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Improving computer science education: Teaching neural network modeling to deepen understanding of AI in schools

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Abstract

In the context of computer science education, the article highlights a problem area associated with effective teaching of neural network modeling as part of a school computer science course. The emphasis is on analyzing the current state of teaching in various countries, warning about the loss of relevance of a Computer Science course without the inclusion of an artificial intelligence section and limiting access to the best materials on a free basis. The goal of the work is to develop a methodology for teaching 11th graders how to model neural networks using MS Excel and a neurostimulator for a deeper understanding of artificial intelligence. The article describes a three-stage pedagogical experiment, starting with an analysis of the current state of teaching artificial intelligence, developing a methodology and its implementation, and ending with an assessment of effectiveness. Methods used include student surveys, knowledge testing, and neural network modeling project work. It is recommended to use the developed methodology for teaching neural network modeling in schools. Its adaptation to different countries and regions can enrich the educational process. The article is of interest to teachers and specialists in the field of curriculum development in computer science and artificial intelligence.

Keywords: Artificial Intelligence, Computer science curriculum, Computer science school course, Neural network.

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1. Introduction

The field of information technology is radically changing the working and living conditions of people. Artificial intelligence (hereinafter referred to as AI) is one of the most advanced areas in the development of the IT industry.

Let's consider the commonly used definition of AI: “AI is the ability of intelligent systems to perform complex tasks.” It is found in various versions as “the science and technology of creating intelligent machines and intelligent computer programs.” In the definitions given in the literature, the concept of AI is presented, on the one hand, as the science of creating humanoid machines, and on the other, as a property of computer technology [1, 2].

It is now clear that the concept of AI has evolved from its original definition. In this regard, AI is currently a complex scientific concept that includes a number of modern technologies and expands the capabilities of computer science. The relevance of creating AI systems today is related to the complexity of the problems that modern society has to solve. AI systems implemented in industry, business, finance, education, sports, entertainment, and other areas demonstrate higher efficiency, faster payback, and clear advantages over previous methods. Currently, the direction of AI is becoming one of the most developed areas of the innovative economy [3, 4].

AI is full of interesting and challenging problems that, if solved, lead to positive consequences, such as improving technology, opening new markets, and increasing social welfare.

At the same time, the shortage of AI specialists worldwide is a significant obstacle to the development of artificial intelligence.

The potential of any country lies in nurturing IT talent, motivating schoolchildren to choose IT professions, and understanding the strategic importance of IT for national development. Therefore, schools should not remain on the sidelines. In this regard, it is important to research and develop effective teaching methods that will enable schoolchildren to master the modeling of neural networks and the use of AI.

In order for schoolchildren to understand the importance of building a personal educational trajectory and providing early career guidance by introducing them to the advanced directions of development in the IT industry (using artificial intelligence and machine learning models), the content of the updated computer science curriculum for 11th grade includes a section titled “Artificial Intelligence” [5].

Conducting this study will enable us to understand how to effectively teach schoolchildren about modeling neural networks and the use of AI, as well as to identify the main factors influencing their readiness and interest in studying AI. This will facilitate the development of improved teaching methods suitable for school environments and promote the development of AI literacy among high school students.

The results of this study will be useful for educators, curriculum developers, and everyone involved in the education of schoolchildren. They will help formulate effective strategies and approaches to training in the field of neural network modeling and the use of AI, contributing to the development of the intellectual potential of the younger generation.

Purpose of the study: to examine the experience of teaching schoolchildren how to model neural networks, utilize AI, and develop intelligent solutions, thereby enhancing teaching methods. The study also explores factors influencing AI literacy among high school students and their intentions to pursue AI studies.

2. Literature Review

For the literature review, we used the Bibliometrix bibliometric information system to analyze the topics and keywords of publications by scientists who studied the problems of teaching artificial intelligence in a school computer science course. Bibliometrix is a system that allows users to collect and analyze data on scientific publications. The system provides a wide range of functions, including the evaluation of research results, such as searching for publications according to various criteria, such as author, topic, and source; analyzing publication data, such as the number of publications and citations; and creating graphs and charts for data visualization.

As a result of the analysis, we identified a list of the most significant topics covered in publications about teaching artificial intelligence in primary and secondary schools: computational thinking, machine learning, and robotics.

Publication data over the past decade was analyzed to identify the most influential authors in a given research area. Subsequently, an analysis of these authors' works was conducted to assess their contributions to the study of the topic.

Thus, the authors of the selected publications analyzed the implementation of AI in the education systems of schoolchildren in various countries around the world, namely: the USA, China, England, Germany, and Israel [6-9].

Also, some of the publications are devoted to the issues of teaching basic concepts and methods of AI in school, it is concluded *that all over the world, the study of AI most often occurs in high school, although there are studies that children can learn the concepts of machine learning from a relatively early age* Dai et al. [10] and Zhang et al. [11].

McCracken et al. [12] state that, typically, machine learning models are developed using text-based programming languages that require coding, which entails understanding programming concepts and syntax. *Based on the publications reviewed, it can be argued that learning the basics of programming facilitates coding machine learning models (ML).*

Indeed, students in grades 5-7 are using Google's Teachable Machine (GTM), a tool that requires no writing or programming experience, to learn about machine learning. GTM combines state-of-the-art classification algorithms with an intuitive, easy-to-learn graphical user interface. Children can explore representations created by intelligent agents by having the computer learn to recognize their voice, facial expressions, or body gestures. This expands the ability to provide new ways of understanding the world, understanding how machine learning models the world, and allows children to practice with machine learning systems and data they encounter in their lives [13].

The article Von Wangenheim et al. [14] demonstrates the results of a systematic mapping study of visual ML learning tools in K-12 over the past decade (2010–2020). They concluded that *active and engaging learning, with a focus on action* *and direct experience, is essential for students* to become not only consumers of AI but also creators of intelligent solutions. Ways to develop image recognition models help make machine learning transparent, allowing students to create the right mental models and encouraging them to develop their own applications.

Thus, learning to code, using apps and web services, and choosing the right visual ML learning tools promotes active and hands-on ML learning.

In the article by Dai et al. [15] and Chai et al. [16], the results of the study showed that AI literacy was not an indicator of readiness to learn AI, and the impact of literacy was mediated by confidence and perceived relevance of AI. Students' AI readiness scores did not influence their anxiety or level of AI literacy. Male students exhibit higher confidence, relevance, and readiness for AI than female students. Students' open-ended responses indicated that they view AI as a powerful and useful technology.

The article by Chai et al. [16] discusses how AI is changing the way people live and work, and how educators have begun teaching AI in high schools. The study examined how Chinese high school students' intention to learn AI was related to eight other important psychological factors.

Background factors were determined based on the theory of planned behavior and included students' AI literacy, subjective norms, and anxiety. The study hypothesized that these factors would influence students' attitudes toward AI, their perceived behavioral control, and their intention to learn AI. The relationship between these factors was theoretically illustrated in a model showing how students' intention to study AI was formed.

Based on the publications reviewed, it can be argued that the results of the described studies and the model for forming schoolchildren's intentions to study AI are useful for teachers in developing curricula on AI and improving students' learning processes.

Bellas et al. [17] developed a specialized AI curriculum for high school students over two years, which was tested at the European level. It was created considering the general perspective of education in the field of AI, making it applicable worldwide. The primary didactic goal is to establish the fundamentals of AI from a practical standpoint, teaching technical concepts through their application in solving specific problems. The approach in educational institutions emphasizes the development of embedded intelligence, that is, programming real devices that interact with the real environment (Figure 1).

	Level	Unit	Topics	Tool	Hours	Weeks	Project
FIRST YEAR	Intelligent Smartphone Apps	1	AI Introduction	Google Slides	4	2	Web search real AI application
			App Inventor tutorial		8	4	
		2	Perception and Actuation		6	3	The School Path Guide
		3	Representation and reasoning	App Inventor	8	4	The School Path Guide II
		4	Learning		8	4	Capture it I
		5	Collective Intelligence		4	2	Capture it II
		6	Sustainability, ethics and legal aspects	Genially	4	2	Myths & Truths
				Total	42	21	
	Basic Robotics	7	·ception and Actuation (IR-motors-encode		6	3	Open-ended movement
		8	rception and Actuation (orientation-came	Robobo &	6	3	Color search and collect
		9	Natural interaction (screen, speaker)	Scratch	8	4	Robobo pet
		10	Human-robot interaction (Impact of AI)	Podcast	2	1	AI tutoring systems
				Total	22	11	
	TOTAL				64	32	
SECOND YEAR	termediate Robotic		Python fundamentals		10	5	
		11	Transition from Scratch to Python	Robobo & Python	8	4	TU7 & TUB
		12	Advanced perception & machine learning		8	4	Recycling
		13	Reinforcement Learning		8	4	Coverage with Q-learning
		14	Representation & Reasoning		10	5	Path Planning
		15	Motivation (Impact of AI)	Canva	4	2	Artificial General Intelligence
				Total	48	24	
	mart Environment		Home Assistant Tutorial	Home Assistant	4	2	
		16	Ambient Intelligence	Home Assistant & Python	8	4	Classroom automation
		17	Smart Environments (Impact of AI)	Thinglink	4	2	Sustainable Development Goals
				Total	16	8	
	TOTAL				64	32	

Figure 1.
AI Curriculum for European Secondary Schools: An Embedded Intelligence Approach.

The proposed curriculum for European secondary schools, based on the "embedded programming" approach, focuses on developing software for embedded systems that interact with the real world through various sensors. Elements of the content of this curriculum, according to the authors of the publication, can also be used in the study of STEM technologies and robotics.

Based on the publications reviewed, it can be argued that the new curriculum developed in Europe for secondary schools represents an important step in the development of education and helps students develop the basics of programming, knowledge of embedded systems, and the ability to develop software to interact with the real world.

The literature review examined publications on the issues of teaching AI in a school computer science course. The main idea of the review is that teaching AI in a school computer science course is an important task that requires further development. Based on the analysis of publications, we can conclude that today, there are a number of studies that show that effective AI training can be based on the following principles:

- Active and practical orientation of training,
- Focus on developing students' programming skills and skills in working with real systems,
- Use of modern technologies and tools for AI training.

AI training in Kazakhstani schools is integrated into the computer science curriculum. Currently, 11th-grade students specializing in science and mathematics are studying two topics within the AI section, and the corresponding learning objectives have been established.

Artificial intelligence:

(1) to explain the principles of machine learning, neural networks (neurons and synapses);
(2) to describe the areas of application of artificial intelligence in industry, education, the gaming industry, and society;

Artificial Intelligence Design:

(3) Design a neural network in spreadsheets/mathematical modeling programs using a ready-made algorithm;
(4) Describe the areas of application of the "supervised learning" method in the development of artificial intelligence.

When studying the computer science course, textbooks recommended by the Ministry of Education and Science of the Republic of Kazakhstan, compiled according to the updated curriculum, are used [18]. Artificial intelligence training in a Kazakhstani school is conducted as part of a computer science course, which includes both theoretical and practical classes. The implementation of this course aims to develop schoolchildren's programming skills and their ability to utilize artificial intelligence in various areas of life.

3. Research Methodology

During the study, theoretical and practical methods were used.

Theoretical methods include analysis of existing theories and models, based on literary and academic sources related to digital and AI competencies, education in the field of AI, and the content of school computer science. A conceptual analysis of the definition of digital competencies formed when studying AI in an advanced computer science course for high school students has also been conducted. A content model for the AI section of an advanced-level computer science course has been determined and formulated.

Practical methods include: a pedagogical experiment to evaluate the effectiveness of the AI module in developing identified digital competencies; collecting data to assess student progress in acquiring AI-related skills and competencies: tests, quizzes, observations, surveys, and student feedback. Data should be analyzed using statistical and qualitative methods to evaluate the AI module and learning outcomes. The effectiveness of the proposed model in improving digital competencies and AI-related skills should be assessed. Conclusions should be drawn regarding the strengths and weaknesses of the educational approach.

The conducted pedagogical experiment consisted of three stages:

- Ascertaining the analysis of the state of studying the direction of artificial intelligence (questioning "yes/no") and students' perception of artificial intelligence as a learning tool (open questions);
- Search (development of methods for teaching AI);
- Formative (implementation of the developed methodology for teaching AI to schoolchildren and testing the effectiveness of the influence of the developed methodology on the quality of education in AI).

"Participants"

At the ascertaining stage of the experiment, the participants were 11th-grade students of a general education school in the natural and mathematical direction, who studied using the author's textbook "Informatics" [19].

At the formative stage of the study, two groups of 11th-grade students (250 people) were selected. The first group is a control group (100 people), the second is chosen as an experimental group (150 people).

In both groups, the average performance in the subject, knowledge, and skills related to AI, programming, and modeling was assessed using entrance testing on a 100-point scale. The analysis of the entrance control results indicated that the groups are comparable and homogeneous in composition and characteristics, with the distribution of points following a normal distribution.

Let us list some possible limitations or errors that may arise in the approach to selecting schoolchildren into control and experimental groups for studying AI experimentally, and some ways to mitigate them. Empirical studies aimed at evaluating the effectiveness of teaching methods have several limitations that can lead to errors in the results. Let's examine potential limitations and biases in the sampling approach and how to address them.

During the ascertaining experiment, a survey of students was conducted. To create questionnaires that are reliable and valid, the following steps were taken:

(1) The purpose of the research is clearly defined to obtain the necessary information and solve the assigned problems.
(2) A review of questionnaires from previous studies was conducted to justify the development and use of validated and reliable questions.
(3) Questionnaire development: The questionnaires included closed yes/no questions and open questions. Closed-ended questions help gather concise and specific information, while open-ended questions give respondents the opportunity to express their opinions and ideas more freely. Data are presented as a percentage of respondents.
(4) Pilot testing, in which a small sample of respondents was surveyed to assess the understandability, clarity, and validity of the questions. This process allowed us to make necessary adjustments and improvements to the survey instrument.
The sample of respondents was probabilistic (random sampling), meaning that each student in the school had an equal chance of being selected for the study.
(5) Expert assessment helped to ensure that the questions were consistent with the topic and objectives of the study, as well as their reliability and validity.
(6) As evidence of the validity of the questions, we provide links to literature, previous studies, or statistical data that confirm the validity and relevance of the survey questions. This helps ensure that survey questions are based on prior research and current data.

As a result, the developed survey instrument combines different types of questions, ensuring the collection of diverse and reliable information. Pre-testing and peer review ensure the quality and reliability of the questionnaires, and evidence of the validity of the questions confirms their relevance in the context of this study.

At the stage of the search experiment, a teaching methodology was developed.

Artificial Intelligence training combines theoretical and practical approaches to help students master core concepts and skills in the field.

The goal of teaching artificial intelligence is to develop students' skills and knowledge necessary to understand and apply artificial intelligence concepts.

Expected learning outcomes include the development of additional skills and competencies related to programming (such as creating algorithms, writing programs for various devices and systems, logical and systems thinking, etc.), setting tasks for artificial intelligence systems, and their training. Personal and professional self-determination, along with interest in knowledge-intensive professions through engagement with achievements in the field of artificial intelligence, are considered important planned educational results.

Content Covered: basic AI concepts such as neural networks, deep learning, natural language processing, computer vision, and various machine learning algorithms. Additionally, the content includes the study of ethical and social aspects of the use of artificial intelligence.

Thus, to introduce schoolchildren to the main problems that can be solved with the help of modern intelligent systems; expand their understanding of machine learning technologies and the prospects for the development of this area of the IT industry; and familiarize them with the main types of problems that can be solved using machine learning systems in various fields and areas of human activity.

While studying the AI section, students become familiar with the properties of intelligence that are currently being taught by machines:

- Predictability: predicting the result based on the input data; providing missing or even non-existent details, pictures;
- Ability to analyze: find patterns, see the logic of events, correctly assess the situation, etc.;
- Ability to learn and memory: acquiring new knowledge and information, mastering skills, and using them to make decisions or take actions based on previous experiences (decisions, successes caused by actions, mistakes, results).

Having mastered the main issues of the topic, schoolchildren become familiar with one of the advanced areas of artificial intelligence, the main components of machine learning: data, features, research, and analysis in accordance with algorithms.

The main feature of the method of teaching the topics of the section is the analysis of real practical examples related to machine learning and solving problems of pattern recognition, adaptation, forecasting, clustering, and their use in various spheres of human life and activity.

Training was carried out according to the author’s textbook “Informatics” [19]. The textbook is compiled according to the updated content curriculum [5] and is also provided online.

3.1. Teaching Strategies and Techniques Used

In the course of the study, a selection of pedagogical and methodological techniques for organization was made, aimed at developing the skills of universal educational activities by involving students in goal-setting activities, choosing ways to achieve them, situational reflection during the lesson, and retrospective reflection afterward.

Students learn to work independently and as part of a team, to conduct dialogue, and to perform various roles and responsibilities. The social experiences and skills they acquire have practical implications.

To improve teaching methods, an analysis of computer software tools that can be used in the school educational process was carried out, and certain difficulties associated with the selection of the necessary software tools were identified. During the practical part of the classes, a special Neurosimulator application and a program built into spreadsheets are offered. This allows students to master working with two fundamentally different models of knowledge representation and logical inference mechanisms. The program and application are freely distributed; they do not require a lot of time to master, and with their help, schoolchildren practice the technology of using modeling tools.

The example given in the article for classes on the topic "Neural Network Design" Rutkovskaya et al. [20] is compiled taking into account the age characteristics of students, their interests, and in accordance with the requirements of the corresponding standard curriculum [5].

The training material includes a description of the implementation of the task of designing a neural network and the use of machine learning algorithms to generate data in an MS Excel spreadsheet for training. Programming languages are mainly used for developing intelligent systems, but some simple algorithms can be implemented on a spreadsheet with a search function and allow various calculations to be performed using built-in functions.

The content of the training was also prepared, designed in the form of theoretical blocks and tasks, taking into account the increasing complexity when studying the topic, practical tasks, step-by-step instructions, and tasks for working in pairs, groups, and individually, including for independent solutions, as well as with the described situations, for which projects had to be completed. Testing and measuring materials and scales have also been prepared.

To conduct the practical part of the classes, the authors proposed a special Neurosimulator application and a program built into spreadsheets. This allows students to master working with two fundamentally different models of knowledge representation and logical inference mechanisms. The program and application are freely distributed, do not require a lot of time to master, and help schoolchildren practice the technology of using modeling tools.

To assess the educational achievements of schoolchildren in the AI section of the Informatics course, assessment tasks were employed. These included research tasks such as "to refute or prove using the analysis of scientific facts..." and project work involving the design and training of a neural network.

4. Results and Discussion

4.1. Practical Tasks

Let us present fragments of practical tasks developed in accordance with the proposed methodology, used for training in the experimental group.

Neural networks are used to solve complex problems that require analytical calculations similar to those of the human brain. The first information about the term "neural networks" was published in 1943. McCulloch and Pitts [21] (in English Warren Sturgis McCulloch) and Pitt William [22] (in English Walter Pitts) found a logical explanation of ideas and neural activity in a fundamental article. The rise of neural network theory is also described in the works of Rosenblatt [23] the perceptron was first proposed by a teacher to simulate training [24, 25].

To model a neural network, it is necessary to collect a large amount of data about the modeled object, determine its features, and create an algorithm consisting of a set of operations performed on a computer. The activity of neural networks is based on classification (sorting), prediction, and recognition of objects or events.

Here, classification is the division of data into parameters. A forecast is a judgment about the future state of a research object based on data. Recognition is currently the most widely used neural network method [26, 27].

For example, creating a neural network that determines the type of this plant based on some of its characteristics according to the "Fisher's Irises" task Figure 2.

Figure 2.
Types of Fisher's Irises.

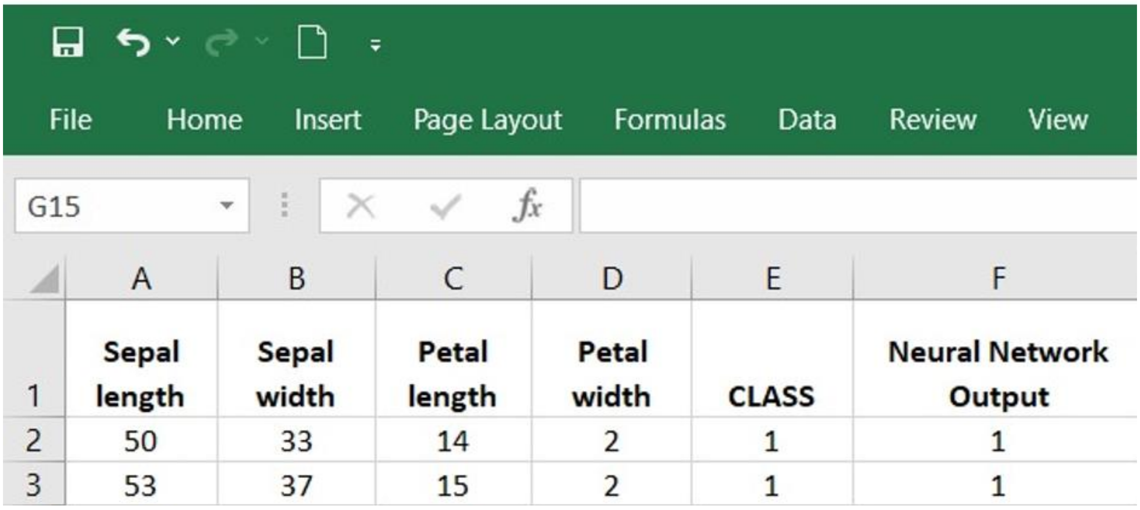
1. Data: Dimensions: 150 pieces of iris, 50 pieces each of three types: setosa, virginica, versicolor (Neural Excel - neural networks in Microsoft Excel // URL: https://www.neurotechlab.ru/https://rassyhaev.ru/zun/).
2. Features: each specimen has 4 features: the length of individual sepals, the width of individual sepals, the length of petals, and the width of petals.

3. To identify any type of iris from the database, we will build an algorithm that can classify it. Classifying an object means indicating whether the type belongs to a given class of worms. In machine learning, the classification problem is solved through the use of artificial neural networks, in particular through experiments with a teacher in the form of learning.
4. Let us describe the process of training a neural network.
5. Download the Neural Excel program from the following link: http://www.neurotechlab.ru/download.
6. Enter the following settings in Excel (File - Settings - Add-ons - Manage - Excel Add-ins - Browse. (View) Find the installed Neural Excel file by browsing.
7. After installation, the Neural Excel distribution will appear in the menu bar, then select "Sample Data" and select "Fisher’s Iris" from the menu that appears.

The table is automatically filled with data. Additionally, you can use pre-existing data and fill in the information as desired.

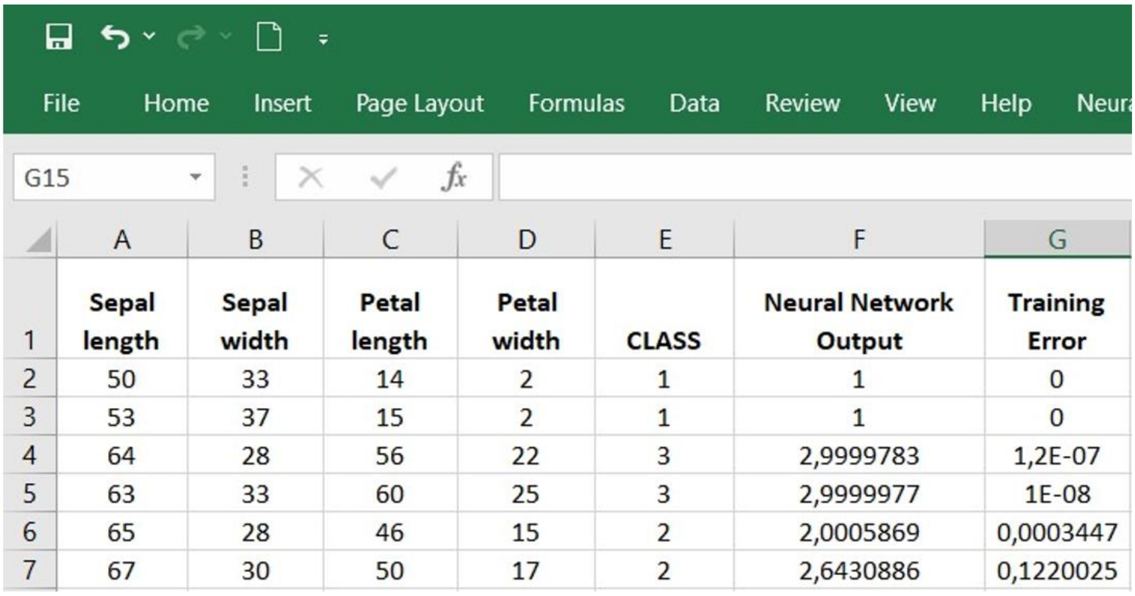
8. Click the “Training Wizard” button and select the “Create a new neural network” command and click OK.
9. Set up the “Set up the neural network training process” window with the symbols shown in the figure: “Field type - Input and normalization type - Linear normalization”.
10. In the CLASS column, select "Field Type - Output and Normalization Type - Linear Normalization". Next, click the “Next” button.
11. Continue setting up to do this change, the number of neurons in the layers, in our case, 17.
12. In the next window, in the line “Description of the neural network”, change the name of the example to “Fisher’s Irises Primer”.
13. Next, click the “Start network training” button and observe the training in the form of a dynamic graph.
14. To check the neural network training, click the “Test trained network” button. For testing, select the data in the 20th row of the table.
15. Click the Calculate button, and the CLASS row will display a value close to the value in the CLASS row of the Excel spreadsheet. Test other values in the same way to ensure that the neural network is trained.
16. In the Excel table, add a column “Output network” and in the first line of this column, enter the following formula:
17. =PREDICT ("NRLNET"; RC1; RC2; RC3; RC4).
18. To enter function parameters, click on the icon in the formula bar and fill in the data sequentially by clicking the button in each line.
19. After clicking “OK” get the result Figure 3.
20. To calculate all data values, click on the cell where the formula is written, and then automatically fill in the other cells Figure 4.
21. To find the size of the training error, create a "Training Error" column

Fill in the columns “CLASS” and “Output network” with a formula that calculates the difference Figure 5.



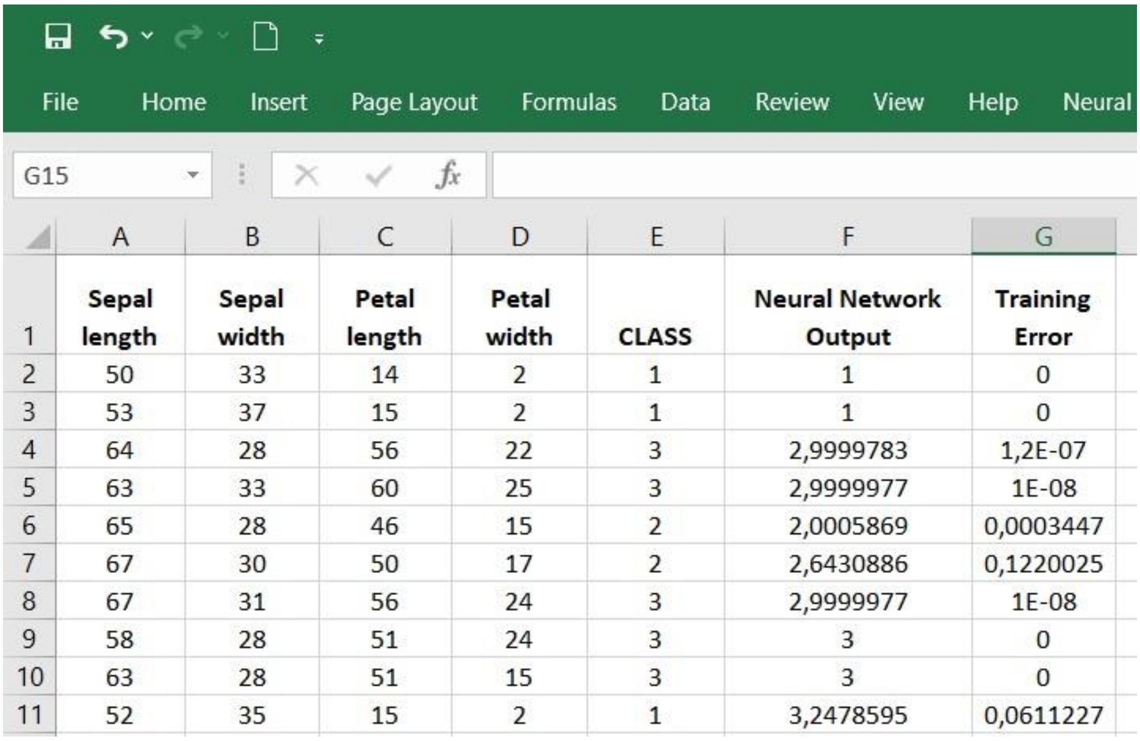
	A	B	C	D	E	F
1	Sepal length	Sepal width	Petal length	Petal width	CLASS	Neural Network Output
2	50	33	14	2	1	1
3	53	37	15	2	1	1

Figure 3.
Output network result.



	Sepal length	Sepal width	Petal length	Petal width	CLASS	Neural Network Output	Training Error
2	50	33	14	2	1	1	0
3	53	37	15	2	1	1	0
4	64	28	56	22	3	2,9999783	1,2E-07
5	63	33	60	25	3	2,9999977	1E-08
6	65	28	46	15	2	2,0005869	0,0003447
7	67	30	50	17	2	2,6430886	0,1220025

Figure 4.
Output Network Column Results.



	Sepal length	Sepal width	Petal length	Petal width	CLASS	Neural Network Output	Training Error
2	50	33	14	2	1	1	0
3	53	37	15	2	1	1	0
4	64	28	56	22	3	2,9999783	1,2E-07
5	63	33	60	25	3	2,9999977	1E-08
6	65	28	46	15	2	2,0005869	0,0003447
7	67	30	50	17	2	2,6430886	0,1220025
8	67	31	56	24	3	2,9999977	1E-08
9	58	28	51	24	3	3	0
10	63	28	51	15	3	3	0
11	52	35	15	2	1	3,2478595	0,0611227

Figure 5.
Result of the "Training Error" column.

The error deviation is insignificant, so the operation of the neural network can be assessed as correct.

(5) The "Neural Network Manager" button is used to import and export files.

In this example, we demonstrated that neural network modeling can be performed by collecting data about an object, highlighting its features, and creating an algorithm, using the example of a neural network computer modeling method for determining the types of caterpillar flowers.

4.2. Research Results

Let's consider the results of the first ascertainment stage; it was important to determine the attitude and perception of the acquired knowledge by students. We present in Tables 2 and 3 excerpts from school questionnaires received through Google Forms.

Table 1.
Students' responses to the questionnaire about studying in artificial intelligence (%)

Questions	Yes	No	Hard to answer
Can you use computer programs to create a neural network?	61.6	38.4	0
Do you know the areas of application of neural networks?	70.7	29.3	0
Is your knowledge about artificial intelligence from secondary school enough to understand how to use ai in everyday life?	68.6	27.2	4.2

Overall, the survey shows positive results, but also indicates a significant proportion of students lack the necessary skills or knowledge in this area. While there is considerable awareness of the applications of neural networks, challenges remain in using computer programs to create neural networks and fully understanding the use of AI in everyday life. These findings could be useful for educators and researchers to improve AI teaching techniques and close knowledge and skill gaps among students.

Table 2.
Students' perception of artificial intelligence as a tool of training (%).

Questions	Yes	No	Hard to answer
Do you use artificial intelligence as a means to complete a task?	74.7	25.3	0
Can you analyze and transform jobs completed by artificial intelligence?	60.7	34.3	5
Do you use any of the tools for text processing: ChatGPT. Nation AI. Jasper?	83.2	26.7	1.1
Do you use any of the tools when processing images: Stockimg AI, Midjourney, Dreamer, DALL·E 2?	78.6	22.4	3.9

Thus, the results of the survey showed that:

- 61.6% of schoolchildren received the necessary knowledge when studying the direction of artificial intelligence and can model a neural network;
- 70.7% can give examples of the use of AI, for example, some respondents gave an example from everyday life;
- 68.6% understand how to use AI in everyday life,
- The majority of high school students use artificial intelligence to complete tasks, at a rate of 74.7%, and can transform and analyze data using AI, at 60.7%. AI is employed in text processing by 83.2% and in image analysis by 78.6%. The inclusion of the AI section in the school's Informatics course has produced positive results.

The general conclusion of the first stage is that students are generally interested and engaged in the field of artificial intelligence and its tools, but there are also certain knowledge and skills that require improvement. The results of the ascertaining stage served as the basis for developing the content of training programs and improving artificial intelligence teaching methods in order to better prepare schoolchildren for the use of this technology in their future careers and everyday life.

The findings of the first stage formed the basis for the development of additional educational materials and a school textbook by the authors [19, 28-32].

Additionally, the results of the initial phase of the experiment have clarified the formulated research hypothesis: teaching AI to schoolchildren, based on deepening the theoretical component with the help of modeling tools within the framework of the developed methodological system, will contribute to:

(1) their effective acquisition of knowledge and skills in the field of AI;
(2) increasing the level of information and logical culture of thinking of schoolchildren.

4.2. Results of the Third Formative Stage

To assess the effectiveness of experimental learning and students' acquisition of knowledge and skills in the field of AI, an analysis of educational achievements in the AI section was conducted.

Student learning outcomes were assessed according to Bloom's taxonomy, which classifies thinking skills into different levels. Assessment items are designed to align with the appropriate levels of Bloom's taxonomy as outlined in Table 3.

Table 3.
Testing thinking skills using bloom's taxonomy.

Levels		Tasks	Note
Low Level of Thinking Skills (LOTS)	First level (Memory, memorization)	Test Tasks	Focus on testing students' basic recall and memory abilities, assessing students' knowledge of facts, concepts, and information acquired during instruction.
	Second level (Cognition, understanding)	Research Tasks	To assess how well students can apply their knowledge to analyze and interpret information and concepts.
Higher Order Thinking Skills (HOTS)	Third level (reasoning: analysis, development, and creation)	Project Work	Emphasis on students' ability to think critically, analyze, synthesize, and create; students' ability to reason, develop solutions, and generate innovative results.

When using Bloom's Level Taxonomy, there is a comprehensive assessment that goes beyond rote memorization and encourages students to develop advanced cognitive skills. This approach ensures that students' academic achievements are assessed at varying levels of cognitive complexity, promoting a deeper understanding of the subject and fostering critical thinking. It also encourages students to engage in creative and exploratory tasks, enhancing their overall learning experience and preparing them for higher-order tasks.

We describe an approach to summative assessment that includes tests, research tasks, and project work, providing valuable information about students' knowledge and understanding of artificial intelligence concepts Table 4.

Table 4.
Results of the quality of knowledge, achievement, and training

Tasks	Number of marks					Performance indicator			
	Excellent, Me	**good, Mg**	**adequate, Ma**	**slow, Ms**	**Untested, Mu**	**AP, %**	**KQ,%**	**L, %**	**AS**
TASKS									
Experimental group	45	60	45	0	0	100	73.3	67.33	4.03
Control group	30	42	28	0	0	100	72	66.96	4.02
Research Tasks									
Experimental group	49	67	32	2	0	98.67	77.33	69.15	4.09
Control group	30	35	33	2	0	98	65	64.6	3.93
PROJECT WORK									
Experimental group	80	65	5	0	0	100	96.67	82.27	4,5
Control group	15	35	50	0	0	100	50	55.40	3.65

The results of educational achievements of schoolchildren (in the control group N=100, in the experimental group N=150) in the AI section of the Informatics course are calculated based on the formula for calculating performance indicators (https://rassyhaev.ru/zun/). The formulas for calculation are given below:

KQ- Knowledge quality

$$\% KQ = (Me + Mg) \cdot 100\% / N \tag{1}$$

AP- academic performance

$$\% AP = (Me + Mg + Ma) \cdot 100\% / N \tag{2}$$

Student level of learning (L- learning):

$$\% L = (Me + Mg \cdot 0.64 + Ma \cdot 0.36 + Ms \cdot 0.16 + Mu \cdot 0.08) \cdot 100\% / \mathrm{N} \tag{3}$$

AS-Average score

$$AS = (Me \cdot 5 + Mg \cdot 4 + Ma \cdot 3 + Ms \cdot 2)/N, \tag{4}$$

where
Me - number of "excellent, 5"
Mg - number of "good, 4"
Ma - number of "satisfactory, 3"
Ms - number of "unsatisfactory, 2"
Mu - number of "n/a without good reason"
N- total number of students

Overall, the experimental group performed better than the control group on all assessment components, including test items, research tasks, and project work. The mean scores of the experimental group were higher in all categories, indicating a greater understanding and application of the subject (artificial intelligence). Project work stands out as a particularly strong area for the experimental group, with a high percentage of students achieving excellent and good progress.

It is important to note that the sample size for the control group is smaller than that of the experimental group, which may affect the results. Additionally, various factors may contribute to the differences in performance between the two groups, including teaching methods, individual student abilities, and other external factors.

To improve the assessment process and support student development, it is important to pay attention to the areas of improvement identified in this assessment. Providing targeted interventions and ongoing support can help improve overall performance and ensure that all students reach their full potential in AI.

Analysis and interpretation of the evaluation results show that the teaching methodology used to teach artificial intelligence and neural network modeling had a positive impact on students' academic achievements.

The study compared the results of knowledge quality, academic performance, training level, and the average scores of the experimental group using the new method and the control group using the traditional method. Three types of tasks were used in the study: test tasks, research tasks, and project work.

4.3. Test Tasks

In test tasks, the experimental group showed results comparable to the control group. In both groups, the average score was 73.3%. However, there were more students with excellent grades (60%) and good grades (45%) in the experimental group than in the control group (42% and 28%, respectively).

4.4. Research Tasks

In the exploration tasks, the experimental group performed significantly better than the control group. In the experimental group, the average score was 77.3%, while in the control group, it was 65%. There were more students in the experimental group with excellent grades (67%) and good grades (32%) than in the control group (35% and 33%, respectively).

4.5. Project Work

In the project work, the experimental group showed significantly better results than the control group. In the experimental group, the average score was 96.67%, while in the control group, it was 50%. In the experimental group, all students received excellent grades, whereas only 35% of students in the control group did so.

The experimental group consistently outperformed the control group, indicating that the approach of using test items, inquiry tasks, and project work, aligned with Bloom's taxonomy, was effective in developing higher-order thinking skills and a deeper understanding of the subject matter.

4.6. Comparison of the Mean Values of the Experimental and Control Groups

To compare the mean values of the experimental and control groups, we will use the t-test for independent samples.

Table 5.
Statistical significance, at significance levels: 0.05.

Task	t	p
Test task	0.25	0.8
Research task	2.47	0.014
Project work	11.44	< 0.001

In test tasks, the average performance values of the experimental and control groups are equal, since $t = 0.25 < t_{cr} = 1.96$, $p = 0.80 > \alpha = 0.05$.

In research tasks, the average performance values of the experimental and control groups differ, since $t = 2.47 > t_{cr} = 1.96$, $p = 0.014 < \alpha = 0.05$.

For project work, the average performance values of the experimental and control groups differ, since $t = 11.44 > t_{cr} = 1.96$, $p < 0.001 < \alpha = 0.05$.

Overall, the t-test results support the conclusions drawn from the descriptive statistics. In test tasks aimed at assessing basic knowledge, the average performance values of the experimental and control groups are equal. In research and project work tasks, which require a higher level of understanding and application of knowledge, the experimental group's mean performance scores were significantly higher than those of the control group.

Thus, we can conclude that the new teaching methodology, based on practical tasks and research projects, leads to improved student performance.

4.7. Let Us Describe the Strengths of the Teaching Methodology

The methodology includes inquiry-based tasks and project work that challenge students to higher levels of thinking, analysis, and problem solving, promoting creativity and innovative approaches.

Using real-world tools such as Excel and neural simulations allows students to gain hands-on experience with machine learning algorithms and neural networks. This helps students learn to apply theoretical knowledge in practice.

The methodology involves project-based work, which allows students to apply their knowledge in practice, preparing them for real-life scenarios and future professional opportunities, developing communication skills, and the ability to work in a team.

The methodology involves the active participation of students in the learning process, and not just passive receipt of information. This helps stimulate student interest and improve their engagement in the learning process.

The methodology offers a comprehensive assessment that includes various types of tasks for different levels of cognitive skills.

This provides a thorough understanding of students' AI capabilities. Including different percentages (AP, KQ, L) allows for a more accurate determination of student achievement levels and highlights areas for further improvement.

At the same time, the weaknesses of teaching methods in the field of artificial intelligence include the following: AI training requires the use of software that may not be available in some schools and can make hands-on activities difficult to implement.

Teaching artificial intelligence training requires specialized knowledge and skills, and finding enough qualified teachers can be a challenge. Additionally, the development of technologies in the field of AI can lead to the obsolescence of educational materials and programs. However, these factors are also typical for any area of study within computer science and information technology in general.

5. Conclusion

In general, the proposed methodology for teaching artificial intelligence, based on the use of tests, research, practical tasks, projects utilizing the simulation of machine learning algorithms, Excel, and neurosimulators, has many strengths that contribute to effective and in-depth student learning in this field.

To address the weaknesses of teaching methods in the field of artificial intelligence, it is necessary to ensure access to essential resources, support the continuous updating of curricula, and train qualified teachers.

Compared to the results of previous studies, where AI training emphasizes understanding programming concepts and syntax, or Google's Teachable Machine (GTM), which is used to teach ML to middle school students, a tool that does not require writing or programming experience, also, by developing image recognition models, students become creators of intelligent solutions. The methodology proposed by the authors for teaching this topic is multifaceted.

Firstly, students are shown the use of computer modeling of neural networks, and secondly, they become familiar with an application program that implements the algorithm for creating a neural network.

Students should understand that this program is just one of a large family of neural network modeling packages designed to solve many problems that arise in human experience.

Thirdly, schoolchildren become familiar with the formulation of problems aimed at finding optimal solutions in one sense or another.

Therefore, it is very important for teachers to demonstrate how neural networks influence everyday life, as well as to provide professional guidance and encourage students to study information technology.

We propose that the training of artificial intelligence in the school computer science curriculum should be structured in such a way that students understand not only the theoretical aspects of this topic, but also know how to apply them in practice in their daily lives. Education should be delivered through simple and accessible language and examples that enable students to easily grasp complex concepts.

We propose that the training of artificial intelligence in the school computer science curriculum should be structured in such a way that students understand not only the theoretical aspects of this topic but also know how to apply them in practice in their daily lives. Education should be delivered through simple and accessible language and examples that enable students to easily grasp complex concepts.

To achieve this goal, various teaching methods such as lectures, discussions, demonstrations, practical exercises and project work can be used. The teacher can use available online resources and software to help students understand the concepts and workings of artificial intelligence.

Overall, the goal of teaching artificial intelligence in a Kazakhstani school should be to provide students with practical skills and knowledge that will help them succeed in the future, when artificial intelligence becomes more common and an integral part of our daily lives.

Research into the effectiveness of the proposed methodology should be expanded to consider the use of modern tools and software, as well as the impact of having in-depth knowledge of neural AI modeling on IT career choices, problem-solving skills, and metacognition in Kazakhstan.

In conclusion, we note that artificial neural networks have firmly entered our lives. Neural network application packages from various companies enable users to work with different types of neural networks and various training methods.

Neural networks are widely used in text and speech recognition, semantic search, expert and decision support systems, stock price forecasting, security systems, and text mining.

In this regard, the results of a study conducted in Kazakhstan are important for understanding the effectiveness of teaching schoolchildren to model neural networks in a school computer science course. This study is the first in Kazakhstan and confirms the findings of other studies conducted in different countries.

The proposed methodology and developed educational and methodological support for lessons textbooks, practical assignments, and didactic material for studying the modeling of neural networks are innovative and in demand.

References

[1] A. P. Sergeev and D. A. Tarasov, *Introduction to neural network modeling: Textbook, A. P. Sergeeva*. Ed. Yekaterinburg: Ural University Press, 2017.

[2] V. G. Redko, *Evolution, neural networks, intelligence: models and concepts of evolutionary cybernetics*. Moscow: Lenand, 2019.

[3] Forbes, "AI goes to high school," 2019. https://www.forbes.com/sites/insights-intelai/2019/05/22/ai-goes-to-high-school/#68826e3f1d0c

[4] J. Hiner, "AI will eliminate 1.8M jobs but create 2.3M by 2020, claims gartner," 2020. https://www.techrepublic.com/article/ai-will-eliminate-1-8m-jobs-but-create-2-3m-by-2020-claims-gartner

[5] Model curriculum, "Model curriculum for the 10–11th grades of general secondary education in the direction of natural sciences and mathematics on updated content from the subject 'Informatics," Ministry of Education and Science of the Republic of Kazakhstan, 2018.

[6] R. F. Murphy, *Artificial intelligence applications to support k-12 teachers and teaching: A review of promising applications, challenges, and risks*. Santa Monica, CA: RAND Corporation, 2019.

[7] P. Liu and X. Si, "Predictions for the potential development of artificial intelligence in Chinese education," in *Proceedings of ICIEI 2018. ACM*, 2018. https://doi.org/10.1145/3234825.3234839

[8] T. K. F. Chiu and C.-s. Chai, "Sustainable curriculum planning for artificial intelligence education: A self-determination theory perspective," *Sustainability*, vol. 12, no. 14. https://doi.org/10.3390/su12145568

[9] A. Sperling and D. Lickerman, "Integrating AI and machine learning in software engineering course for high school students," in *Proceedings of the 17th ACM annual Conference on Innovation and technology in Computer Science Education*, 2012, pp. 244-249.

[10] Y. Dai, C.-S. Chai, P.-Y. Lin, M. S. Jong, Y. Guo, and J. Qin, "Promoting students' well-being by developing their readiness for the artificial intelligence age," *Sustainability*, vol. 12, no. 16, p. 6597. https://doi.org/10.3390/su12166597

[11] Y. Zhang, H. Tang, and Y. Wang, "Research on development status and strategies of artificial intelligence courses in primary and secondary schools in China," presented at the Proceedings of the 6th International Conference on Education and Multimedia Technology, Guangzhou, China, 2022. https://doi.org/10.1145/3551708.3556211

[12] M. McCracken *et al.*, "A multi-national, multi-institutional study of assessment of programming skills of first-year CS students," in Working group Reports from ITiCSE on Innovation and Technology in Computer Science Education, 2001, pp. 125-180.

[13] H. Vartiainen, T. Toivonen, I. Jormanainen, J. Kahila, M. Tedre, and T. Valtonen, "Machine learning for middle schoolers: Learning through data-driven design," *International Journal of Child-Computer Interaction,* vol. 29, p. 100281, 2021. https://doi.org/10.1016/j.ijcci.2021.100281

[14] G. C. Von Wangenheim, J. C. R. Hauck, F. S. Pacheco, and M. F. Bertonceli Bueno, "Visual tools for teaching machine learning in K-12: A ten-year systematic mapping," *Education and Information Technologies,* vol. 26, no. 5, pp. 5733-5778, 2021. https://doi.org/10.1007/s10639-021-10570-8

[15] Y. Dai *et al.*, "Collaborative construction of artificial intelligence curriculum in primary schools," *Journal of Engineering Education,* vol. 112, no. 1, pp. 23-42, 2023. https://doi.org/10.1002/jee.20503

[16] C. S. Chai, X. Wang, and C. Xu, "An extended theory of planned behavior for the modelling of chinese secondary school students' intention to learn artificial intelligence," *Mathematics*, vol. 8, no. 11, p. 2089. https://doi.org/10.3390/math8112089

[17] F. Bellas, S. Guerreiro-Santalla, M. Naya, and R. J. Duro, "AI curriculum for European high schools: An embedded intelligence approach," *International Journal of Artificial Intelligence in Education,* vol. 33, no. 2, pp. 399-426, 2023. https://doi.org/10.1007/s40593-022-00315-0

[18] Ministry of Education of the Republic of Kazakhstan, "Ministry of education and science of the republic of Kazakhstan," 2023. https://www.gov.kz/memleket/entities/edu?lang=kk

[19] D. N. Issabayeva, G. A. Abdulkarimova, L. B. Rakhimzhanova, and M. A. Aubekova, "Informatics: A textbook for the 11th grade of the natural and mathematical direction of a general education school. Almaty: Atamura," 2020. https://www.okulyk.kz/informatika/825/

[20] D. Rutkovskaya, M. Pilinsky, and L. Rutkovsky, *Neural networks, genetic algorithms and fuzzy systems*. Moscow: RiS, 2013.

[21] W. S. McCulloch and W. Pitts, "A logical calculus of the ideas immanent in nervous activity," *The Bulletin of Mathematical Biophysics*, vol. 5, no. 4, pp. 115-133, 1943. https://doi.org/10.1007/BF02478259

[22] Pitt William, "William Pitt and public opinion, 1757," *The English Historical Review,* vol. 88, no. 346, pp. 54-80, 1973. https://doi.org/10.1093/ehr/LXXXVIII.CCCXLVI.54

[23] F. Rosenblatt, "The perceptron: A probabilistic model for information storage and organization in the brain," *Psychological Review*, vol. 65, no. 6, pp. 386–408, 1958. https://doi.org/10.1037/h0042519

[24] A. A. Uskov and A. V. Kuzmin, *Intelligent control technologies artificial neural networks and fuzzy logic*. Moscow: Hot Line – Telecom, 2004.

[25] N. A. Ezhova, "Neurocomputer networks and problems of neural network modeling," Proceedings of International Conference on Soft Computing and Measurements, 2016, vol. 1, pp. 524–527, 2016.

[26] Howard and S. Gugger, *Deep learning for coders with fastai and pytorch*. Boston: O'Reilly, 2020.

[27] Types and varieties of irises, "Stroy-podskazka," 2022. https://stroy-podskazka.ru/irisy/sorta/vidy/

[28] D. Issabayeva and G. A. Abdulkarimova, "To the question of learning modeling a neural network in school course of informatics. Bulletin of Abai KazNPU," *Series of Physical and Mathematical Sciences,* vol. 4, no. 72, pp. 159–164, 2020.

[29] L. B. Rakhimzhanova, S. N. Issabayeva, M. A. Zhumartov, K. T. Nazarbekova, and K. E. Turganbay, "modeling in studying computer graphics in the fundamentalization of computer science," *Periódico Tchê Química,* vol. 16, no. 32, pp. 755–767, 2019.

[30] G. Baidrakhmanova, D. Issabayeva, L. Rakhimzhanova, L. Sultangaliyeva, and G. Suleymenova, "Modeling for computer graphics study in terms of fundamentalization of information science," *Opción: Revista de Ciencias Humanas y Sociales,* vol. 35, no. 89, pp. 733–755, 2019.

[31] T. Balykbayev, D. Issabayeva, L. Rakhimzhanova, and S. Zhanysbekova, "Distance learning at KazNPU named after Abai: Models and technologies," in *2021 IEEE International Conference on Smart Information Systems and Technologies (SIST)*, 2021, pp. 1-6.

[32] E. Ospankulov, U. Abdigapbarova, L. Rakhimzhanova, D. Issabayeva, K. Nazarbekova, and Z. Issabayeva, "Using the digital platform in personalized student learning," in *Proceedings of the 8th International Conference on Frontiers of Educational Technologies*, 2022, pp. 23-28.