

The use of artificial intelligence in teaching students programming languages

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Abstract

New technologies are increasingly becoming a part of a person's life, in particular at the stage of education. Education is the main component of comprehensive personality development and affects all spheres of human life. Hence the emergence of Artificial Intelligence (AI), which is introduced into all spheres of life, could not remain unnoticed by higher education institutions (HEIs). Research conducted by the global scientific and pedagogical community along the advent of AI has shown its positive impact on the organization of the educational process for students in higher education institutions. In the modern world, programming is becoming a basic skill for many professions and requires a modern approach to the organization of teaching programming languages to students of HEIs, since traditional teaching methods cannot always provide the necessary level of student training in the conditions of rapid technological development. That is why the use of AI in teaching programming languages is relevant for several reasons: increasing the student's competitiveness in the modern labor market; introducing innovations into the educational system, which makes the learning process more exciting and motivating; increasing the effectiveness of teaching programming languages. The present study presents the results of the analysis of AI platforms that can be used in the process of teaching programming languages to students, according to the following criteria: intelligent educational systems; automated assessment; interactive educational platforms; tutoring systems; analysis of educational data; mobile applications for learning; virtual laboratories and AI for creating educational materials. It establishes that AI provides new opportunities for the teacher in the educational tasks development as well as provides a list of proposed 30 tasks that can be performed using AI. A survey was conducted among students of 1-4 years of study in HEIs, which showed that most of the respondents know about AI and actively use it in their educational activities. The most active users of AI turned out to be 1st-year students, that is, those who are just starting their way in programming and are ready to implement innovations in their educational and later professional activities. At the same time the 3rd-4th year students are more cautious in using AI, substantiating their attitude by the imperfection of existing models. The use of AI in teaching students programming languages provides an opportunity to adapt educational materials to the needs of each student. However, this requires the creation of new assessment methodologies and an individual approach to learning, which can be complicated for various reasons.

Keywords

artificial intelligence, students, programming languages, ICT in education, AI in education, educational technology

1. Introduction

Artificial intelligence (AI) is increasingly being implemented in various fields, including education. Its use in programming languages teaching in higher education institutions (HEIs) is especially important. In the conditions of rapid development of technologies, there is a need for specialists who know modern programming languages. Nowadays there are already many examples of AI use in the educational process worldwide. Such platforms as Codecademy (<https://www.codecademy.com>), Coursera (<https://www.coursera.org>) and edX (<https://www.edx.org/>) that provide self-learning opportunities for students, actively use AI algorithms to adapt educational materials to the students' level of knowledge. They analyze the progress of each user, provide individual recommendations and adjust the training program in real time.

Despite the fact that AI has been available for use only since 2023, the European and domestic community has already developed a number of regulatory documents regarding its use, both at the

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international and Ukrainian levels, as well as at the level of universities.

Thus, at the international level, on March 21, 2024, the UN General Assembly adopted a landmarking resolution on promoting “safe and trustworthy” artificial intelligence (AI) systems, which will also contribute to sustainable development for all [1]. The draft resolution on artificial intelligence itself is posted on the Internet for discussion [2]. Although the draft resolution is not obligatory, it was supported by more than 120 countries, including China, and approved without a vote by all 193 UN member states [3]. US Vice President Kamala Harris praised the agreement, saying that this “resolution, initiated by the US and co-sponsors of more than 100 countries, is a historic step toward establishing clear international norms for AI and for fostering safe, secure, and trustworthy AI systems to establish clear international norms for artificial intelligence systems” [2].

If artificial intelligence in Ukraine is considered, it is worth noting that the Concept of the Development of Artificial Intelligence was approved in this field. This Concept defines the purpose, principles and tasks of the development of artificial intelligence technologies in Ukraine as one of the priority directions in the field of scientific and technological research [3].

The National Technical University of Ukraine “Ihor Sikorsky Kyiv Polytechnic Institute”, one of the first, approved and put into effect by the order dated 12.29.2023 № HOH/393/2023 the document “Policy of using artificial intelligence for academic activities at NTUU KPI”. The university supports rational experimentation with generative AI tools, provided that the following important aspects of such tools use are taken into account: information security, data confidentiality, compliance with the requirements of copyright and academic integrity [4]. The University supports scientific and pedagogical workers as well as students of HEI in improving their literacy regarding the use of AI in the educational process.

Thus, the introduction of AI into education on the basis of compliance with regulatory documents is supposed to give teachers an impetus to active implementation of the innovations, as well as to open new opportunities for individualization and improving the efficiency and quality of education in the teaching of programming languages. However, it also poses a number of challenges, that require a systemic approach and comprehensive solutions from universities, including the readiness of teachers and students to use it.

2. Literature review

Recent studies in the field of using AI in education have shown that the use of AI in the educational process in HEIs is advisable both for evaluating the educational achievements of students, aiming at increasing their motivation to study, intensifying the feedback between students and teachers, and improving educational services in general in HEIs responding to the changes occurring in society.

Thus, some studies have shown that the use of AI platforms by teachers has enabled them to perform various administrative functions: to organize checking and evaluation of students’ tasks more effectively and efficiently, which contributed to the improvement of their teaching activities quality. Since AI platforms use machine learning and adaptability, the curriculum and subject content can be customized and personalized according to the needs of students, which will promote better learning and retention of learning material, thereby improving both student learning achievements and the overall quality of learning [5, 6, 7, 8].

The introduction of AI technologies and chatbots into the system of higher education will contribute not only to the growth of students’ involvement in the learning process, increasing their learning opportunities [9], but also to the quality management of learning processes in higher education institutions, forming a synthesis of available opportunities for management, learning and evaluation of educational achievements [10].

One of the global trends in the higher education system is students’ mobility and the desire to obtain high-quality knowledge in leading educational institutions that organize the process of online education for foreign students. To solve many issues of organizing the education of such students, it is advisable to use AI to 1) organize personalized education with created and customized educational content that corresponds to the student’s abilities; 2) via adaptive testing make it possible to evaluate students’

abilities and improve feedback; 3) via predictive or educational analytics show how teachers understand and support students' academic success; 4) basing on analytics determine the factors that contribute to the success of foreign students [11].

The main paradigm of the 21st century is lifelong learning [12], one of the ways of its implementation is the inclusion of AI in the educational process, the construction of an appropriate learning organization model based on it in the higher education system, where its components can be considered [13]:

- the creation of conditions for cognitive training of students;
- the support of the learning process, provided that students work in co-authorship with AI;
- the expanding of the possibilities for learning process organizing, which creates the conditions unlimited environment for students' activities.

The implementation of these components requires [14, 7]:

- The adaptation of educational materials to the learning process in order to achieve higher learning results.
- The application of innovative learning methods and technologies for assessing the levels of students' educational achievements within the learning process. The learning outcomes evaluation based on the use of AI takes place at the stages of both formative and final evaluation, as well as self-evaluation and cooperative evaluation, whereas the obtained results provide an opportunity to analyze the learning effectiveness.
- The change of the approach to the organization of communication between the student and the teacher by means of feedback for adjusting both learning and teaching and for replenishing educational losses.

In a study conducted in the United States of America to examine the impact of assessment and feedback on student outcomes and performance in higher education, four artificial intelligence platforms were chosen: I-FCN, ANN, XG Boost, and SVM. The authors of the study found positive results from various assessment and feedback practices that can improve both the learning experience and student outcomes. The authors name I-FCN as the best platform, which generalizes most of the methods of artificial intelligence, machine learning and learning analytics to evaluate and provide qualitative and intelligent feedback to students [7].

Despite the positive results of AI introduction in the evaluation of students' educational achievements and the organization of feedback, the following problems should be noted:

- HEI students do not always understand the advantages of such assessment over the traditional one and therefore do not perceive it positively [15], which may arise as the result of the lack of adaptability to innovations in an educational institution;
- scientific studies conducted by surveying young people worldwide and in particular in Ukraine showed that young people in Ukraine do not fully operate the information about the essence of artificial intelligence, about its possible advantages and disadvantages, they have not developed practical skills for using AI in problematic life situations, the solution of which is possible subject to the involvement of additional information resources to resolve issues; the lack of theoretical knowledge about the possibilities of AI for its application in the educational process, in particular the use of search systems, processing and presentation of the results of students' educational and cognitive activities results is proven [16].

Ural Keleş and Aydın [15] conducted a survey on 130 different faculties students in Turkey which covered only detecting the state of students' readiness to use AI in the learning process. The study showed that, in general, students have little knowledge of AI and the majority have a negative attitude towards such technologies.

Last years, various courses began to appear in universities around the world, which were initially aimed at improving general literacy in AI use: visual, media, computer, digital literacy and literacy in

information and communication technologies as well as in artificial intelligence technologies, and later for the implementation of AI in teaching programming.

Kong et al. [17] describes an experimental study conducted at universities in Hong Kong. One of the investigated issues was the formation of the ability to develop a conceptual understanding of artificial intelligence by introducing it into a course on programming. This course covered such basic concepts as artificial intelligence, machine learning, supervised and unsupervised learning. The results of the study proved that participants of both sexes with different initial educational levels can understand the concepts of machine learning, supervised learning, regression, classification, unsupervised learning and clustering.

Final testing showed that the course enabled its participants to achieve statistically significant improvements in understanding AI concepts, in self-aware literacy, and AI empowerment. In addition, the course successfully narrowed the gender gap in AI literacy and empowerment. The testing also showed that prior knowledge of programming was not a prerequisite for developing AI literacy. Participants reported a positive perception of the learning process and its outcomes in terms of increasing their AI literacy [17].

Based on the results of the study [18], in which eight components of the use of AI for education were distinguished: intelligent learning system, student evaluation, student movement, mood, recommendations, group monitoring, personalized learning, results prediction, Cheng et al. [19] distinguished each criterion six sub-items, three of which included positive thinking, and three included negative thinking. These criteria corresponded from the point of view of psychology and provided an opportunity to approach each student individually. Such a research scale was named “Students’ Conceptions of AI in Education Scale” (SCAIES).

The results of the study showed that intelligent learning systems create conditions for high-quality training of students, allow receiving feedback to overcome gaps in learning, provide students with the opportunity to receive an individual approach in accordance with their educational achievements. At the same time, there are a number of unsolicited criteria, such as group monitoring, as well as the use of chatbots in the learning process, that appear as such, which were not yet presented to the public at that time. Whereas the part of students who have a negative attitude towards AI due to the possibility of violations of the rules of academic integrity can not be rejected.

A study on the use of chatbots in China’s higher education system conducted in 2023 showed that, such use of AI has generally a positive effect on student academic achievements [20]. In its turn the study of robot introduction into the process of teaching programming turned out to be even more interesting. The results of the study show that university students have a high tendency to use AI-based robots for educational purposes, as well as are determined to improve their skills and keep up to latest developments in artificial intelligence technologies.

Lytvynova et al. [21] emphasize the need for a comprehensive approach to implementing AI in education, encompassing the analysis of key aspects such as providing suitable conditions for students, developing effective security measures, and adapting learning materials to meet the individual needs of each learner. They argue that this approach is essential for the successful integration of personalized learning into the educational process [22, 23].

İpek et al. [24] investigating the use of ChatGPT have determined positive categories and subcategories of ChatGPT integration into education and have established a link between education and artificial intelligence. They have indicated that ChatGPT and its derivatives will establish a new paradigm in education as a whole.

AI-powered robots offer an exceptional learning tool for both students and teachers, recreating deep learning experiences for learning subjects in an immersive way. This gives students a chance to explore and gain new knowledge, building a personal learning trajectory, as the use of robots in the educational system provides an opportunity to create a safe and welcoming learning environment where students feel naturally convenient [25].

3. Problem statement

A number of problems that slow down the introduction of innovative technologies into the educational practice of teachers of higher education institutions were identified while analyzing the AI researchers' publications, in particular, the need for constant adaptation of educational programs, as well as insufficient flexibility of higher education institutions to introduce innovations.

The main challenge is to adapt AI for effective teaching of students with different pre-training levels and learning styles. Students who study programming languages have different levels of knowledge and skills. AI can manage this by using adaptive algorithms to tailor learning materials to each student's needs. However, the development of such algorithms is a complex task that requires a deep understanding of pedagogics as well as programming learning methods.

Another challenge arose in creating effective interactive learning tools. AI can be used to develop interactive environments where students can write code, receive instant feedback, and see the real time results of their actions. However, creating such environments requires significant resources and technological expertise. In addition, it is necessary to ensure that these tools are intuitively accessible to students of different training and learning levels.

Ensuring the quality and relevance of educational materials also appears to be a significant challenge. AI can analyze large amounts of data and automatically update curricula, but this requires constant monitoring and adjustments by teachers. It is important that the learning materials meet the modern standards and requirements of the industry.

There also arises an ethical problem. The use of AI in education requires maintaining the confidentiality of student data and ensuring their security. This includes protecting personal data and preventing misuse of personal information.

The integration of AI into the existing educational infrastructure is also an important aspect. This requires appropriate training of teachers, who must understand how to effectively use AI in their educational process. Investments in technological infrastructure and ongoing support also appear to be necessary.

Therefore, it is worth noting, that the scientific problem of using AI in teaching students programming languages is multifaceted and requires a comprehensive approach. Solving these challenges can significantly improve the quality of education and training of future specialists in the field of programming.

In the present study, such aspects as: students' readiness to use AI in learning programming languages; attitude of students to this innovative tool; the level of AI use by students during practical tasks; restrictions on AI use; forming a list of tasks that can be performed using AI are considered.

4. Research methodology

The present study describes the results of analysing the state of AI use by HEI students as well as their readiness to use AI in programming languages learning. 281 students of the 1st-4th year of NTUU "Ihor Sikorsky Kyiv Polytechnic Institute" of the Faculty of Informatics and Computer Engineering of the Department of Information Systems and Technologies took part in the survey. The scope of the research involved monitoring of practical tasks performance by HEI students; a questionnaire was developed in order to find out the level of use and readiness to learn programming languages with the use of AI.

The survey was conducted in March 2024. Students were not dependent on the results of exams or tests. The questionnaire was to be answered online at a time convenient for them. The ratio of students participating is as follows: 1st-year students – 41.3%, 2nd-year students – 21.0%, 3rd-year students – 31.3%, and a small number of 4th-year students – 6.0% (figure 1).

The survey outcomes also showed that the most active are the students aged 16 to 19 – 67.3%, less active are students aged 20-24 - 24.2%. In comparison to 25-29-year-olds (2.1%) the over 30-year-olds were more active with the percentage of 6.4% (figure 2).

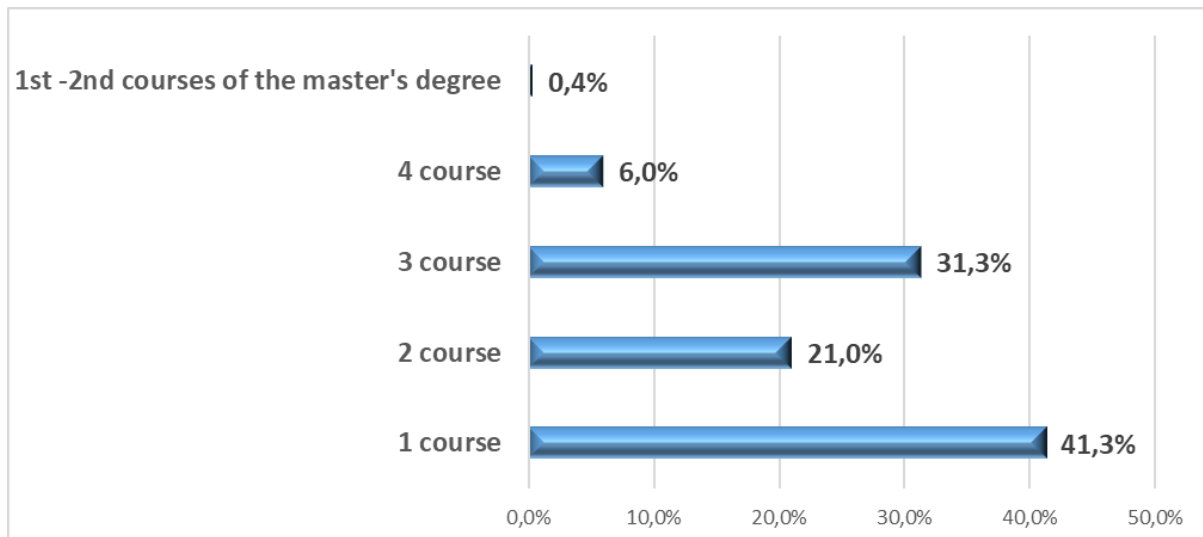


Figure 1: Quantitative composition of students participating in the survey.

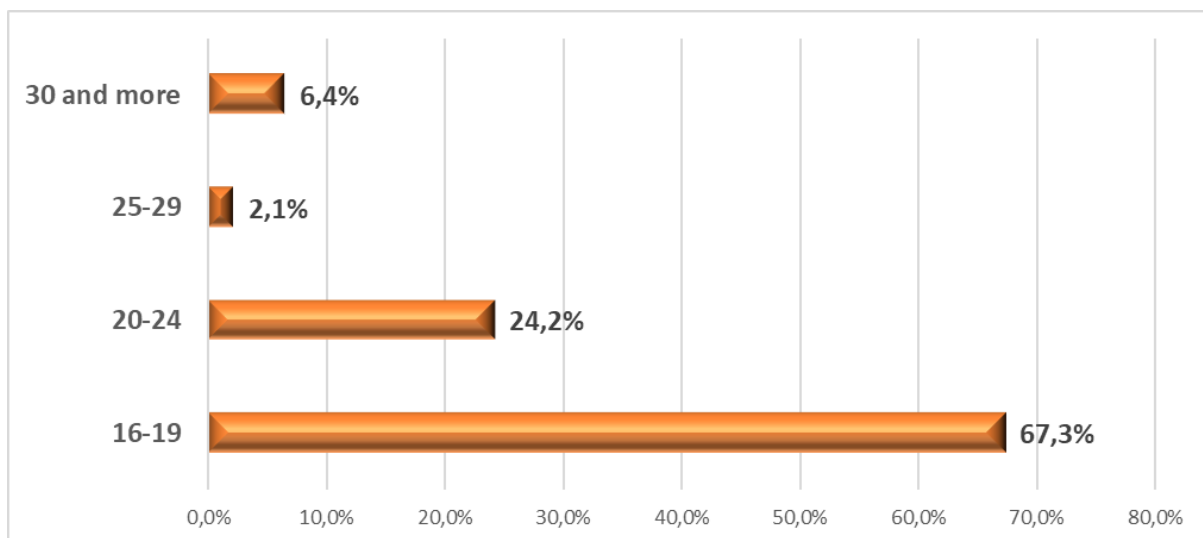


Figure 2: Age composition of students participating in the survey.

According to the survey results, first-year students were the most active and, therefore, more motivated to perceive innovations.

5. Research results

5.1. Possibilities of artificial intelligence for teaching students programming languages

It is necessary to consider several aspects that affect the AI use in teaching students programming languages, namely: the readiness of students to use an innovative tool, as well as the approaches and solutions in AI use in the process of teaching programming.

Artificial intelligence is the ability of an automated software system to perform actions or tasks that were previously only available to humans: intelligent reasoning, analysis and processing of information, acquisition of experience and optimization. AI uses machine learning algorithms to acquire and process information and therefore plays a key role in the educational process.

The use of AI in the educational process creates conditions for the implementation of such educational innovations:

- *Individualization and personalization of learning.* AI can adapt learning material to the individual needs of each student, providing more effective learning that matches their interests and level of knowledge;
- *Increasing students' motivation to study.* The use of AI can help students manage the learning material by introducing interactive tasks, virtual tutors, and an individualized approach to learning;
- *Prediction of students' success throughout the entire study cycle.* AI based on data analysis can predict risks in student learning and suggest ways to solve them;
- *Improving the quality of education* (learning, teaching) by selecting optimal training courses and programs to overcome educational gaps;
- *Automation of assessment of students' educational activities.* AI can automatically grade assignments, reducing the human factor and providing objective student learning outcomes.

Despite the above-mentioned advantages of AI use in the educational process, the downsides should also be mentioned [26, 27]: ethical norms – the threat to academic integrity, democratization of plagiarism; students' cognitive abilities decrease; social isolation – loss of the identification as a student in connection with the communication reduction between peers and teachers; loss of creativity and the creative approach to problem solving.

In the modern world, programming is becoming a basic skill for many professions and requires a modern approach to the organization of the process of teaching programming to HEI students, since traditional teaching methods cannot always provide the necessary level of training for students in the conditions of rapid technological development. Hence the use of AI in learning programming languages is relevant for several reasons:

- *Labor market development.* Programmers with AI skills are more in demand on the job market as they can develop AI implementations, create intelligent systems and optimize processes.
- *Innovative processes in education.* The use of AI in the educational process of higher education institutions provides an opportunity to introduce new active learning methods, create interactive platforms and expand student learning opportunities.
- *Efficiency and time saving.* The use of AI provides the possibility to automate many educational processes, which allows teachers and students to use their time more efficiently.
- *The influence of global trends.* AI is one of the key technologies of the future, and its use in education is a necessity for training competitive future professionals.

The use of artificial intelligence in programming languages teaching to students of higher education institutions covers several different fields. A more detailed description of each of the branches as well as the examples of some platforms for their provision are given further in the article.

- *Intelligent educational systems (IESs).* IESs use AI to create personalized educational plans, adapt educational materials to the needs of each student. Such systems include: Coursera – a platform that uses AI algorithms to analyze student progress and offer appropriate courses; edX – provides personalized recommendations based on student performance data.
- *Automated evaluation (AE).* AI systems for automatic evaluation of written programs that can analyze codes for correctness, efficiency, and programming style. For example, CodeSignal (<https://codesignal.com>) uses algorithms for code validation and error analysis; HackerRank (<https://www.hackerrank.com>) provides automatic grading of coding tasks and provides feedback.
- *Interactive learning platforms (ILPs).* Interactive platforms use AI to create simulations, virtual labs, and games that make learning more engaging and effective. These platforms include: Codecademy (<https://www.codecademy.com>) offers interactive programming exercises with automatic feedback; SoloLearn (<https://www.sololearn.com>) provides interactive AI-powered courses for learning programming languages.

- *Tutoring systems (TSs)*. AI tutors provide real-time support by answering students' questions and explaining complex concepts. Such systems can be: IBM Watson Tutor (<https://developer.ibm.com>), which can interact with students, providing answers to their questions and explaining the material; Socratic by Google uses AI to help students solve programming problems.
- *Educational data analysis (EDA)*. AI analyzes large volumes of educational data to identify trends and recommendations for curriculum improvement. For example, BrightBytes (<https://www.brightbytes.net>) collects and analyzes data to improve educational strategies; Knewton (<https://www.wiley.com/en-us/education/alta>) uses data to tailor curriculum to individual student needs.
- *Mobile applications for learning (MAL)*. Mobile apps use AI to deliver personalized learning materials and assess student progress in a convenient format. Such applications are: Mimo (<https://mimo.org>) offers interactive training in programming using AI; Grasshopper is an application that helps you learn the basics of programming through interactive lessons (<https://rhino3d.online/uk/product/grasshopper>).
- *Virtual laboratories (VL)*. Virtual laboratories provide students with hands-on tasks and experiments in an AI-driven virtual environment: AWS Educate (<https://aws.amazon.com/ru/education/awseducate>) provides access to cloud-based labs where students can practice programming skills; Google Cloud Platform (<https://cloud.google.com>) offers laboratories for learning and working with real cloud tools.
- *Artificial intelligence in the creation of educational materials*. AI is used to automatically create learning materials such as textbooks, video lessons, and tests. Educational materials can be created with the help of: Content Technologies, which uses AI to create personalized textbooks; Querium, which generates adaptive tests and learning materials based on the analysis of student data.

The above-listed fields demonstrate a wide range of possibilities for AI use in teaching programming languages, each aiming at improving the efficiency and quality of education.

Despite the numerous advantages, the use of AI in programming languages teaching has certain limitations and features:

- *Technical limitations*: AI algorithms cannot yet always accurately interpret creative or non-standard solutions, which might lead to incorrect evaluations.
- *Ethical questions*: The use of AI involves the collection and analysis of large amounts of data about students, which may raise issues of privacy and data security.
- *Implementation cost*: The development and implementation of AI systems into the educational process requires significant financial investment, which is not always available for all educational institutions.

Taking into account all the advantages and disadvantages of using AI in teaching students programming, it is advisable to single out the main components in the structure of such training organization: introduction to programming with AI; AI as a partner for an idea; navigation of algorithms with the help of AI; AI as a partner for program set-up (figure 3).

The tasks offered to students while learning theoretical and practical content were analyzed in order to study the influence of artificial intelligence on the educational activities of the respondents. The tasks that can be performed with the use or support of AI were further highlighted:

- theoretical information search;
- primary code writing;
- checking the correctness of code writing;
- code optimization;
- test case generation;
- automatic software testing;
- statistical analysis of the code to identify errors or deficiencies;

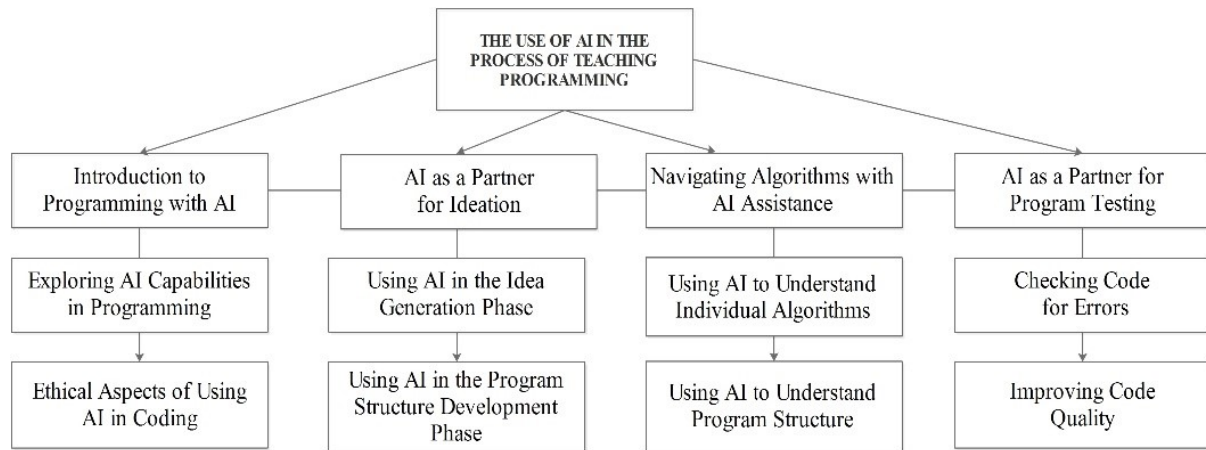


Figure 3: The structure of teaching programming to students using AI.

- writing documentation for the code;
- code refactoring;
- determining the algorithm effectiveness;
- software performance forecasting;
- automatic generation of error reports;
- application of machine learning for specific tasks solving;
- building and training machine learning models;
- analysis and processing of big data;
- development of chat-bots or other intelligent agents;
- recommendation system creation;
- data visualization;
- user behavior analysis;
- image or speech recognition system development;
- natural language processing (NLP);
- automatic error correction in the code;
- integration of artificial intelligence into existing software products;
- server or network monitoring and analysis;
- game development using artificial intelligence algorithms;
- AI application for cyber security;
- routine programming tasks automation;
- image recognition and processing;
- system design and simulation;
- new projects or products idea generation.

Every student of a higher education institution must aim at becoming competitive in the global labor market, which demands constant developing their qualifications by improving knowledge and skills.

For increasing their own knowledge and improving their skills, students learning programming are required to use:

1. *Programming languages.*

- Python: a popular language for developing web applications, scientific computing, artificial intelligence and many other areas;
- JavaScript: used to develop the external interface of web applications and user interaction;
- Java: used in many large corporate projects and mobile applications;

- C++: used for system programming, graphics and games;
- C# – used to create dynamic web applications based on the powerful ASP.NET framework from Microsoft

2. Frameworks and libraries.

- Django: Python framework for developing web applications;
- React: JavaScript library for external interface development;
- Angular – a JavaScript framework for developing complex and highly loaded web systems;
- Vue.js – a JavaScript framework for developing user interfaces;
- Spring: Java framework for building corporate applications.

3. Development tools.

- Visual Studio Code (VS Code): a popular text editor for programmers;
- Git: a version control system for collaborative work on software code;
- Jupyter Notebook: an interactive environment for data analysis and scientific computing.

4. Other technologies.

- Docker: containerization of applications for convenient deployment;
- SQL and NoSQL databases: for example, MySQL, PostgreSQL, MongoDB.
- Artificial intelligence and machine learning: TensorFlow, PyTorch, Scikit-learn;
- REST (JSON, XML) technology: Architectural style for creating web services.

To provide effective work with artificial intelligence, programming students are also required to familiarize themselves with the following programs and courses that give them the opportunity to deepen their knowledge and skills:

- “IBM Introduction to Artificial Intelligence (AI)” – the course provides an introduction to algorithms, applied machine learning, neural networks, computer vision, and other key aspects of AI (Coursera);
- “AI For Everyone” - the course helps to understand the basics of data, deep learning and business transformation (DeepLearning.AI);
- “Explore free artificial intelligence courses and more” – this artificial intelligence course and others can be found on edX;
- “Machine Learning, Computational Thinking, Deepfakes” – online courses that help expand knowledge of artificial intelligence (MIT OpenCourseWare).
- “AI For Business” – this course covers machine learning, data analysis, algorithms, etc. (University of Pennsylvania).

As noted by scientists and practicing teachers, AI can significantly improve the quality and efficiency of education, personalize the approach to each student, and make the learning process more interactive and interesting. There already exist tools like CodeSignal, LeetCode, and HackerRank that use AI to automatically score written programs, analyze bugs, and provide feedback. This gives students the opportunity to quickly understand their mistakes and improve their programming skills.

CodeSignal, LeetCode, and HackerRank are online platforms for practicing coding and preparing for technical job interviews. As a result of the comparative analysis, the functional criteria of the specified platforms were determined (table 1).

Common features of these platforms include:

- coding: all three platforms offer a wide range of coding tasks covering different topics, different levels and programming languages. Such a wide range of tasks creates conditions for practicing practical coding skills as well as provides an opportunity to learn new algorithms and concepts;
- support for several programming languages: C++, Java, Python, JavaScript and many others;

Table 1
Online platforms for AI-enabled coding.

Criterion	CodeSignal https://codesignal.com/	LeetCode https://leetcode.com/	HackerRank https://www.hackerrank.com/
Focus	preparation for job interviews	preparation for job interviews	competitive programming, training
Task complexity	high	high	medium
Tasks	original, varied in complexity and updated	a wide range of tasks, including those used in real companies	various tasks, including thematic competitions
User interface	modern, convenient, simple and intuitive	more complex, but includes more features	simple, modern and elegant
Price	both free and payable tariff plan	only payable tariff plan	both free and payable tariff plan
Learn process organization	interactive courses and tips	detailed explanations and articles	tutorials, videos and certifications
Community	smaller, but active	large and active	large and global
Advantages	automatic test generation, detailed analysis of results	a large number of tasks, an active community	a wide range of tasks, competitions, certifications
Disadvantages	a less wide range of tasks than on HackerRank	less convenient interface than on CodeSignal	tasks may not be as difficult as on CodeSignal and LeetCode
Utility	preparation for technical job interviews	preparation for technical job interviews, coding practice	coding practice, participation in competitions, receiving certificates
Additional functions	automated testing; code execution visualization; modes of study and practice	discussion forums; competitions; possibility of creating own tasks	code editor; teamwork tools; possibility of placing own contests
Choice options	a good choice for beginners who want to improve their coding skills and prepare for job interviews	suitable for experienced developers who want to practice solving complex problems and compete with others	excellent choice for those looking for an all-in-one solution for training, practice and certification

- interactive interface: all three platforms have an interactive interface that allows you to write and run code directly in the browser, which saves time and makes the process of solving problems more convenient;
- the system for solved tasks evaluation is automatic, which helps to track progress and identify areas that need improvement;
- community: all three platforms have active user communities which enables communication between programmers, knowledge share and access to support in solving problems.

Each of the above-described platforms helps in solving specific problems, which means that the choice of a more convenient and functional one is purely personalized

5.2. Readiness of students to use artificial intelligence in programming languages

The introduction of artificial intelligence (AI) into the field of programming marks a new era in software development. AI opens up many opportunities for students to automate tasks, improve productivity and create more innovative solutions. However, in order to effectively use AI in programming, students are required to have not only the knowledge of programming languages, but also the understanding of how AI works, as well as the skills to integrate AI into their projects.

In this section the authors present the indication of the level of students' readiness to use AI and analyze the factors influencing this readiness, such as knowledge about AI, programming skills with AI, perception of AI as an assistant for software development. Responses to the question "Do you have experience using AI?" showed that more than 45% of the students use solutions proposed by artificial intelligence; 27% use them sporadically and almost 23% use ready-made solutions on a professional basis (figure 4).

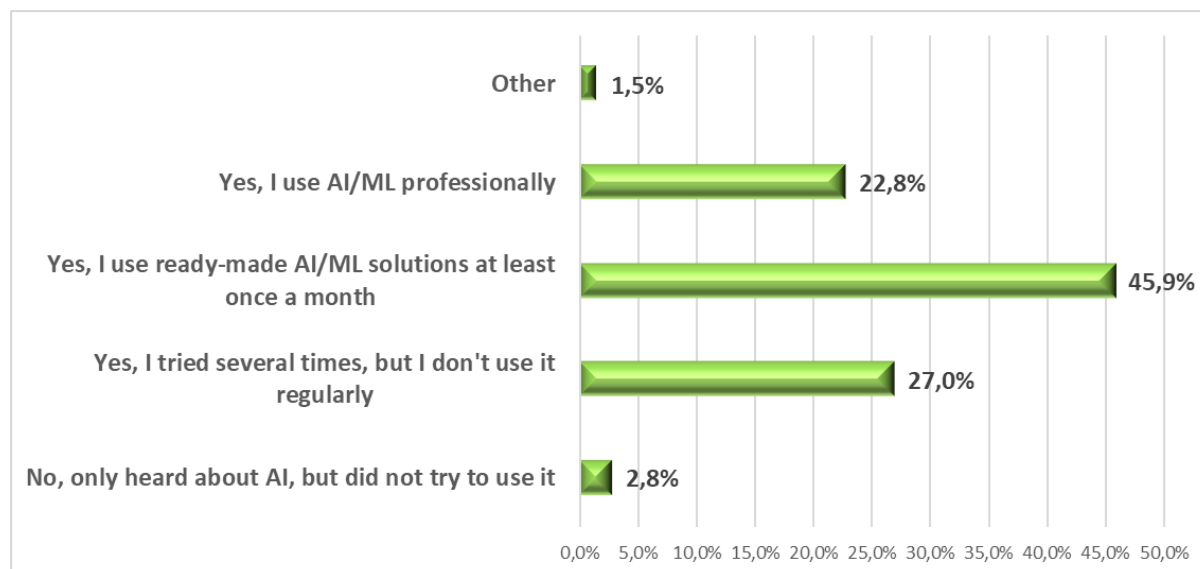


Figure 4: Student experience of AI use.

The question "Do you feel that the frequency of AI calls is increasing?" was in 40.4% of the cases answered yes, rather yes – in 43.3%. However, 5.3% of the respondents noted that they do not feel such changes (9 students of the 1st year of study, 4 students of the 2nd year, the students of the 3rd and 4th years did not experience such changes – with only 1 student in each), 11% of respondents rather do not feel the increase of AI calls (1st year – 10 students, 2nd year – 8 students, 3rd year – 11 students and 4th year – 2 students) (figure 5).

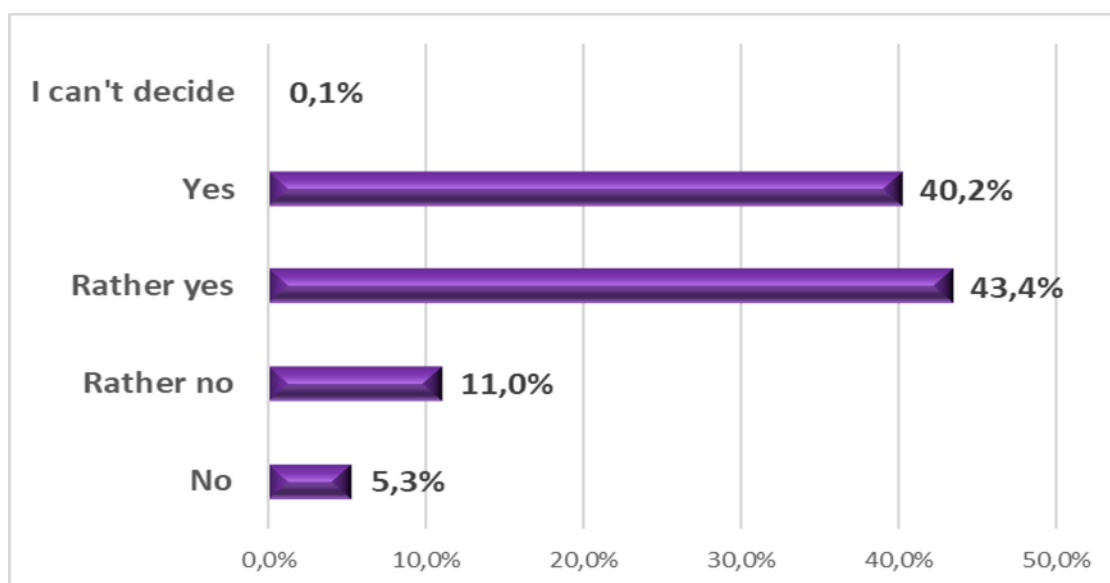


Figure 5: Student demand in AI calls.

Analysis of answers to the question "Do you feel that new questions arise while working with AI?"

showcased that almost 70.8% of students indicated that they face new questions while working with AI. The questions that arise concern both the clarification of the request to the AI itself, and the responses of the AI – their detailing, clarification and addition.

This aspect of working with AI confirms the authors' opinion that during work with AI, students are gradually immersed in the subject being studied. Clarifying and detailing the answers helps students understand the essence of the question or deepen their knowledge of the issues being studied or researched.

While analyzing the answers “no”, “rather not”, it was found that 29.2% of students are satisfied with the primary answers of AI (figure 6).

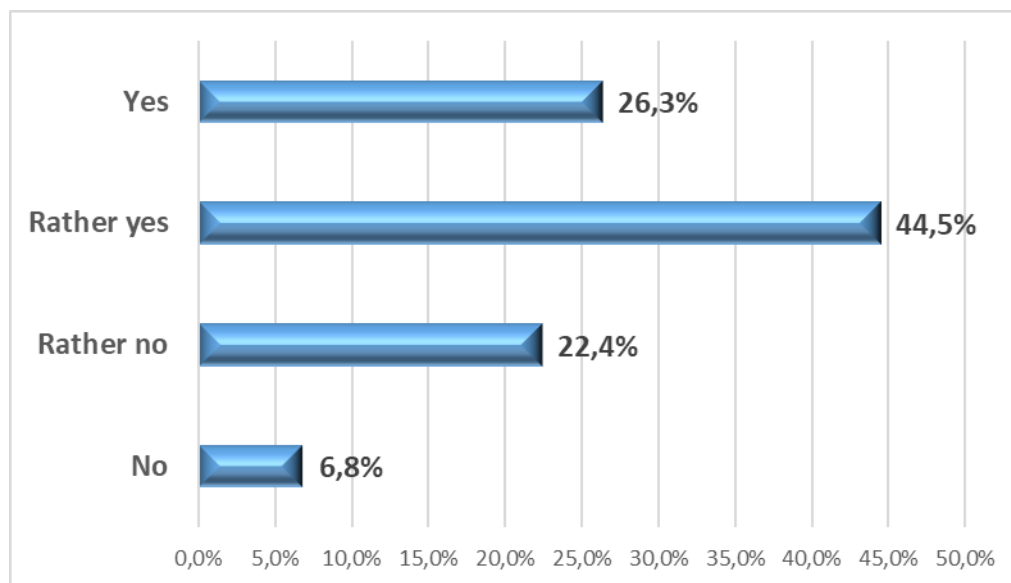


Figure 6: Student immersion in work with AI.

The use of artificial intelligence by programming students while learning and performing practical tasks has a number of significant advantages:

- *Improving productivity:* automating routine tasks – AI can automate many routine and repetitive tasks, such as testing, writing documentation or generating code, allowing students to focus on more creative and complex aspects of programming; faster information search – AI can quickly find the necessary theoretical information or code examples, which significantly reduces the time required for research and training; improving code quality – occurs through error and flaw detection, as AI tools for statistical analysis of code can automatically detect errors, potential bugs or flaws in code, which helps students write better and more reliable codes; code optimization – AI can recommend some improvements to optimize code performance, which is an important skill for programmers.
- *Individualization of learning:* adaptive learning – systems that use AI can adapt learning materials and tasks according to the student's level of knowledge and learning pace, which ensures more effective and personalized learning; interactive assistants – chatbots and AI-based virtual assistants can answer students' questions in real time, providing support and clarification.
- *Development of skills for working with new technologies:* practice with real AI tools – students get the opportunity to work with modern AI tools and technologies, which is important for their future careers; introduction to advanced methods – the use of AI provides students with the opportunity to learn and apply advanced methods and approaches in programming and software development.
- *Improving analytical and critical skills:* big data analyzing – AI can help students analyze large volumes of data, identify patterns and make predictions, which creates conditions for the devel-

opment of their analytical abilities; solving complex problems – AI can offer new approaches to solving complex problems, promoting the development of student critical thinking.

- *Simplification of the testing process*: automatic test generation – AI can automatically create various test cases to test the code, which greatly facilitates the process of testing and bug identifying; automatic testing – AI tools can perform automatic code testing, which ensures fast and effective detection and correction of errors.

After analyzing the above-mentioned advantages, the logical question arose “Do students feel the demand to turn to AI if they start developing a new program, generating text or creating an image?”.

In response to this question, the following results were obtained: the students are not yet completely sure of the AI effectiveness, but 69.1% of the respondents still turn to AI and almost 30% start work on their own (figure 7).

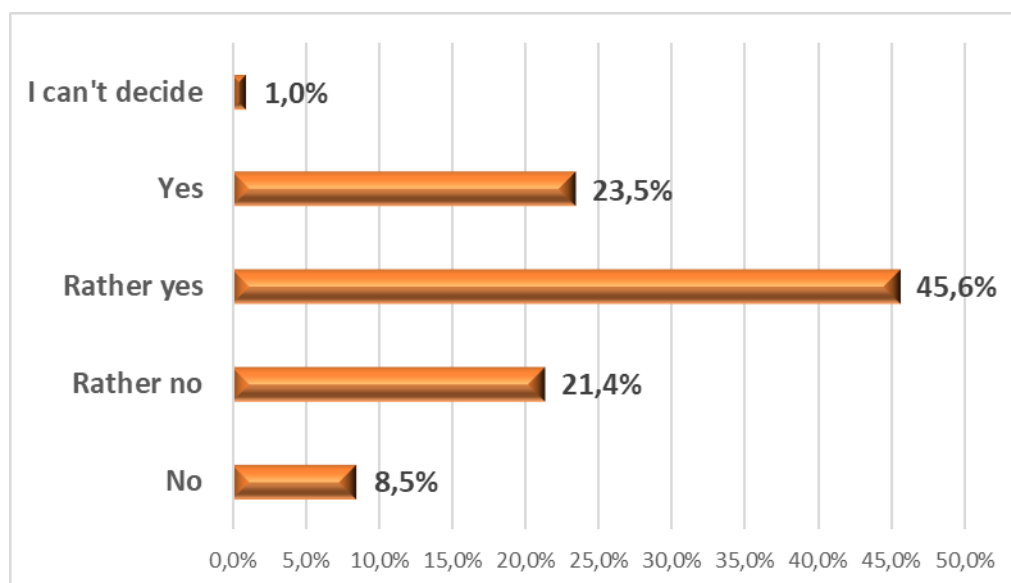


Figure 7: Students' demand in turning to AI while developing a new program, generating text or creating an image.

It is worth noting that creating a code is the students' task in the case. While performing this exactly type of work students feel the need to turn to AI (creating a primary code) – 39.1%, 10% – use it constantly, while– 9.6% once a week, used it only once – 11.7%, did not use – 21% (figure 8).

The criteria for respondents' call to AI was revealed when detailing the students' answers: 1) not able to find an error; 2) creation of samples that function; 3) for program structure creation; 4) as a source of information; 5) in search of solutions, etc.

A question about the quality of code generated by artificial intelligence arises logically at this point. The study results revealed that only 2.5% of the respondents used the initial version of the AI generated code in their work. 55.2% used AI, but refined the code (made corrections) independently, and 12.8% used only a part of the code generated by AI (figure 9).

In addition to the scope of code generation, students indicated areas where they use AI: 79.9% – for their own needs, not related to education; for generating ideas – 63.3%; in information search – 59.8%; text creation – 58%; for laboratory work – 51.6% and practical work – 47.3%; for data analysis – 46.6%; quick acquisition of program code – 43.4; text translation – 43.1%; creating presentations – 34.5%; fact checking – 32.4%, etc. (figure 10).

The study on students' demands on applying AI led to detailing the AI models used by the students: ChatGPT – 81.5%; 40.9% use it constantly for learning, and 1.8% do not use it at all. Version 3.5 gained popularity as a free version, but 16.4% of students use the paid version 4.0.

The Gemini model has not yet gained popularity. It is not used by more than 60.1% of students, 16% of respondents turn to this AI model on random demand (from time to time): once a week – 4.6%, twice

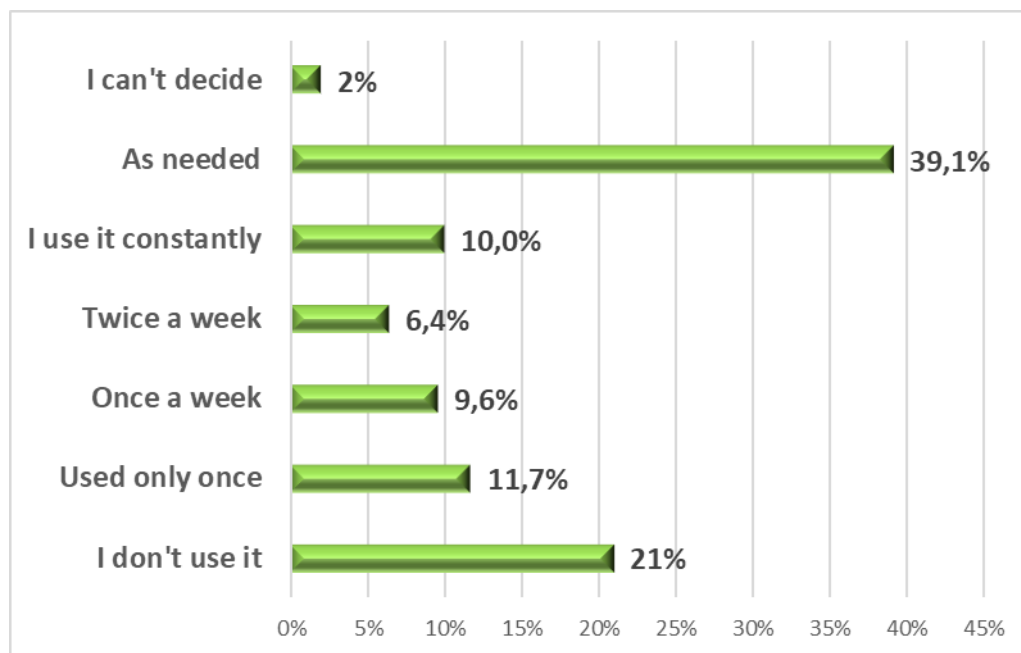


Figure 8: Frequency of AI use by students.

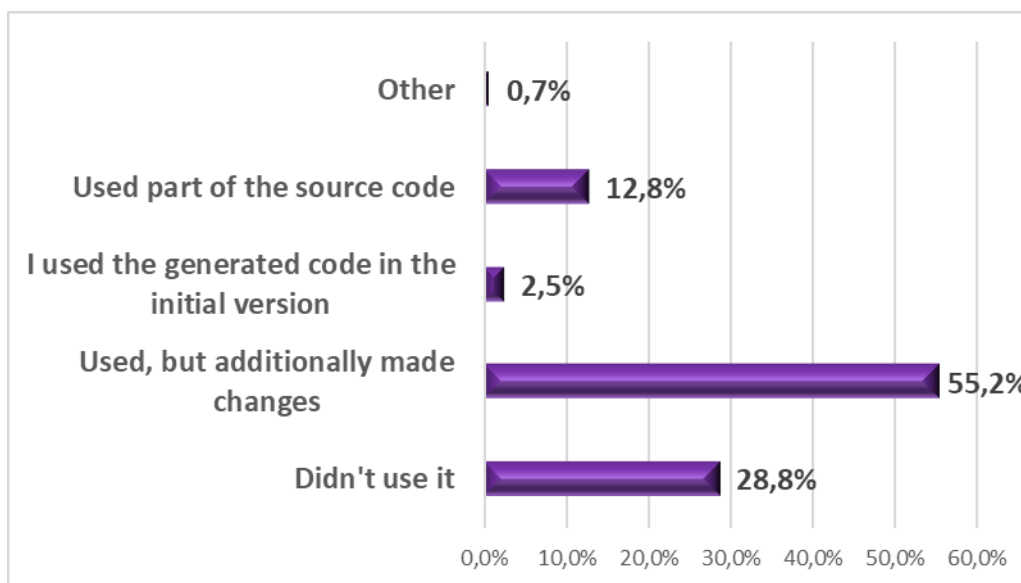


Figure 9: Students' use of AI-generated code.

a week – 2.8%. Whereas 5.3% use it constantly.

The Copilot model appeared later than the previous one and also did not gain popularity among students: 64.8% of the respondents do not use this model, 12.1% – use it when necessary, 4.3% once a week, and 2.5% twice a week. Those who use it constantly make 5.3%.

As shown by the monitoring of the emergence and implementation of the latest technologies (2004-2023): the time from the emergence of technology to its use is reduced, design and manufacturability are simplified and become available to all users. That is why students did not take the advantage of additional training on AI use, making it possible for 95.7% of the students to independently master the skill of applying AI.

An important aspect of a student's development as a professional is his creativity, inventiveness as well as his demand in the labor market. Therefore, the issue of reducing students' creativity, which is

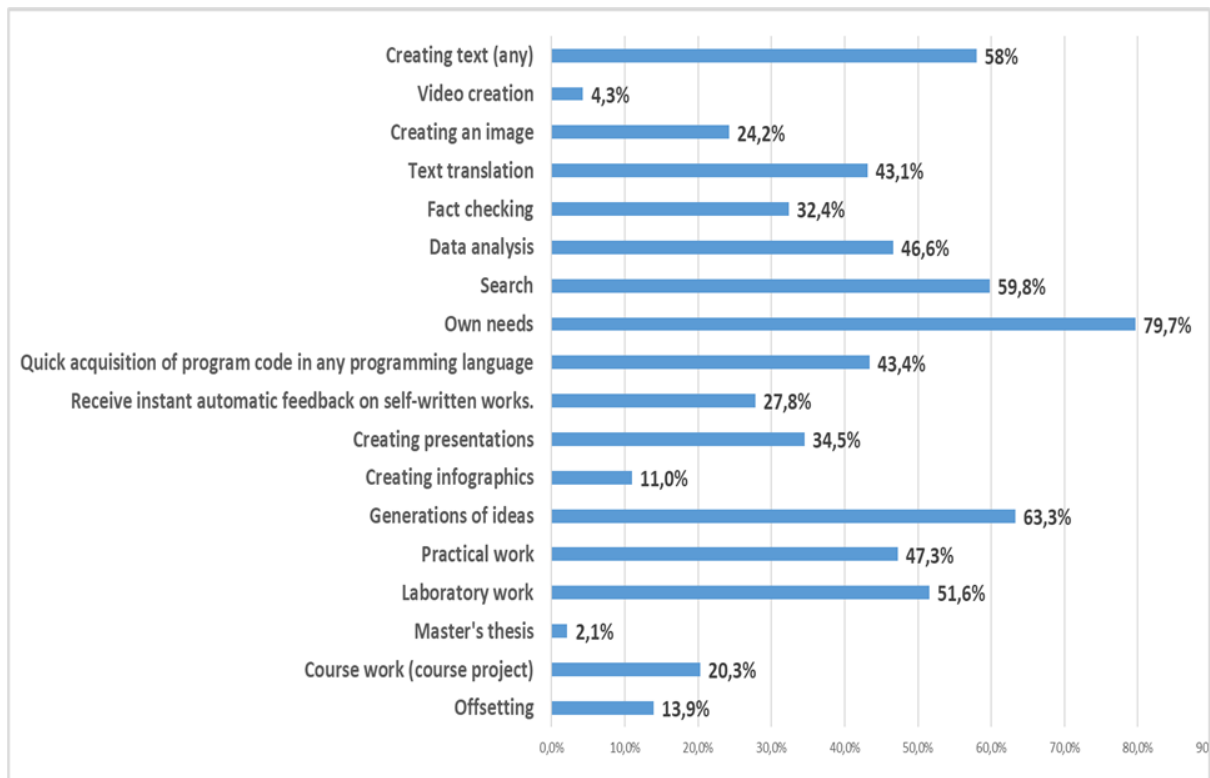


Figure 10: Student experience in creating materials using AI.

one of the disadvantages of introducing AI into the educational process, has become a key issue. In the scope of analyzing students' answers, it was found that, according to the respondents, creativity does not decrease: 48.6% of the students answered that rather not, whereas 28.9% confidently said no (figure 11).

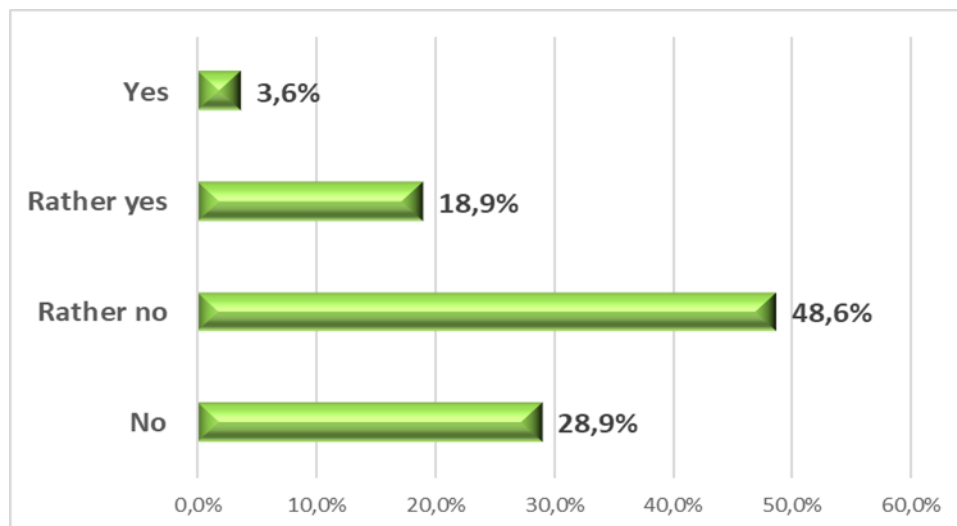


Figure 11: Decrease in students' creativity while applying AI.

At the same time 22.5% of students expressed the worry that this could happen. The data (figure 12) showcase that students' desire to do the task themselves decreases by more than 39.2%. However, 58.7% of students claim that this does not happen.

AI is expected in the future to become an assistant not only to the teacher, but also to the student.

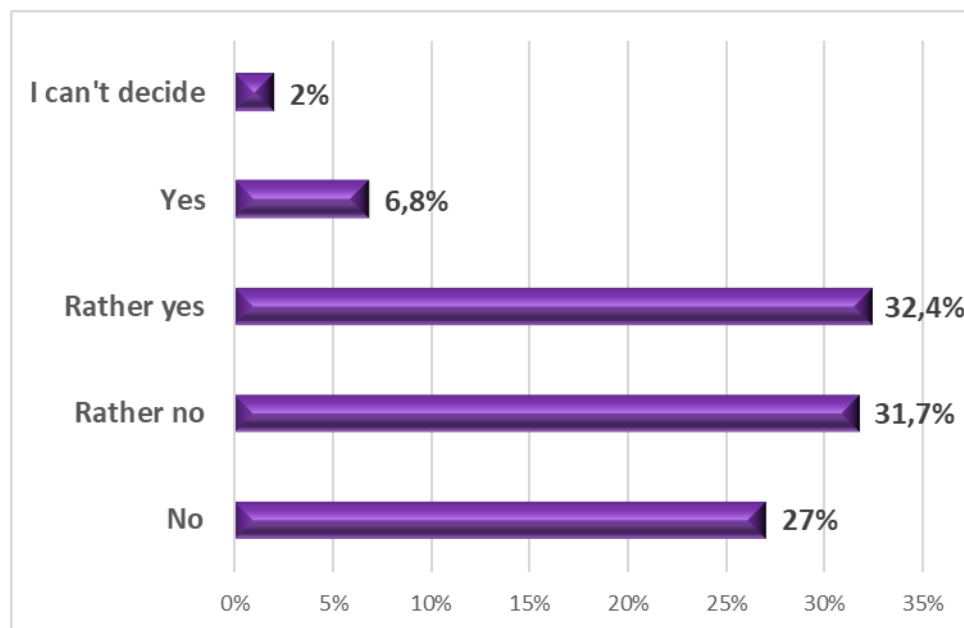


Figure 12: Decreased motivation to complete tasks independently.

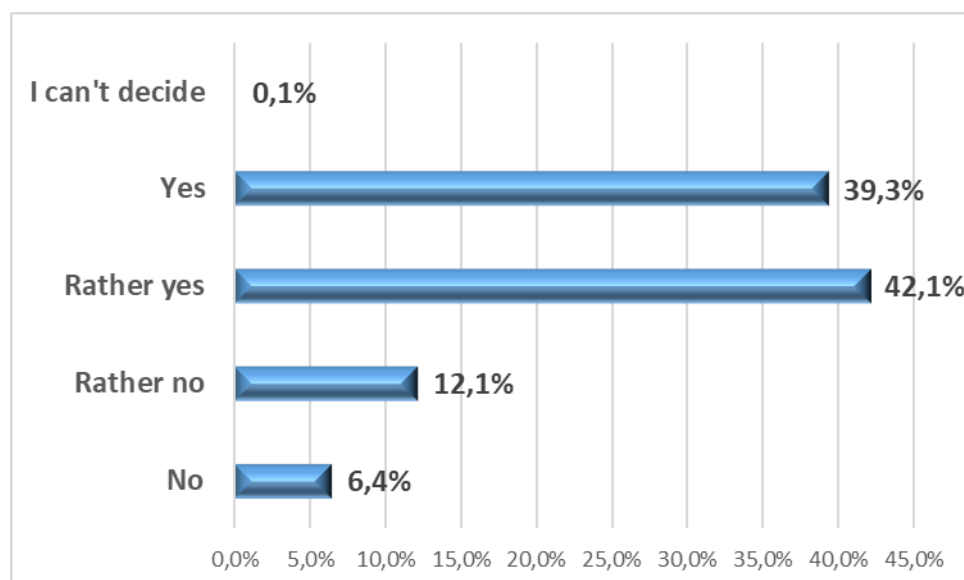


Figure 13: Trends in AI use as student assistance.

81.4% of the respondents claim for this, whereas 18.5% of students do not share this opinion (figure 13).

That is why it is important today to form in the society a positive attitude towards its use in the education system, to outline the relevant requirements, as well as to adhere to ethics.

6. Conclusions and recommendations for further research

Despite the above-outlined disadvantages, the use of artificial intelligence in teaching programming languages to HEI students is a promising direction that provides an opportunity to improve the quality of education and ensure training of highly qualified specialists who are competitive in the global labor market.

The results of the conducted research proved the following:

- students of the first year of the programming specialty use the latest technologies more actively than students of senior years, in particular, the 4th year study students for the bachelor's degree and the students of the 1st-2nd years study for the master's degree;
- despite the existing problems, the development of technologies and the growing demand for programming specialists make the integration of AI into the educational process relevant and necessary;
- not all HEIs have a sufficient technical base and financial capabilities to implement innovative technologies, such as AI. This creates a gap in the provision of educational services between well technically equipped and less technically equipped educational institutions;
- existing learning programs may be outdated and may not meet the modern requirements of the labor market. Constant updating of course content in accordance with new technologies and teaching methods requires considerable effort and time on the part of teachers;
- the use of AI provides an opportunity to adapt educational materials to the needs of each student. However, this requires the creation of new assessment methods and an individual approach to learning, which can be difficult in large groups;
- introduction of new technologies often meets resistance from both teachers and students who are used to traditional teaching methods. Changing mentality and adapting to the new conditions require time;
- teachers are required to obtain appropriate knowledge and skills for working with AI and other modern technologies. This requires regular professional development and professional education of the teaching staff. The use of AI in education raises the problem of student data privacy and their protection. It is necessary to create a legal framework that would regulate these aspects;
- teaching programming languages and implementing AI require the integration of knowledge from different disciplines, which can complicate the educational process and require closer cooperation between different faculties and departments.

Thus, the implementation of AI in education, especially in the programming languages teaching, opens up new opportunities for individualization and increasing the effectiveness of education. However, this also poses a number of challenges for the HEIs, which require a systemic approach and comprehensive solutions. Further research and improvement of AI technologies in this area will contribute to their more effective use and solving existing problems.

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