменениях, произошедших в системе подготовки специалистов под высокотехнологичное производство. *Заключение.* Выделены положительные аспекты применения профессионально ориентированного сетевого курса для развития вычислительного мышления инженеров (например, для получения опыта формулирования проблемы с учетом неопределенности будущего студенты выполняют анализ корпоративной сети, определяют маску подсети для разных условий и т. п.). Предложены варианты практического применения результатов исследования: в работе Всероссийского сетевого проекта по сортоиспытанию «Малая Тимирязевка», в деятельности центра довузовской подготовки и цифровой кафедры академии.

Ключевые слова: цифровая технология, информационное взаимодействие, инженер нового поколения, сетевая образовательная программа, вычислительная сеть, дистанционный курс

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Problem statement. A UNESCO report was presented at the Internet Governance Forum in Berlin, where Guy Berger and Xianhong Hu presented the case for the need to control artificial intelligence and advanced ICT in the digital society. The experts concluded that the need to study and use the capabilities of information and communication technologies to improve the general cultural and professional level has become a condition for the development of modern man[1]. They

[1] UNESCO report on the activities of the Internet Governance Forum. Available from https://www.unesco.org/ru/articles/chto-esli-my-vse-budem-upravlyat-internetom-yunesko-prezentovala-novoe-issledovanie-na-forume-po (accessed: 12.08.2023).

also noted that in order to be able to effectively use computer equipment and digital tools, modern people need to have computational thinking.

B. Uslu notes that international educational strategies aimed at promoting and strengthening transnational cooperation between universities are subordinated to the following task: to develop in young people, lifelong learners, the skills and competencies that they need to solve professional problems [1]. Computational thinking skills are significant in this context.

V.V. Grinshkun, and E. Bidaibekov mention that participants in the educational process are increasingly resorting to artificial intelligence tools to organize communication and solve a variety of creative problems [2].

According to the conclusions of P. Tadeu, and C. Brigas, one of the fundamental principles of using artificial intelligence in education is coding and computational thinking, because they allow everyone to produce code and find the solution using algorithms [3].

Based on N. Berman, computational thinking uses specialized methods to apply computational principles such as abstraction, decomposition, generalization and pattern recognition to formulate and solve problems [4].

These ideas are continued by E.V. Soboleva, E.G. Sabirova, N.S. Babieva, M.G. Sergeeva, and J.V. Torkunova, who argue that in the digital age computational thinking is an important skill for students to succeed in modern technological society and therefore it is necessary to develop computational thinking in school years [5].

At the same time, until recently there has been little specialized research on the concept of “computational thinking” in Russia. An exception is the work of E.K. Henner, who analyzed the concept from the perspective of a foreign author and drew attention to its relevance for domestic education [6]. The author determines that this term focuses on updating the content and didactic methods, and supports the education system in increasing efforts to form demanded meta-subject results.

Additionally, according to the conclusions of E. Varshavskaya and E.S. Kotyrlo, it follows that global digital transformation has significantly influenced the demands of society, business, and the state regarding professions in demand in the future [7].

In their research N. Abdikeev, Yu. Bogachev, and Yu. Kalmykov substantiate that the maximum demand during the period of digital transformation will affect specialists who have [8]:

– ability to forecast and plan when the future is uncertain;

– the ability to independently indicate problems and present the best option for solving it;

– the ability to develop a solution algorithm and implement it using software and hardware.

In practice, schools and universities still train graduates, including future specialists in the field of science and technology related to the operation, repair, and maintenance of transport and transport-technological machines for various purposes, without taking into account trends in long-term planning, competitiveness, and uncertainty future [9].

E.V. Soboleva, T.N. Suvorova, S.V. Zenkina, and M.I. Bocharov evaluate the current state of career guidance work of universities of various profiles with schoolchildren and applicants and determine possible ways to improve it [10]. In particular, they propose to use information tools (electronic educational resources, online simulators, etc.) in the following educational situations:

– provide students with opportunities to analyze everyday problems from different points of view;

– develop the ability to create and implement innovations;

– understand what technology can offer.

The work of E. Matos, and F. Rezende describes the capabilities of network resources for the formation of computational thinking [11]. According to their conclusions, the inclusion in training of e-mail, blog technology, wiki technology, podcasts, web forums, linguistic corpora, electronic dictionaries, Internet reference resources, synchronous video Internet communication tools, and navigators will contribute to future graduates:

– will be able to develop computational thinking skills and an understanding of the principles of computer science that underlie all digital technologies;

– learn how to use computers to solve problems, allowing them to make informed decisions in the digital world.

The advantages and didactic capabilities of a distance course for each level (technological, content, and organizational) are described in the work of E.N. Bakurova, T.A. Parshutkina, O.M. Kudryavtseva, M.P. Chernovol [12]. The significance of the presented work for the ongoing research is as follows:

1) the authors describe a methodological approach, during which students are offered tasks aimed at searching for information using keywords, reading with an understanding of the main content, reading with a full understanding of the content, summarizing, annotating, tasks on working with digital technologies, an analytical review, tasks on drawing up a research plan, assignments for the correct design of the structure of an article and report, etc.;

2) a holistic network resource (distance course) is presented, which is modular in nature. Those. its components are modules (sections), standard tests, tests, guidelines for working with course topics, and educational literature.

In the course of an experimental study by E.N. Bakurova, T.A. Parshutkina, O.M. Kudryavtseva, and M.P. Chernovol, it is proved that the use of a professionally oriented distance course in a foreign language and modern digital technologies can significantly help in the formation of educational independence and research skills of undergraduate students.

Thus, there is a contradiction between the requirements of the modern economy for a high level of computational thinking among sought-after professionals, identified by the significant didactic potential of information technology, and the insufficient development of the methodological basis for the use of network training courses for training specialists for high-tech production.

The research hypothesis is that supporting the educational and cognitive activities of students through a professionally oriented online course will contribute to the formation of actions that determine the essence of computational thinking.

An analysis of the scientific works listed above allows us to identify a problem associated with the need for additional study of the development of computational thinking among future engineers when working with materials from a professionally oriented distance course.

The study **aimed** at substantiating the effectiveness of using a professionally oriented distance learning course to develop the computational thinking of engineers of the new generation.

Methodology. The study takes into account the requirements of the current federal state educational standards of higher education of the Russian Federation for undergraduate programs, in which great importance is attached to creating the necessary conditions for students to gain work experience in conditions of increasing complexity of technological processes and equipment, rapidly changing requirements for competitive products, and for making non-standard decisions.

The conducted research is also based on the provisions of the system-activity approach. The activity system is considered in the virtual environment of a professionally oriented distance course implemented in Moodle: students use the functionality of a network resource to analyze data, formulate a problem, build an information and mathematical model, develop an optimal solution algorithm, and its effective implementation on a computer.

The Moodle platform is universal and can be flexibly customized to suit the research tasks required. This distance learning system was originally developed for schools and universities. Thanks to the collaboration of developers and a large community of users around the world, Moodle is constantly evolving, supplemented with new tools, extensions, and modules.

In the presented study, the network form of implementation of educational programs means the organization of training using the resources of several universities, as well as companies and enterprises.

The authors understand a network course as a didactic, software, and technical interactive complex for learning primarily in the Internet environment. Such a resource ensures the continuity and completeness of the didactic cycle, presentation of theoretical material, provision of training educational activities, control of knowledge acquisition, and support for information retrieval activities.

As M.M. Klunnikova justifies, the concept of “computation” can be considered not just as the performance of arithmetic operations, but as a much broader concept, a way of thinking, the basis for any scientific research [13]. She notes that the concept of “computation” can be seen not just as performing arithmetic operations, but as a much broader concept, way of thinking, and the basis for any scientific research. At the same time, the author notes that, most likely, computational thinking refers to the human ability to formulate problems in such a way that their solutions can be represented as a sequence of steps or algorithms that will be carried out using a computer. This necessitates the formation of new qualities of a future specialist.

We propose our approach to the interpretation of the concept of “computational thinking”. In this work, this term is used to describe cognitive activity, including the following sequence of actions: activation from human memory of a system of images of objects, and connections between them; formulation of the problem taking into account the uncertainty of the future; development of a solution algorithm and its effective implementation using software environment tools. The proposed approach reflects all the components that make up the essence of the “computational thinking” phenomenon and determines the basis of engineering education.

The research was carried out using the author's distance learning course in the discipline “Computer science and networks”. The distance learning course is modular in nature. Its components are modules (sections), standard tests, tests, guidelines for working with course topics, educational literature, questions for intermediate certification, and a link to the course registration certificate (no. 24877 dated 08/28/2021).

In identifying factors influencing the effectiveness of using a professionally oriented network course for the formation of actions that determine the essence of computational thinking, experimental work was organized and carried out at the Russian State Agrarian University – Moscow Agricultural Academy named after K. A. Timiryazev. With the support of the Department of Computer-Aided Design and Engineering Calculations.

68 bachelors in the direction of training 23.03.03 “Operation of transport-technological machines and complexes”, profile: “Automobiles and automotive industry” were involved in the study. All students are first-year students.

The program aims to ensure the formation of highly qualified, competitive engineers of the new generation, capable of the following types of professional activities: calculation and design; production and technological; experimental research; organizational and managerial; installation and commissioning; service and operational.

The average age is 19 years (16% are girls, 84% are young people).

To assess the maturity of the skills that form the basis of computational thinking, a test is used that takes into account the requirements of federal educational standards for the selected training program in the discipline “Computer Science and Networks”:

– the ability to solve standard problems of professional activity based on information and bibliographic culture using information and communication technologies and taking into account the basic requirements of information security (GPC-1);

– the ability, as part of a team of performers, to carry out theoretical, experimental, and computational research on the scientific and technical substantiation of innovative technologies for the operation of transport and transport-technological machines and equipment (PC-19);

– willingness to study and analyze the necessary information, technical data, indicators, and results of work to improve the technological processes of operation, repair and maintenance of transport and transport-technological machines and equipment for various purposes, their units, systems and elements, to carry out the necessary calculations using modern technical means (PC-22).

For each competency, 10 tasks were compiled, with a total of 30 questions in the test. Determination of the level of computational thinking and its interpretation are presented in the results of the study.

Pearson's χ^2 criterion was used at the stage of statistical processing of the results.

Results and discussion. A network educational program, according to the conclusions of A.A. Verbitsky, E.P. Komarova, S.A. Bakleneva, and A.S. Fetisov, is a specially designed training that is provided via the Internet [14]. In her space, students can complete assignments, take tests, participate in discussions, and receive feedback from teachers and peers. This form of education has become particularly popular in recent years as it provides academic flexibility and the ability to study materials from anywhere in the world. Ministry of Education and Science of Russia in 2022, as part of a webinar on the topic "Expanding the practice of implementing educational programs in the online form by educational organizations of higher education. Practical preparation – the practice of implementation", organized a discussion of the regulatory work done, as well as the exchange of best practices in network interaction.

According to the conclusions of M. Kolmykova, N. Gavrilovskaya, M. Barsukova, and D. Kozlovskaya, such interaction makes it possible to improve the quality and accessibility of higher education, as well as expand the list of specialties and areas of training offered by universities [15].

The Russian State Agrarian University – Moscow Agricultural Academy named after K. A. Timiryazev also notes the importance of the connection between science, education, and business in training specialists of the future. V.L. Snezhko, D.M. Benin, N.V. Gavrilovskaya, M.V. Petukhova, and A.V. Podobnyy determine that the theoretical knowledge and practical skills acquired by undergraduate students allow graduates to confidently represent themselves in the labor market or continue in-depth studies in a master's program [16]. The programs implemented at the university mainly include disciplines that form the professional competencies of the graduate. Research work within the framework of industrial practice allows engineers of the new generation to develop their professional skills in any of the areas of science and practice that interest them. For example, in the field of molecular breeding, cell and tissue culture, genetic engineering, or traditional breeding.

In the 2022/2023 academic year, enrollment in seven new online programs began. One of the disciplines implemented in network form is "Computer science and networks".

The goal of the discipline "Computer science and networks" is for students to obtain theoretical knowledge about the general principles of the functioning of computer technology and computer networks, about the implementation on their basis of information processes for collecting, transmitting, and accumulating information when solving problems of professional activity.

The discipline "Computer science and networks" is included in the variable part of the disciplines of the Curriculum in the direction 23.03.03 "Operation of transport-technological machines and complexes", profile: "Automobiles and automotive industry".

To support the implementation of the discipline in a network form of education, a professionally oriented network course was developed.

When developing the online course, the authors adhered to the following order:

1) development of documents regulating the process of creating a network site;

2) selection of software tools;

3) preparation of an interaction scenario;

4) individual parts of the online course;

5) preparation of content following the standard structure of a network educational complex;

6) registration of a network course in the selected software environment and placement on the university server.

The resulting network electronic educational resource was focused on conducting all types of classes in the discipline.

The instructional block contains a description of the goals, organization of the educational process, and methodological recommendations for self-studying the course.

Text in a block linked to work programs in .doc, .docx, .pdf format, or on the Moodle platform.

The information block contains educational information on the discipline. The discipline includes sections examining the basic concepts of computer networks, general principles of building networks, the advantages of using networks, the general task of switching, addressing schemes for nodes in a network, the purpose and characteristics of active and passive communication equipment, issues of routing and dividing the address space of networks into subnets. An important place is occupied by consideration of the procedure for interaction of two computers on a network based on the open systems interaction (ISO/OSI) model, as well as standard network technologies and the TCP/IP communication protocol stack.

A special feature of the discipline "Computer science and networks" is that it plays a key role in the formation of practical skills in the use of new information technologies, which allow collecting, accumulating, and processing information on a new information basis. At the same time, the discipline is practically oriented in nature and contributes to the development of new research methods in the field of natural science.

The study is built based on the discipline "Informatics" (1st semester), and serves as the basis for studying the disciplines "Information systems of motor transport enterprises" (4th semester), and "Information technologies in transport" (4th semester). The work program of the discipline "Computer science and networks" for people with disabilities and people with limited health capabilities is developed individually, taking into account the psychophysical development, individual capabilities, and health status of such students.

A special feature of the discipline is the execution of all calculation tasks on a personal computer using application software.

The total volume of the discipline is 108 hours. Contact work with the teacher is 34.4 hours, independent work is 73.6 hours, and monitoring the development of learning outcomes is 33.6 hours. The course provides for practical work on a personal computer, including using network technologies, working in application software packages, and performing tests. Intermediate control: exam.

The communication block is implemented using the Moodle platform, is universal for all courses, and does not require preliminary development. Its availability and user access are ensured by employees of the informatization department of the University named after K.A. Timiryazev.

The control block is represented by tasks for test and rating control in an authorized mode.

When designing the course, the authors provided links and other navigation elements for quick and targeted movement through the educational material: to work programs, to methodological recommendations for completing tests, to individual tasks for completing tests, how to submit a test for checking, to questions for preparation for intermediate certification, for a certificate of registration of an electronic resource.

It is essential that methodological recommendations are structured in such a way as to enable students to move from teacher-led activities to independently organized activities.

So, the recommendations detail reasonable techniques for the types of activities described, criteria for the accuracy of decisions and suggestions for the effective use of consultation.

The main goal of the experimental work was to test the effectiveness of using a professionally oriented distance learning course in developing the skills that form the basis of computational thinking.

At the preparatory stage, the authors of the study clarified the sequence of actions characteristic of computational thinking and the list of skills that are most in demand in a modern technological society. To assess the input conditions, materials from specially organized testing were used, taking into account the requirements for the training direction 23.03.03 "Operation of transport-technological machines and complexes", profile: "Automobiles and automotive industry".

Next, a test of 30 tasks was carried out by the requirements for the results of mastering the discipline (listed earlier). For each competency, 10 questions were developed.

Examples of questions for each competency were developed.

Task 1 for GPC-1. Using one of the search engines, find the information and enter it into a table.

Task 2 for GPC-1. The identifier of some Internet resources has the following form: http://www.ftp.ru/index.html. Which part of this identifier indicates the protocol used to transfer the resource? Write down the correct part.

Task 1 for PC-19. Create an algorithm for a novice engineer to use the Calculator to make the following conversions: 15 miles – into kilometers; 100 weeks – in hours; 4 carats – in grams; 1 American pint – in liters; 1 British gallon – in liters; 20 horsepower – in kilowatts.

Task 2 for PC-19. A text of 500 characters is given. It is known that the symbols are taken from a table of size 16×16, in which all cells are filled with different symbols. Create an algorithm that will allow another user to determine the information volume of the text in bytes.

Task 1 for PC-22. Fill out the form and do the calculations:

1) meter readings at the beginning of each month, starting from February = readings at the end of the previous month;

2) Consumption kW = Difference between meter readings at the beginning of the month and the end of the month;

3) Amount rub. = Consumption kW*Tariff.

Task 2 for PC-22. Four pieces of paper were found at the crime scene. The investigation established that they contained fragments of the same IP address. Forensic scientists have labeled these fragments with the letters A, B, C, and D. Recover the IP address. In your answer, provide the sequence of letters representing the fragments in an order corresponding to the IP address. If there are several possible solutions, write them all separated by commas.

For correct completion of each task, the student received 2 points. Those for the entire test, the maximum a new generation engineer could score was 60 points.

Determination of the level of computational thinking in total (for all competencies): 55 or more – "high" level; 30–54 – "average"; 29 or less – "low".

Level "High" – A next generation engineer is proficient in multiple network modeling tools. The student develops programs to solve a class of professionally oriented problems, using a modular approach and knowledge gleaned from scientific and technical literature in the field of computer technology. The student sees possible problems when implementing algorithms; correctly justifies the choice of method for solving a problem depending on its formulation, can reduce the problem to one that has already been solved previously; and competently substantiates the obtained result. He constructs tests that confirm the correct operation of the network. The engineer is active in finding more efficient sharing methods. The student is motivated for professional growth and shows interest in the practical application of knowledge in other areas.

Level "Average" – a new generation engineer has most of the necessary knowledge on the principles of functioning of computer technology and computer networks; correctly divides his work and the activities of the team into separate modules. He is quite confident in using scientific and technical literature in the field of computer technology. Implements procedures for interaction between two computers on a network based on the open systems interaction model (ISO/OSI), as well as standard network technologies and the TCP/IP communication protocol stack. The student can justify the choice of method for solving professionally oriented problems. The student has little difficulty in mastering methods for setting up internal routing protocols, VLSM, and CIDR, skills in using various methods of connecting remote networks and to a provider, and methods for designing a hierarchical network. There is a selective attitude towards studying the discipline; episodic activity appears.

Level "Low" – a new generation engineer has the necessary minimum knowledge of the general principles of the functioning of computer technology and computer networks. The student is weak (partially) able to use scientific and technical literature in the field of computer technology, analyze the corporate network, define modular zones, and ensure security in the computer system while using the network. Does not show activity, interest, and independence when studying the discipline.

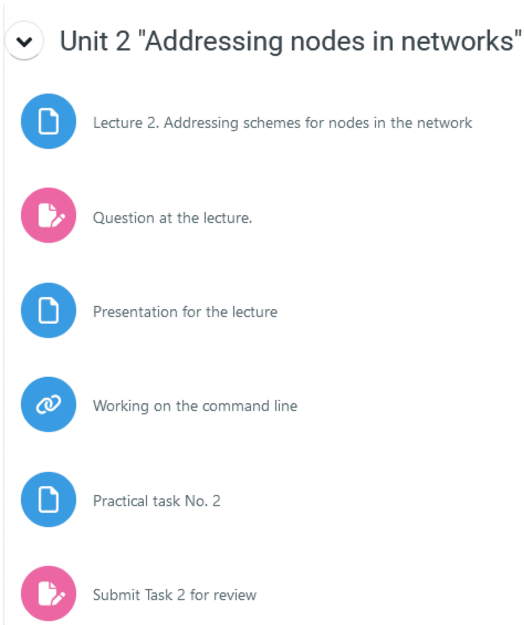
Based on the testing materials, a control group (34 new generation engineers) and an experimental group (34 new generation engineers) were formed.

Students of both groups within the discipline studied according to the following plan:

Section 1. "Computer technology and networks in the industry": "Fundamentals of data networks"; "Addressing nodes in networks"; "Network hardware"; "OSI Open Systems Interconnection Model"; "Standard technologies of local networks"; "TCP/IP communication protocol stack."

Section 2. "Specialized software for road transport": "Automated system for managing ATP processes."

Let us reveal the differences between the training of the experimental and control groups using the example of the topic "Addressing nodes in networks" (the structure of the topic is shown in Figure).



Presentation of the topic in a professionally oriented online course

Source: made by Elena V. Shchedrina, Olga N. Ivashova, Maksim S. Paliivets, Anna V. Ashcheulova.

Students in the experimental group studied the topic materials using a professionally oriented distance learning course.

The content of Lecture 2 "Addressing schemes for nodes in the network" was not available to them until the condition was met: Course element Test No. 1 must be marked as completed, and the score must be higher than the passing grade.

Next, the Presentation for the lecture and Practical Task No. 2 opened.

After completing the latter, the link "Submit Task 2 for review" became active.

Then it became possible to complete Practical Task No. 3.

After completing the latter, the link to "Submit Task 3 for review" became active.

Similarly, Practical task No. 4 and "Submit Task 4 for review".

Then, in electronic format, they were offered Crossword No. 2 Test No. 2. The test was also not available unless all previous items were marked as completed and the practice tasks were submitted for review.

Examples of tasks for each practical work.

Practical task No. 2. Determine the maximum number of subnets that can be organized within the 192.168.4.0 network and what the mask should be.

Practical task No. 3. For some subnets, the mask is 255.255.255.192. How many different computer addresses does this mask theoretically allow if two addresses (the network address and the broadcast address) are not used?

Practical task No. 4. The organization rents a subnet of IP addresses, the rent is 460,800 rubles. per month. Determine the subnet mask if the annual fee for Network 1 node is 10,800 rubles.

As part of the final testing for the course, the engineers of the experimental group were asked to complete the following task:

It is necessary to design a local area network for a manufacturing enterprise consisting of the following departments with a specified number of employees:

– management department (A person);
– accounting (B people);
– planning department (Person);
– HR department (D people);
– Projects department (E people);
– design department (F people);
– Information Technology Department (G people).

Tasks to be developed:

1. Identify the advantages of deploying a network in a given organization and the tasks that can be solved with its use.
2. Develop a basic (physical) diagram of the network and depict the placement of computers, communication, and peripheral equipment, as well as cable routes on the floor plan (to scale).
3. Justify the choice of active communication equipment and indicate its features.
4. Analyze possible ways to connect an enterprise local network to the Internet and describe the most suitable solution in these conditions.

As part of working with course materials, students had the opportunity to take part in the All-Russian network project for variety testing “Malaya Timiryazevka”.

Here are examples of practical tasks for engineers in the control group.

Task 1. Can the host IP address be like this? Please enter incorrect IP address options. Justify your answer.

– 192.168.255.0
– 167.234.56.13
– 224.0.5.3
– 172.34.267.34
– 230.0.0.7
– 160.54.255.255

Task 2. Find the 3rd subnet on the network 178.0.34.0/18.

Task 3. An organization has been allocated a class B network: 185.210.0.0/16. Determine the masks and the number of possible addresses of new subnets in each of the following subnetting options:

1. Number of subnets – 256, number of nodes – at least 250.
2. Number of subnets – 16, number of nodes – at least 4000.
3. Number of subnets – 5, number of nodes – at least 4000. In this option, indicate at least two solutions.

Thus, students in the control group were not involved in working with the materials of the professionally oriented distance course.

At the control stage of the experiment, repeated testing was carried out among new generation engineers. The test materials and assessment procedure were developed according to the previously described principles. The results of assessing the level of development of computational thinking “before” and “after” using a network resource are presented in Table.

So, $\chi^2_{observ.1} < \chi^2_{crit}$ (0.061 < 5.991), and $\chi^2_{observ.2} > \chi^2_{crit}$ (6.842> 5.991). Consequently, the shift towards increasing the level of computational thinking of engineers of the new generation can be considered non-random.

Comparison of the results of work with materials in the discipline "Computer science and networks" for the control and experimental groups allowed us to draw the following conclusions:

– the dynamics at the "high" level among new generation engineers in the experimental group was 23.53%. In the control group, there is also an increase, but quite minimal: 2.94%;

– there was a qualitative change in the "low" level in both groups: from 50.00% to 41.18% in the control group and from 52.94% to 20.59% in the experimental group. Those. dynamics for the latter – 32.35%. It can be argued that the majority of such engineers are occupied by those respondents who initially had an average level, i.e. made mistakes in analytical activities, at the level of decision-making for professionally oriented problems, arithmetic calculations, recording the answer/code, and when evaluating the result obtained;

– at the "average" level, qualitative changes also occurred in both groups.

Dynamics of development of computational thinking among future engineers

Level of computational thinking development	Groups			
	Experimental (34 engineers)		Control (34 engineers)	
	Before the experiment	After the experiment	Before the experiment	After the experiment
High	1	9	1	2
Average	15	20	16	18
Low	18	7	17	14

Source: compiled by Elena V. Shchedrina, Olga N. Ivashova, Maksim S. Paliivets, Anna V. Ashcheulova.

Analysis of the cognitive activity of future engineers also made it possible to confirm that working with an electronic resource in a network format, due to interactivity increased feedback, and increased information interaction, creates additional opportunities for orienting training to the challenges of the professions of the future.

Students learn the general principles of computing and networking and how to harness the power of computers so that they can become digital creators rather than just users. To work with the materials of the network course in the discipline "computer science and networks" a new generation engineer performs a sequence of actions characteristic of computational thinking:

1) task analysis (formulation of the task as a computational problem);

2) breaking down (decomposing) the problem into small logical steps;

3) development of an algorithm (definition and clarification of the steps necessary to achieve a solution);

4) analysis and evaluation of this algorithm.

These facts confirm the importance of using a professionally oriented distance course in the discipline "Computer science and networks" for the development of computational thinking.

The findings are consistent with the conclusions of UNESCO experts on the possibilities of digital technologies for developing the computational thinking of sought-after professionals of the future.

In addition, the presented methodological approach to organizing a professionally oriented network course expands the results of the work of E.N. Bakurova, T.A. Parshutkina, O.M. Kudryavtseva, M.P. Chernovol [12]. These authors considered the possibilities of developing research skills among university students based on digital technologies in distance learning. In our work, as part of a course on the Moodle platform, the new generation of engineers learn current scientific and academic facts and understand patterns and knowledge about innovative methods and tools. Students make logical choices and effectively apply algorithms at a high technical level. They then analyze the results and put them into practice.

Thus, the conclusions of P. Tadeu, and C. Brigas that computational thinking as a mental process involves the active use of analytical and algorithmic approaches to setting and formulating a problem, analysis, and its solution are confirmed [3].

Conclusion. Summarizing the results of students' work with the online course, we note that training in this format has many advantages:

– optimization of the learning process by expanding information and communication capabilities;

– ensuring open access to network resources of organizations in an individual mode;

– optimization of the ratio of theoretical and practical (engineering) training;

– expanding opportunities for solving social problems (training people with disabilities, etc.).

In addition, the electronic system for presenting knowledge and developing skills and abilities ensures the continuity and completeness of the distance learning process, including information and retrieval activities of students.

So, pre-computer thinking is computational thinking, which provides future engineers with the ability to analyze everyday problems from different perspectives, develop the ability to create and innovate and understand what technology has to offer.

Participants in the experiment also noted that computational thinking allows one to more confidently formulate problems and tasks in such a way that a computer (information processing agent) can effectively solve them.

The results of the study made it possible to highlight the following positive aspects of the use of a professionally oriented network course in the discipline "Computer Science and Networks" for the development of computational thinking of new generation engineers:

– in terms of activating from human memory a system of images of objects, and connections between them, students are invited to use scientific and technical literature in the field of computer networks;

– to gain experience in formulating a problem taking into account the uncertainty of the future, it will be useful to analyze the corporate network and determine the subnet mask for changing conditions;

– the stage of developing solution algorithms and their effective implementation by tools of the software environment is supported by activities in the design of a local computer network for a manufacturing enterprise, consisting of the following departments with a specified number of employees in them.

By completing simple projects in the "Computer science and networks" discipline, students develop computational thinking skills and an understanding of the computer science principles that underlie all network technologies. They learn how to use computers to solve problems, allowing them to make informed decisions in the digital world.

Conclusions about the possibilities of developing computational thinking through a distance professionally oriented course are already being actively used in organizing the work of the All-Russian network project for variety testing "Malaya Timiryazevka". Its key idea is the involvement of students of educational organizations in educational and experimental, research and practical activities.

The results obtained can be used in other online training courses and the activities of the Pre-University Training Center. They can become the basis for the work of the digital department of the Timiryazev Academy, which develops programs taking into account the latest trends in the IT field together with leading industry experts.

References

[1] Uslu B. Strategic actions and strategy changes in European universities: clues from institutional evaluation reports of the European University Association. *European Journal of Higher Education*. 2018;8:215–229. http://doi.org/10.1080/21568235.2018.1432370

[2] Grinshkun VV, Bidaibekov E. How the education system should respond to the technological development and informatization of the society. *Communications in Computer and Information Science*. 2021;1024:26–33. http://doi.org/10.1007/978-3-030-78273-3_3

[3] Tadeu P, Brigas C. Multiple intelligence's and computational thinking. *Journal of Computer and Education Research*. 2022;10(19):1–17. http://doi.org/10.18009/jcer.1027934

[4] Berman N. Formation of computational thinking in the process of teaching university students. *Russian Journal of Education and Psychology*. 2020;11:16–19. (In Russ.) http://doi.org/10.12731/2658-4034-2020-1-16-19
Берман Н.Д. Формирование вычислительного мышления в процессе обучения студентов вуза // Russian Journal of Education and Psychology. 2020. Т. 11. С. 16–19. http://doi.org/10.12731/2658-4034-2020-1-16-19

[5] Soboleva EV, Sabirova EG, Babieva NS. Formation of computational thinking skills using computer games in teaching mathematics. *Eurasia Journal of Mathematics, Science and Technology Education*. 2021;17(10):1–16. http://doi.org/10.29333/ejmste/11177

[6] Khenner EK. Computational thinking. *The Education and Science Journal*. 2016;(2):18–33. (In Russ.) http://doi.org/10.17853/1994-5639-2016-2-18-33
Хеннер Е.К. Вычислительное мышление // Образование и наука. 2016. № 2 (131). С. 18–33. http://doi.org/10.17853/1994-5639-2016-2-18-33

[7] Varshavskaya E. Graduates in engineering and economics: between demand and supply. *Educational Studies. Moscow*. 2019;2:98–128. http://doi.org/10.17323/1814-9545-2019-2-98-128

[8] Abdikeev N, Bogachev Yu, Kalmykov Yu. Improving the system of management and coordination of state policy on the institutional provision of technological breakthrough in the Russian economy. In *Socio-Economic Systems: Paradigms for the Future*. 2021;314:1781–1788. http://doi.org/10.1007/978-3-030-56433-9_185

[9] Soboleva EV. Preparing Engineers of the future: the development of environmental thinking as a universal competency in teaching robotics. *European Journal of Contemporary Education*. 2020;9(1):160–176. http://doi.org/10.13187/ejced.2020.1.160. EDN TOONYZ.

[10] Soboleva EV, Suvorova TN, Zenkina SV, Bocharov MI. Professional self-determination support for students in the digital educational space. *European Journal of Contemporary Education*. 2020;9(3):603–620. http://doi.org/10.13187/ejced.2020.3.603. EDN DKNBKI.

[11] Matos E, Rezende F. Raciocínio computacional no Ensino de língua Inglesa na escola: um relato de experiência na perspectiva BYOD. *Revista Eletrônica de Educação*. 2019;14:3116073. http://doi.org/10.14244/198271993116

[12] Bakurova EN, Parshutkina TA, Kudryavtseva OM, Chernovol M. A professionally oriented distance learning course in a foreign language as the basis for the formation of undergraduate students' research skills. *Perspectives of Science and Education*. 2023;(2):262–279. (In Russ.) http://doi.org/10.32744/pse.2023.2.15
Бакурова Е.Н., Паршуткина Т.А., Кудрявцева О.М., Черновол М.П. Профессионально-ориентированный дистанционный курс на иностранном языке как основа формирования научно-исследовательских умений студентов вуза // Перспективы науки и образования. 2023. № 2(62). С. 262–279. http://doi.org/10.32744/pse.2023.2.15

[13] Klunnikova MM. The methods of developing computational thinking of students while studying the course "Numerical Methods" based on blended learning. *Informatics and Education*. 2019;6:34–41. (In Russ.) http://doi.org/10.32517/0234-0453-2019-34-6-34-41
Клунникова М.М. Методика развития вычислительного мышления студентов при изучении курса «Численные методы» на основе смешанного обучения // Информатика и образование. 2019. Т. 6. С. 34–41. http://doi.org/10.32517/0234-0453-2019-34-6-34-41

[14] Verbitskiy AA, Komarova EP, Bakleneva SA, Fetisov AS. Professional-subject development of a teacher based on context-network technology. *Language and Culture*. 2020;52:123–139. (In Russ.) http://doi.org/10.17223/19996195/52/8
Вербицкий А.А., Комарова Э.П., Бакленева С.А., Фетисов А.С. Профессионально-предметное развитие педагога на основе контекстно-сетевой технологии // Язык и культура. 2020. Т. 52. С. 123–139. http://doi.org/10.17223/19996195/52/8

[15] Kolmykova M, Gavrilovskaya N, Barsukova M, Kozlovskaya D. Use of microblogging, social networking, and short messages in e-learning for information culture building. *International Journal of Emerging Technologies in Learning*. 2021;16(4):22–37. http://doi.org/10.3991/ijet.v16i14.22391. EDN NUQMXA.

[16] Snezhko VL, Benin DM, Gavrilovskaya NV. Automated measuring complex for monitoring the level mode of channels and atmospheric parameters. *Environmental Engineering*. 2022;5:6–14. (In Russ.) http://doi.org/10.26897/1997-6011-2022-5-6-14. EDN WBLSVD.
Снежко В.Л., Бенин Д.М., Гавриловская Н.В. Автоматизированный измерительный комплекс для мониторинга уровневого режима каналов и параметров атмосферы // Природообустройство. 2022. Т. 5. С. 6–14. http://doi.org/10.26897/1997-6011-2022-5-6-14. EDN WBLSVD.

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