**[1]Meruert Serik, [1]Aigul Sadvakassova, [1]Nassipzhan Duisegaliyeva,
[2]Muratbay Alaminov, [1]Kaliya Kariyeva, [1]Danara Tleumagambetova**

*[1]L.N. Gumilyov Eurasian National University, Kazakhstan, Astana.
[2]Nukus State Pedagogical Institute named after Ajiniyaz, Uzbekistan, Nukus*

USING MACHINE LEARNING ALGORITHMS IN TRAINING FUTURE COMPUTER SCIENCE TEACHERS

Abstract: The beginning of the application of artificial intelligence in various areas of society in recent years has put forward the requirements for the introduction of innovative technological methods into education. Improving the knowledge of future computer science teachers is being connected with the directions of modern artificial intelligence. In the process of training computer science teachers in the higher education system of the country, new disciplines are taking a place in the composition of educational programs. In particular, the direction of artificial intelligence machine learning is included in educational programs for training computer science teachers and gives positive results. In the educational process, the theoretical foundations of machine learning are being practically implemented in modern programming languages; in particular, the Python language with the use of the ChatGPT chatbot and the R language for programming scientific problems are being used.

Keywords: knowledge improvement, machine learning, computer vision, computer science teachers, application of machine learning in the learning process.

Introduction

Humanity is on the threshold of the age of artificial intelligence. This concept was originally associated with a computer program designed to automatically prove mathematical theorems. Later, the system went beyond algorithmic work, functions such as collecting knowledge, analyzing, solving problems, Planning and forecasting were integrated, and the ability to think was introduced into artificial intelligence. For this purpose, a digital copy of the neural networks of the human brain was created.

Despite the achievements of neural networks, artificial intelligence is still in its early stages of development, but this level alone is enough to increase the effectiveness of teachers. Experts say that the use of artificial intelligence and machine learning technologies will soon become a key factor in the evolution of the entire education system [author not available, 2024]. Machine learning is different from the traditionally understood concept of program learning or computer learning, that is, machine learning should be understood as a branch of artificial intelligence.

Work is being carried out from a scientific, educational and methodological point of view in the professional training of future computer science teachers at the Department of Computer Science within the Faculty of Information Technologies of the Eurasian National University named after L.N.Gumilev. Intensive development of new information and communication technologies, including distributed data organization technologies, high-performance computing, parallel computing technologies, cloud computing, creation of large data sets, mobile autonomous robotics, computer vision, information storage and security issues are being introduced into the educational process in the training of future computer science teachers.

Machine learning is considered a branch of artificial intelligence, based on the ability to self-teach and create an algorithm by itself based on the first data entered into the computer, it gives the concept of machine learning. According to the conventional understanding, we first create a program, and the computer produces results according to our created program. Researchers and engineers thought that why not do the opposite, let the computer itself create an algorithm and show us the result, and they equate the implementation of those ideas with the concept of machine learning, that is, technological operations have begun to be implemented here, based on engineering solutions.

Currently, thousands and millions of data embedded in the computer are based on such a process. As the amount of data increases, the results obtained from the training data become more accurate. A part of such large volume of data is used for testing and results are obtained using the remaining large volume of data. For example, in a dataset consisting of 70,000 elements, 10,000 test data and the remaining 60,000 data are considered as training data.

In machine learning, as the amount of data increases and the algorithm is reused, the algorithm improves and the results become more accurate.

For example, if we consider optimizing the delivery of information search results to the user on the Google network. When we enter the required word (query) in the search bar, we are offered many links on several pages. We click and select one of the links on the first page and browse the information on the page, that is, we spend some time reviewing the information on this page. At this point, Google "understands" that we've found the information we're looking for.

Machine learning is used in various ways in the field of education, its application in the field of general education is considered in such directions as acceleration and improvement of the learning process. Some technical higher education institutions of well-known foreign countries and our country pay a high level of attention to the problem of artificial intelligence, including the field of machine learning. The main goal of our work is related to the training of teachers currently working in schools and future computer science teachers studying in higher educational institutions in machine learning.

Let us focus on the scientific and methodological works on the application of machine learning in the field of education, one of the directions of artificial intelligence.

Literature review

Educational Data Mining (EDM) is considered to be an important resource where large amounts of data play a crucial role in helping academic policymakers make decisions in the field of education today. This database mentions that machine learning is used to predict student performance, academic grades, dropoutrates, andmore [Ben Said et al., 2024].

In the work on the use of artificial intelligence in lesson planning, using the method of least squares and PLS-SEM-ANN artificial neural network, the authors studied the effect of artificial intelligence on lesson planning of teachers in their research, that is, they considered the effect of productivity, strength, habit, hedonic motivation, social conditions. The use of artificial intelligence was found to be one of the most important positive predictors of social influences in less on planning [Acquah et al., 2024], - noted.

The authors used a ready-made program, and in our work, students were taught how to create such programs, mastered and used in their future work. It continues with mastering the creation of neural networks in a type of machine learning called deep learning.

They emphasize that machine learning can be used in individual training as one of the works in the direction of using ready-made software, and note its role in this regard: The individual training has not been paid attention to in the education system, and the importance of machine learning for the possibility of real-time feedback between the teacher and the

student [Mukhamedyeva, 2020, p. 76] and its possibilities for use in the field of higher education [Tokzhigitova et al., 2022].

The World Economic Forum also mentioned that artificial intelligence will fundamentally change the labor market in the next five years. At the same time, it also shows the idea that such new technology will become a teacher's assistant, and that it is too early to say that artificial intelligence will replace humans [Kudaibergen, 2023].

Using different machine learning models to predict student performance and compare results, the paper states: «At the heart of developmental progress is knowledge, which requires the study and implementation of various modern methods to ensure the success of learners at various levels. However, there are obstacles to this success, which can be divided into three main groups: personal factors, family factors and social factors. These factors can manifest in the form of absenteeism and boredom, which threaten the future of both learners and society at large. Teachers may have difficulties in solving such problems. The purpose of this work is to use a wide range of methods for selecting and applying features that are unconventional in some educational sectors, but proven reliable in other areas.By combining machine learning (ML) and deep learning (DL) models, we attempt to predict learner learning performance based on these identified factors. Subsequently, taking into account the importance of various factors, a comparative analysis is conducted to determine the most effective model» (Laakel et al., 2024). From this, the teacher is shown how to solve the problems encountered in the lesson process.

Online learning has made education accessible. But the question arises as to how much artificial intelligence has to do with it. Here, the question is not only about the quality of teaching, but also about solving the problem of bad teachers. Artificial intelligence can identify and distinguish teachers who do not strive to improve their teaching methods or do not really care about the success of their students, and it can identify teachers who do not care about achievement. In addition, artificial intelligence can expand and improve the abilities of good teachers. While artificial intelligence can solve some aspects of education, it can never replace the human interaction of a dedicated teacher who builds strong relationships with students, creates an immersive learning environment, and truly cares about their success (author not available, 2024), - concludes the thought.

The following thoughts are expressed on the use of ready-madesoftwareequipment: Machinelearningmethodscan be used to simplify manual labor and reduce workload during exam grading. This allows teachers to spend more time on other tasks. However, when it comes to grading exams, completely eliminating manual labor is not possible even with highly accurate automated grading, as any grading errors can have serious consequences for students. Here, the automated grading approach is extended from measuring the workload relative to the accuracy of the automated grading to measuring the total workload required to score the exam with the support of machine learning.

The time spent on various assessment activities was measured along with the effort reduction achieved by clustering responses and using automated scoring. The overall workload reduction was significant, from 74% to 64% compared to fully manual assessment (Weegar et al., 2024).

Experts work with clients around the world to develop technology solutions for education. From language learning apps to chatbot virtual assistants, engineers are working on powerful solutions that transform the learning experience. Powerful tools are offered to make education fun and accessible (author unknown, 2024)

Another example is "the application of the machine learning algorithm in text grouping:
- the written language of the text is determined;
- documents are checked for similarity to each other; the algorithm determines the keyword from the text;

- adaptation to the Kazakh language is performed using a known algorithm for keyword detection; incorrect words are corrected using the necessary algorithm during keyword detection," it is stated (Iskakov, 2015). As we have already noted, this work is not intended to use ready-made programs for machine learning, but to improve the professional competence and programming skills of future specialists.

Machine learning algorithms were used to analyze consumer loan portfolios of Kazakhstani banks. The study is an attempt to assess the creditworthiness of individuals using machine learning algorithms based on data provided by second-tier banks to the National Bank of the Republic of Kazakhstan. Assessing the creditworthiness of borrowers allows the National Bank of the Republic of Kazakhstan to study the quality of loans issued by second-tier banks and predict potential systemic risks. Two-linear and six-dimensional nonlinear classification methods were used in this study. Nonlinear models show more accurate predictions than linear models. In particular, the most promising results were shown by the random forest and k-nearest neighbors nonlinear models on re-discredited data (Baikulakov et al., 2021), it is noted. The authors link their work to the concept of mastering machine learning from a technical and technological perspective.

The authors further justify with the following concepts: First, the following concepts will be discussed: The central idea of machine learning is the mathematical relationship between any combination of inputs and outputs. In a machine learning model, it is not possible to know this relationship in advance, but it can be created if a sufficient data set is given. This means that each machine learning algorithm is built around a mathematical function that can be transformed. The foundations of machine learning are focused on the principle that all complex databases can be mathematically related to computer systems if they have enough data and computing power to process this data. Therefore, the accuracy of the output data is directly proportional to the size of the input data (Baikulakov et al., 2021).

With the rapid growth of user-generated content, multi-scene learning has become a rapidly developing trend in the fields of pattern recognition and data analysis. Due to the significant application value of multi-scene learning, research based on machine learning methods and traditional deep learning paradigms has been continuously emerging. The main challenge in multi-scene learning lies in using consistent and additional information to build a unified, comprehensive representation. However, many multi-scene learning tasks are based on graphical structured data, which makes existing methods unable to effectively extract information contained in multiple data sources for input. Among them, graph neural network (GNN) methods are widely used to work with non-Euclidean data. Therefore, it is very important to combine the advantages of GNN models and the powerful learning ability of multi-scene data. According to the input form of the models, the taxonomy of GNN-based multi-scene learning methods is considered, namely multi-relation, multi-attribute, and mixed attribute. Then, applications of multi-scene learning are introduced, including recommendation systems, computer vision, etc. In addition, several common datasets and open source codes are introduced for implementation. Finally, the challenges of applying GNN models to various multi-scene learning tasks are analyzed and new future directions in this field are discussed (Xiao et al., 2024).

Using advanced analytical techniques such as artificial intelligence (AI), automated prediction of students' enrollment and graduation has recently attracted the attention of educators in both theory and practice. Although various concepts and theories have been proposed to analyze and assess the topic, most of the existing methods cannot technically represent some of the factors of the known difficulties. For this purpose, the retention and graduation data collected in higher education settings about students are considered. This study proposes a machine learning model called RG-DMML (Retention and Graduation Data

Processing and Machine Learning), which is an algorithm for predicting enrollment and graduation status (Okoye et al., 2024).

Research methodology

Thus, the application and mastery of machine learning in various fields and areas, in particular, the mastery of robotics, machine vision, neural networks, expert systems, etc. by students is a matter of time.

In machine learning, algorithms use input data sets that are built as we know them, without pre-programmed instructions. The computer is given a large set of data, told the correct answers, and then the computer itself constructs algorithms that satisfy these answers. We have already seen that as the amount of data increases, the learning of the algorithm improves and the accuracy of the prediction also improves.

Another feature of machine learning is the ability to implement computer vision. By using the camera of a computer, smartphones, you can use the achievements of performing activities such as computer vision, video recognition in real time and through saved files.

The questions under consideration are also implemented on the basis of methods of the main areas of machine learning - supervised learning and unsupervised learning. In the form of supervised learning, a prediction is made, and as a result, the fulfillment of that prediction is monitored. The type of unsupervised learning allows self-learning (training), as a result of which the unknown required data can be determined.

In 2-3 years, the subjects of the educational program will be supplemented with the content of rapidly improving technologies, provided with educational and methodological programs. Currently, educational-methodical, practical works are included in the training process of teachers of computer science, physics and computer science of Eurasian National University named after L.N. Gumilev and Karaganda University named after Academician E.A. Buketov. In the process of training doctoral students at the Department of Computer Science of Eurasian National University named after L.N. Gumilev, the results of the research work are being implemented, and they are presented in the composition and content of the dissertation work.

In the process of training computer science teachers in secondary schools and specialized vocational and technical education systems, starting from the 2016-2017 academic year, we began to introduce the use of machine learning in a number of educational institutions of the country, that is, original subject plans were developed and introduced on the following issues: cloud computing and parallel computing technologies, remote database organization platforms and use of resources through cloud technologies, BigData, Data Mining, Data Set, computer vision, creation and use of neural networks in deep learning, organization of parallel computing on multi-stream data, STEM and computer science, creation of mobile social robots, information security.

The research methods were based on the work "Fundamentals of Scientific and Pedagogical Research" proposed by Esekeshova (2018).

The purpose of the study is to determine the application situation and practical implementation of machine learning algorithms in the training of future computer science teachers. The tasks are related to consideration of ways of introduction of machine learning into the field of education and improvement of knowledge and formation of new knowledge and skills of students based on creation of neural networks in machine learning in the training of future computer science teachers.

Theoretical analyzes were made in the first defining period of the research. The state of inclusion of subjects on machine learning in educational programs of higher educational institutions was differentiated. It was determined that this issue should be given a high level of attention across the country. There were cases where the concept of machine learning was not

fully mastered and not understood.

Since the content of the work depends on machine learning algorithms and technologies in the formative period, a special course is introduced, in its content students use mathematical methods and engineering solutions.

The empirical method was carried out by preparing survey questions and conducting a survey in the Google environment, rating evaluation in the Platonus environment, and taking an exam. The results of the observation method were implemented when assigning rating grades and taking an exam, and the question-and-answer method was implemented when conducting surveys.

During the implementation of our work, we focus on the following methods of using machine learning algorithms:

- data analysis to solve the task in the implementation of machine learning;
- familiarization with machine learning applications;
- learning to choose machine learning algorithms.

Activities to be focused on during practical lessons:

- selection of machine learning algorithms and model creation;
- choosing a programming environment, programming language;
- if there are errors in writing the program code, the ability to use AI-Google CoLab artificial intelligence capabilities and resources;
- differentiating the result.

Implementation of human face recognition technology, use of Python Open CV (Open Source Computer Vision Library) library (recognition of faces from photos and webcams) in the application of computer vision of machine learning in the field of education; application of DLib library (using "manual" or machine learning to mark people in photos, photo enhancement, face analysis, face verification by the DLib library); use of the Face recognition library to detect faces using the camera online; using Haar and MTCNN algorithms to detect and recognize face geometry; the methods of using the DeepFace library to determine a person's age, gender, and emotions by means of faces and ready-made photos were implemented in the learning process.

Results and discussion

Machine learning fundamentals are currently being introduced and implemented in the training of computer science teachers at the L.N. Gumilyov Eurasian National University, and in the educational process of the future computer science and physics and computer science majors at the Academician E.A. Buketov Karaganda University. Surveys were conducted among students of these educational institutions. The survey was conducted using the Google Disk platform. Figure 1 shows excerpts from the survey questions. The survey questions are posted on the Google Disk platform.

Figure 1
Survey questions organized on the basis of the Google Disk platform

Show the directions of artificial intelligence (you can select multiple options)
• computer vision
• machine learning
• deep learning
• expert systems
• natural language processing
• voice recognition
• media reports
• mathematical equations

To what point do the Haar and Dlib recognition concepts correspond?
• libraries for various educational materials
• proctoring system
• computer vision
• face recognition
• to type mathematical formulas
• DataSet
• STEAM directions

Students participated in the survey voluntarily, and it was explained in advance that it would be conducted anonymously. The purpose of the survey was to determine the level of knowledge on such modern topics as distributed data, machine learning, application of machine learning in industries, and STEM education. As a result of the survey, students had high scores on the motivational component, while the previous score on the content and technological components was about 43%, and after completing the subject, they had a score of 87%. Figure 2 shows one of the results of the experimental work of 3rd-year students of the educational program "6B01511-Informatics" of the Eurasian National University named after L.N. Gumilyov on the topic of facial recognition. The study results were sorted using the MS Excel program. Currently, 68 students are improving their knowledge on the research topic in the experimental experimental group. In the next new academic year, it is planned to introduce it into the educational process of other higher educational institutions of the republic, and educational programs are being developed.

Figure 2
Overview of survey results for the subject "Fundamentals of Machine Learning"
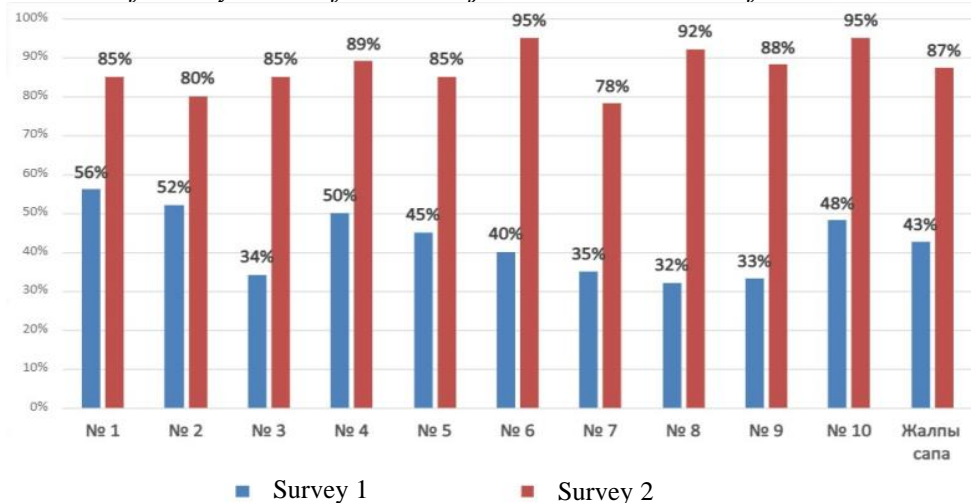
Pearson's χ^2 criteria were used to calculate the final results of the research work. For the content component, χ^2 =10.50. The degree of freedom was 2. Compared to the critical value, 10.50>9.21, that is, the calculated value was in the required range. The null hypothesis H_0 was rejected, and the alternative hypothesis H_1 was accepted, which confirmed the hypothesis that the content results of the research work conducted on students confirmed.

Practical-experimentalworksrelatedto embedded machine learning are included in the syllabus of «Fundamentals of Machine Learning» at the bachelor's level, «Management of large-scale data» at the master's level, in the content of the teaching-methodical complex. For example, the subject plan of the subject «Basics of Machine Learning» is «Concept and basic methods of the basics of machine learning. Building a neural network in multidimensional computing» and «Computer vision. Methods of identifying and recognizing faces (objects)» modules are considered.

The first module includes machine learning - artificial intelligence; the connections and differences between artificial intelligence, machine learning, deep learning, and data; supervised and unsupervised types of machine learning (also referred to as tutored and untutored), methods and basic algorithms used; topics such as machine learning, deep learning type of machine learning and neural networks in deep learning, open big data sets are covered, and in the next module, computer vision, human face or object detection and recognition system, how to install libraries; traditional methods of facial recognition, modern methods; human emotion prediction algorithm; includes such topics as the implementation of the algorithm for predicting human emotions, age and gender using traditional methods (the number of data 30-50000) and the implementation of the algorithm for predicting percentages using modern methods (the number of data 3-120 million). Implementation of these theoretical materials was carried out in Python language, R language, GoogleColab, Anaconda, Spyder, PyCharm environments, Excel program.

Our research work is being carried out with the aim of introducing this modern direction into the field of education, improving the knowledge of students, and forming new skills and abilities. Figure 3 below shows an example of a scene from the lesson "Computer Vision" of the subject "Fundamentals of Machine Learning" of 3rd year students of the educational program "6B01511-Informatics" on the topic of using machine learning algorithms.

Figure 3
A scene from the face detection methods topicin the practical lesson of the «Basics of Machine Learning» subject
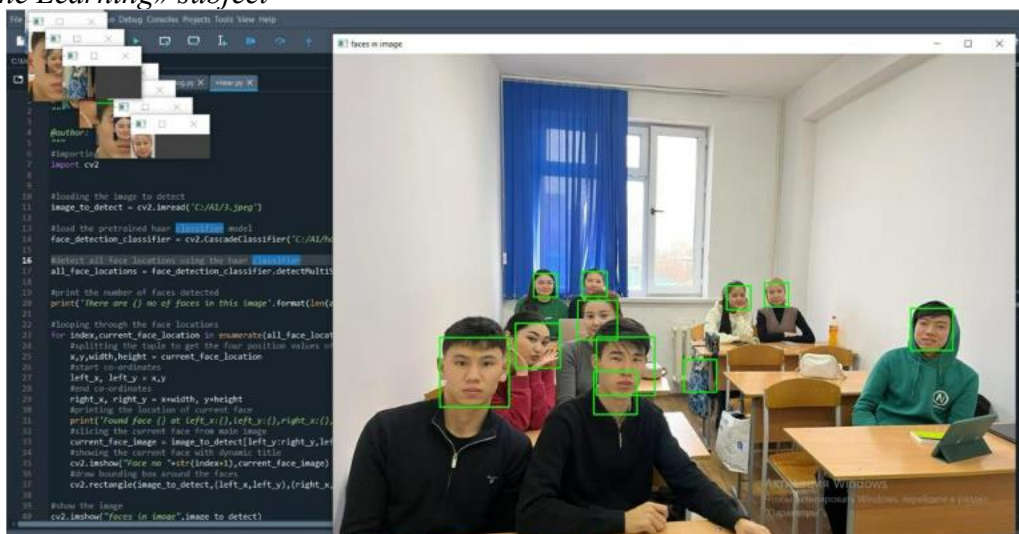
The university's doctoral students are working on deep learning, a branch of machine learning, including the creation of multidimensional neural networks, and are using it in their research.

Working with large data (Big Data, DataSet), using modern programming languages, using the server platforms and resources of large foreign companies (Serik et al., 2022), as well as using the university's Param-Bilim supercomputer through a special application, and using the IBM Quantum Experience quantum computer for programming have become a great foundation for the formation of new skills and abilities in students (Yerlanova et al., 2021).

While third-year students studying Computer Science are studying machine learning algorithms in Python in the Jupyter environment of the Anaconda system during a practical lesson on the subject "Fundamentals of Machine Learning" (Figure 4), undergraduates of the "7M01511-Informatics" educational program are using the machine learning algorithm "Linear Regression" in R to process BigData on a topic related to the use of DataSet, and are achieving good results (Figure 5).

The content of the topics considered in our work is taken from real life. In particular, analyzing and processing the price of apartments in Karaganda using the regression method in big data processing and producing results.

Prior to work, learners will need to master techniques such as loading and formatting large DataSets.

Figure 4

Application of machine learning "Linear Regression" algorithm to predict the price of apartments on the left and oil on the right
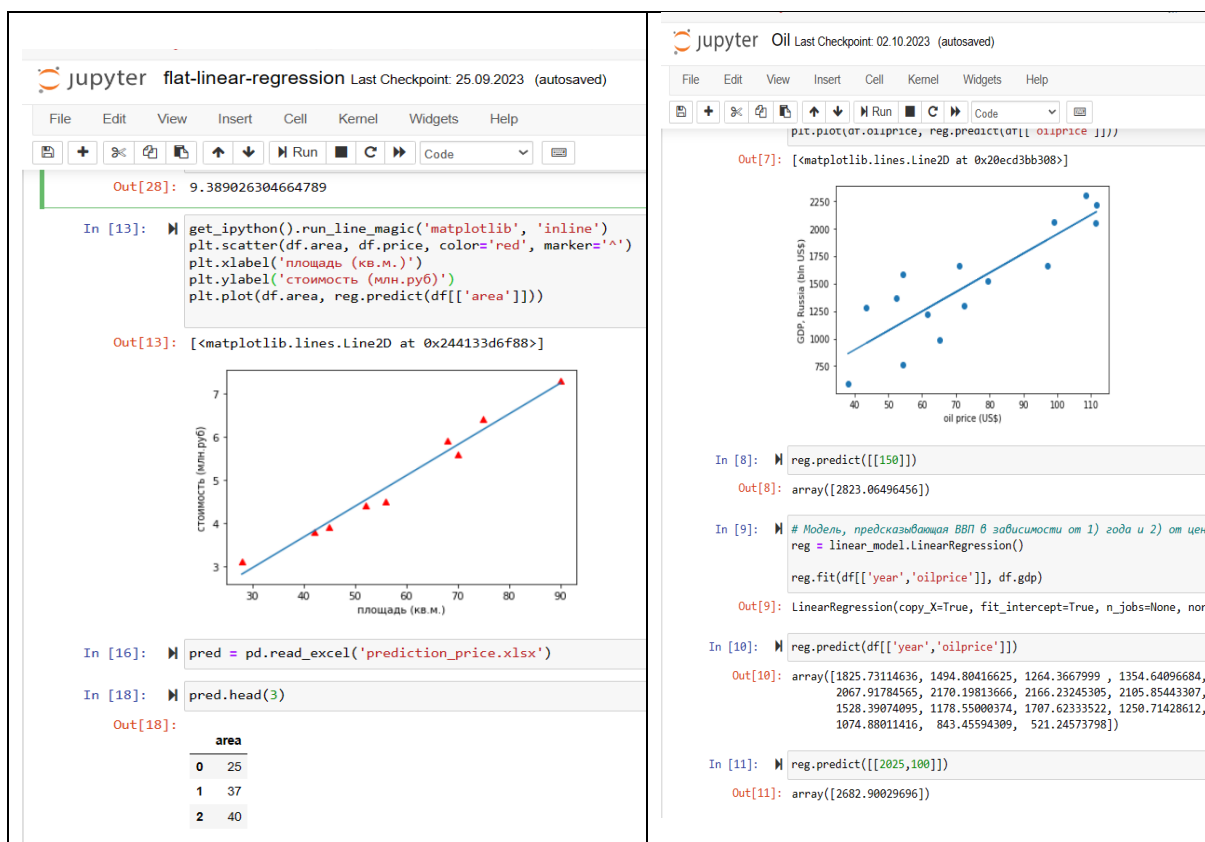
In the educational process, methods for creating and using neural networks in deep learning, a branch of machine learning, have been implemented in the construction of robots (Serik et al., 2022). These topics have been included as new courses in the educational programs for undergraduate and graduate students studying computer science.

Neural networks are increasingly being used in machine translation based on machine learning and deep learning principles. Neural machine translation has achieved significant success and has become a fundamental method in practical systems. The application of neural networks focuses on computer architecture, decoding, and data augmentation techniques (Tan Zh. et al., 2020). As mentioned above, our presented information is related to engineering solutions, where neural networks in computer vision are based on the mathematical foundations of machine learning. Data augmentation and increasing data volume in computers enable the training of neural networks, leading to effective results. Thus, machine learning is no longer solely reliant on statistical data but has evolved into a technology-driven approach based on modern engineering solutions. This is also highlighted in the work of Zhu W. et al. (2022). Machine learning primarily relies on experts' knowledge to solve learning tasks, data processing, model development, optimization algorithms, and evaluation metrics, making it a labor-intensive process. In education, we observe a growing demand for specialists equipped with such modern and essential competencies.

Figure 5

An example of the application of the "Linear regression" algorithm in salary calculation
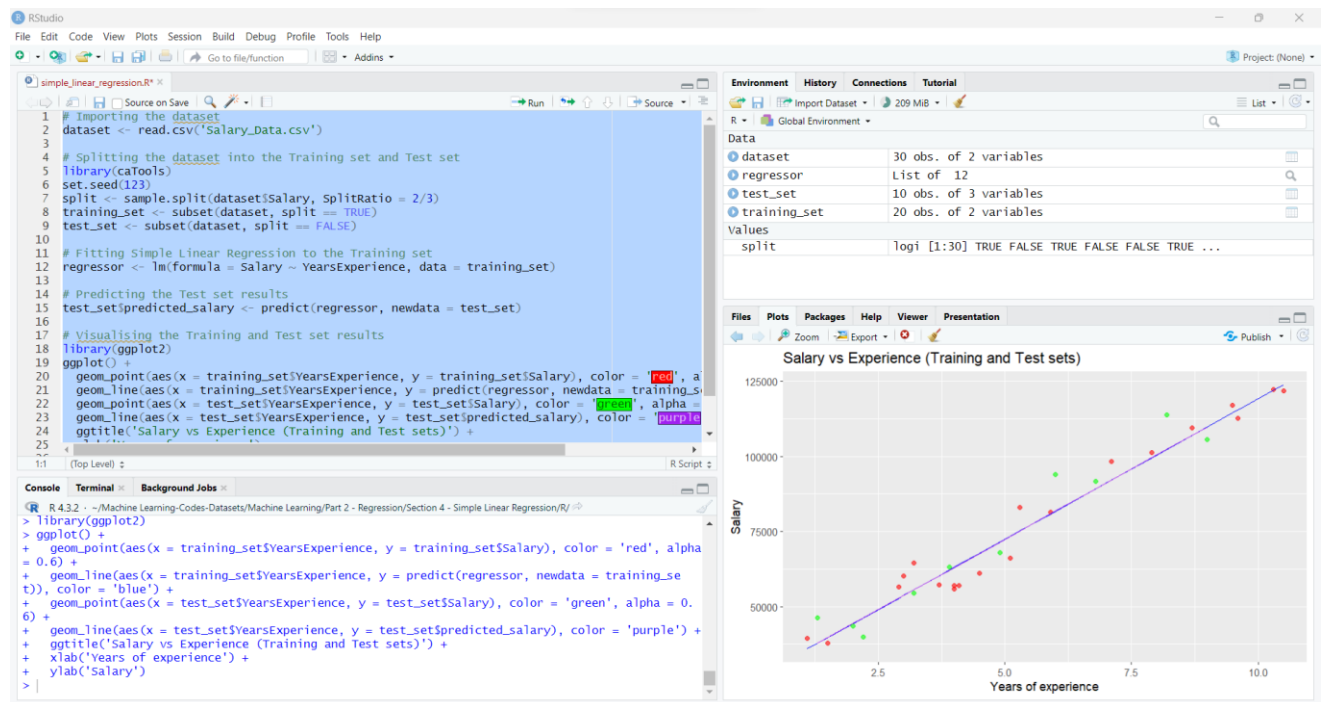
The topic "Neural Networks" was covered using the IBM Quantum Experience quantum computer. In this case, sigmoid or ReNU functions were used as activation functions in building a neural network.

We considered the following example to help students master the creation of a neural network with three inputs and one output and the training of a neural network. In this topic, they understood the concepts of "weights" and "shifts" for connections in the layers of a neural network and mastered the questions of algorithms (Figure 6).

Figure 6
An example of building a neural network on the "IBM Quantu" quantum computer

On the basis of the practical work carried out, we noticed a qualitative change in the training of computer science teachers based on the introduction of the above-mentioned subjects, surveys and rating and examination evaluation of the levels of education. When going to work at the school, the graduate goes to the field of artificial intelligence as a ready specialist with advanced professional knowledge and skills in machine learning. We notice that mastering such a complex direction as artificial intelligence programming is causing difficulties. Work is underway to familiarize graduates who are currently working in schools, but did not study such subjects, with the content of digital educational resources.

The training of specialists in the areas of artificial intelligence, including the training of computer science teachers, requires the improvement of the content and quality of knowledge on modern technologies such as artificial intelligence, machine learning, etc. We note that the content of the educational programs of the Faculty of Information Technologies of the Eurasian National University named after L.N.Gumilev, Department of "Computer science" has been updated and supplemented with author's courses::

- Content of the 4th semester of the educational program "6B01511- Computer Science" is "Information security", contents of the 5th semester are "Fundamentals of machine learning", "Robotics on the Arduino platform", "Methods of teaching high-performance computing", "Parallel computing", the content of the 6th semester has been updated with subjects such as "Fundamentals of cloud technologies in education", the contents of the 7th semester are "Creating mobile applications", "Distributed database management systems", "Big data processing";

- The content of the first semester of the educational program "7M01511-Computer Science" was combined and supplemented with subjects such as "Extensive data management", "Multilevel client-server technologies", "Robotics" in the second semester, "Modern programming languages" currently in use in the third semester, as "Parallel and cloud computing" subject;

- The educational program "7M01525-STEM education" implemented in 2020-2021 is considered an innovative educational program, graduate students are being trained based on the results of the Erasmus+ program project.

- The results of the research were incorporated into the educational process of the

master's students of the Computer Science specialty of the Nukus State Pedagogical Institute named after Ajiniyaz, lectures and practical classes were conducted online.

All of the proposed author's courses are closely related to machine learning as a modern direction of information and communication technologies.

A lot of attention was paid to the creation of digital didactic materials for mastering topics related to machine learning. The teaching-methodical complex of the subject, digital educational resources built on neural networks are widely used. On the basis of the educational program for the training of computer science teachers, an informational educational portal related to machine learning is being created. Currently, for the first version, hosting, server space is being taken, and the portal is being tested. The content of the information portal is closely related to the issue of information security. It will be possible to log in and use the user's biometrics, using a QR code and using a personal registration record. The portal of information education was one of the information resources used by users in the learning process, in the classroom.

Based on the implementation of such works, we emphasize that training of highly qualified specialists cannot be slowed down when the level of creation and use of technical tools is higher than the leveloftheiruse.The research work was related to the process of training future computer science teachers at the L. N. Gumilyov Eurasian National University. In the future, research work will continue in the educational process of other higher educational institutions of the Republic.

Conclusion

It was mentioned that the use of machine learning applications in the field of education is limited.The purpose of our work is for students not only to use ready-made applications and systems, but also to create the applications and systems themselves, to improve their knowledge of artificial intelligence and to form new skills and abilities, to learn complex algorithms for creating applications in the educational process, that is, to master the programming of new network distributed technologies of artificial intelligence related to the training of computer science teachers.

In addition, the "Computer Science" department conducts subjects related to information and communication technologies and digital technologies in all specialties of the university. Therefore, the perspective of the research work is to introduce ready-made technologies and applications in the educational process in the directions of artificial intelligence in the training of students studying in pedagogical specialties.

In the learning process, an informational education portal has been developed, and the results of the mentioned studies are presented as an open informational resource (Figure 7). The informational resource used in the learning process is implemented in the following model: security.org.kz.

Figure 7
View from the information resource model (in Kazakh)

The results of the work are used in the educational process of students studying in technical, natural sciences, and other specialties related to information and communication technologies. At the same time, it can be incorporated and used in the learning process for students studying in secondary vocational and technical education systems.

In the training of future computer science teachers, new subjects such as machine learning, big data, social and autonomous robots, high-performance parallel computing, cloud computing, and others have been introduced into the curriculum. The content of these subjects widely incorporates artificial intelligence approaches and machine learning algorithms.

The research focuses on the process of training future computer science teachers. In the future, the research materials and findings will be utilized by students in other IT fields, as evidenced by over 600 accesses to courses available on the aforementioned educational portal. Faculty members and students from several universities in Kazakhstan are actively using these resources.

The future strategy of the research will be related to the use of machine learning algorithms and methods in STEM areas, which are currently being implemented at all levels of education. Work is also being carried out in this direction in the process of training computer science teachers. . The base university of the research work was connected with the process of training future computer science teachers at the Eurasian National University named after L.N. Gumilyov. In the future, the research work will be continued in the educational process of other higher educational institutions of the republic.

Funding Information

Conflict of Interest Statement

The authors declare no potential conflicts of interest regarding the research, authorship, or publication of this article.

Author Contributions

M. Serik: Conceptualization, Methodology, Project administration A.K. Sadvakassova: Data curation, Writing- Original draft preparation. N.A. Duisegaliyeva: Visualization, Software. M.H. Alaminov: Formal analysis, Supervision. K.U. Karieva: Resources, Validation. D.Sh. Tleumaganbetova: Writing- Reviewing and Editing, Investigation.

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Information about authors

Serik Meruert –,Doctor of Pedagogical Sciences, Professor, L.N. Gumilyov Eurasian National University, Kazakhstan, Astana, email: serik_meruerts@mail.ru, ORCID 0000-0002-2801-432X *(corresponding author)*

Sadvakassova Aigul - associate professor, PhD, L.N. Gumilyov Eurasian National University, Kazakhstan, Astana, email: sak79@bk.ru, ORCID 0000-0001-8219-5515

Duisegaliyeva Nassipzhan–doctoral student, L.N. Gumilyov Eurasian National University, Kazakhstan, Astana, email: nasipzhan@mail.ru, ORCID 0000-0002-5066-3609.

Alaminov Muratbay - professor, PhD in Physics and Mathematics, Head of the Department of Methods of Teaching Computer Science, Nukus State Pedagogical Institute, Uzbekistan. email: alaminov1962@gmail.com, ORCID 0009-0004-7366-9626

Kariyeva Kaliya - Senior Lecturer, Candidate of Pedagogical Sciences, L.N.Gumilyov Eurasian National University, Kazakhstan, Astana, email: karieva_kalya@mail.ru, ORCID 0000-0003-4888-7723

Tleumagambetova Danara - doctoral student, L.N. Gumilyov Eurasian National University, Kazakhstan, Astana, email: be_attentive@mail.ru, ORCID 0009-0007-4221-3900